Overtraining and Burnout in Young English Athletes

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Submitted by Nuno Filipe Machado de Matos to the University of Exeter as a thesis for the Doctor of Philosophy in Sport and Health Sciences

I certify that all work is in this thesis which is not my own work has been identified and that no material has previously been submitted and approved for the award of a degree by this or any other University.

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ABSTRACT

The purpose of this thesis was to investigate overtraining (OT) and burnout (BO) in young athletes. Very little data on the incidence of OT in young athletes is available, hence the purpose of the 1st study was to investigate the prevalence and symptomology of NFOR (non-functional overreaching) and OT in young English athletes practicing different sports and competing across all competitive levels. Data from 376 young athletes (age 15.00 ± 1.97 y) indicated that 29 % had experienced at least one episode of NFOR/OT, and that NFOR/OT was significantly higher at national and international competitive levels ($p < 0.01$). Presenting symptomology was similar to that reported in adults, with both training and non-training stressors identified as important associates: losses of appetite during periods of hard training, frequent injuries and feelings of a lack of recovery from training, combined with apathy, feeling intimidated by opponents, and being "moody" were the most frequently reported physical and psychological symptoms, respectively. Training load, the commonly believed cause of NFOR/OT, had no significant association with NFOR/OT incidence; however competitive level and gender were significant predictors of NFOR/OT, albeit of a small explained variance (~4%). This study demonstrated that NFOR/OT is evident in young athletes and that the associated factors are multifactorial. The 2nd study monitored prospectively, 4 national-level female swimmers during an 11-month competitive season. Two swimmers (16.00 ± 1.41 y) were diagnosed as OT based on performance decrements (mean decrement of 9 %). One of the OT swimmers (OT2) presented with the classical psychophysiological profile, i.e. high monthly training volumes, low IgA concentration, depressed maximal lactates and high self-reported distress. Conversely the other OT swimmer (OT1) only presented with high Training Distress Scale (TDS) scores. These findings show that

both, OT is a complex problem to diagnose and that it's approach needs to be individualized. The 3rd study investigated the acute psycho-physiological responses to a 6-day training camp in 4 young female swimmers (15.00 ± 1.21 y), of which one was OT and another burnt out (OT1 swimmer from study 2). Both mal-adapted athletes showed performance decrements of ~8 % that lasted for more than 6 months. The OT swimmer, unlike her BO friend, showed a depressed IgA concentration, an unresponsive cortisol, reduced maximal lactate production, and high psychological distress, measured by the TDS. Both swimmers reported slower reaction times on the Stroop test, with the BO swimmer evidencing the worst performance. Finally, the BO swimmer reported very high scores on the Athlete Burnout Questionnaire (ABQ; reduced sense of accomplishment = 4.3; emotional/physical exhaustion = 2.6; sport devaluation = 3.7). This study showed that the psychophysiological profile of an OT swimmer may differ considerably from a BO athlete, with the ABQ being potentially the most efficient tool to diagnose BO. Once more, the individuality of the profiles reinforces the importance of investigating this phenomenon on a case by case basis. The final study used Interpretative Phenomenological Analysis to investigate the psychosocial nature of OT and BO in a 15 year-old female swimmer (OT1 and BO from studies 2 and 3, respectively) and revealed how multiple sources of training and non-training stressors all combined to negatively affect the athlete. The swimmer revealed a past in which she experienced rapid success at an early age and a training mentality of "the more, the better" which was promoted by parents, coaches and herself. Her strong unidimensional identity – centred on swimming – provided few recreational or social opportunities outside the sport. She also reported communication difficulties with her coaches, unwelcome changes in coaching staff, periods of separation from her family, and an over-involved mother. The findings of this thesis suggest that NFOR/OT and BO are issues that many young athletes have to contend with during their sporting careers. The multifactorial nature of these conditions mean that any screening, prevention or recovery interventions must address the problem from a holistic standpoint and as such, Ken Wilber's (1998) Integral Model is proposed as a suitable framework through which this condition may be investigated in young athletes.

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LIST OF ABBREVIATIONS

ABQ	Athlete Burnout Questionnaire
ACh	Acetylcholine
ACTH	Adrenocorticotropic hormone
ADR	adrenaline
ANS	Autonomic nervous system
AQAL	All quadrants, all levels, all lines, all states, all types
AR	Autoregressive modelling
AV	Atrio-ventricular node
BM	Body mass
BMI	Body Mass Index
BO	Burnout
Ca	Calcium
CBG	Cortisol binding globulin
CFS	Chronic fatigue syndrome
CHO	Carbohydrate
CRH	Corticotropin-releasing hormone
CV	Coefficient of variance
DALDA	Daily Analysis of Life Demands for Athletes
DNA	Deoxyribonucleic acid
ECG	Electrocardiogram
ELISA	Enzyme-Linked ImmunoSorbent Assay
EPE	Emotional/ physical exhaustion
FINA	Fedération Internationale de Natation Amadora
FOR	Functional overreaching
GnRH	Gonadotropin releasing hormone
HF	High frequency
HPA	Hypothalamic-pituitary-adrenal
HR	Heart rate
HRV	Heart rate variability
IgA	Immunoglobulin A
IgA-Osm	IgA relative to salivary osmolality
IG2	Immunoglobulin G2
IG3	Immunoglobulin G3
IOS	Integral Operational Systems
IPA	Interpretive Phenomenological Analysis
K	Potassium
IL-1β	Interleucin 1β
IL6	Interleucin 6
La	Lactate
LF	Low frequency
LF/ HF	Low frequency to high frequency ratio
LH	Leutinizing hormone
La/ RPE	Lactate to RPE ratio
[$\dot{V}O_{2max}$]	Maximal oxygen uptake
NA	Noradrenaline

NFOR	Non-functional overreaching
NK	Natural killer cells
NKCA	Natural killer cells activity
NIA	National and international athletes
NORM	Not overtrained
n.u.	Normalised units
OR	Overreaching
OT	Overtraining
% Fat	Percentage fat
PNS	Parasympathetic adrenomedullary
POMS	Profile of mood states
PRS	Perceived Recovery Scale
PSD	Power spectral density
RA	Reduced sense of accomplishment
RMSSD	Root mean square of the sum of the differences between adjacent RR intervals
RPE	Rates of perceived exertion
RSA	Respiratory sinus arrhythmia
RSQ	Recovery-stress Questionnaire
SAM	Sympathetic adrenomedullary
SA	Sino-atrial node
SD	Sport Devaluation
SHBG	Sex hormone-binding globulin
s-IgA	IgA as secretion rate
SNA	Sub-national athletes
SNS	Sympathetic nervous system
T/C	Testosterone/ cortisol ratio
TDS	Training Distress Scale
TMB	Tetramethylbenzidine
TNF-α	Tumour necrosis factor α
URTI	Upper respiratory tract infections
UUS	Unexplained underperformance syndrome
VLF	Very low frequency

CHAPTER I

Introduction

1.1. The Overtraining and Burnout problem

Overtraining (OT) has been identified as a problem in sports since the 1920s (Griffith, 1926; Parmenter, 1923) although, only recently, public awareness has increased in regards OT. It is suggested that this is due to the increase in training loads that has occurred in the past 30 to 40 years, which has led some athletes to train so much that they ended up OT (Raglin, 1993). For example Roger Bannister, who in 1954, broke the 4-minute mile was training about 30 minutes per day (Bannister, 1989). Since that time, the volume and intensity of training in the majority of sports has increased dramatically. From 1975 to 1980 it was estimated that the total number of yearly training hours in endurance athletes had increased by 10 to 22 % (Bompa, 1983). For example, the Olympic swimmer Mark Spitz, winner of 7 gold medals in the 1972 Olympics, was training around 9 km per day. But within 20 years, the average college swimmer exceeded this training load (Counsilman & Counsilman, 1990); between 1972 and 1995, American elite-level swimmers increased their training loads from around 9 Km per day to 36 km per day (Peterson, 2005). Thus, it is apparent that training levels have increased substantially in the past 30 to 40 years.

1.2. Historical perspective on overtraining research

Some of the earliest published work reporting the existence of an OT type condition was in the 1920's (Griffith, 1926; Parmenter, 1923). Parmenter (1923) suggested that overtraining is a problematic issue to understand and study, and 3 years later Griffith (1926) first referred to the mal-adaptation arising from excessive training as staleness, a term that was to be used frequently in the years following. Research on overtraining prior to the 1980s was carried out sparsely (Counsilman, 1955; Michael, 1961; Parmenter, 1923; Wolf, 1971), but in the 1980s and 1990s more research was conducted. Since then, the research has helped to define the nature of the problem as well as to suggest possible solutions (O'Connor, 1997). Despite research studies showing that changes in physiological and psychological variables correlate to changes in volume and intensity of training (Lehmann, Foster, & Keul, 1993; O'Toole, 1998; Rowbottom, Keast, & Mortan, 1998; Steinacker & Lehmann, 2002), the research on OT has not been able to identify markers that can differentiate between what is considered to be a positive adaptation to increases in training load and a negative one (Martin, Anderson, & Gates, 2000; Rowbottom et al., 1998; Steinacker & Lehmann, 2002). The lack of clarity between possible OT markers makes it hard for the sport scientist or coach to diagnose an athlete who is showing mal adaptations to training. Research on OT has focused essentially on the symptomology of the athlete (Gleeson et al., 1999b; Halson & Jones, 2002; Hedelin, Kentta, Wiklund, Bjerle, & Henriksson-Larsen, 2000a; Hedelin, Wiklund, Bjerle, & Henriksson-Larsen, 2000b; Hooper, Mackinnon, Howard, Gordon, & Bachman, 1995b; Nederhof, Lemmink, Zwerver, & Mulder, 2007; Nederhoff, Zwerver, Brink, Meeusen, & Lemmink, 2008; O'Connor, Morgan, Raglin, Barksdale, & Kalin, 1989; Passelergue & Lac, 1999; Urhausen & Kindermann, 2002), leaving the possible causes of the problem largely under-studied. In the late 1990s new research emerged that used qualitative methods (Appleton, Hall, & Hill, 2009; Gould, Tuffey, & Udry, 1996a; Gustafsson, Hassmen, Kentta, & Johansson, 2008; Hill, Hall, Appleton, & Kozub, 2009; Lemyre, Hall, & Roberts, 2008; Meehan, Bull, Wood, & James, 2004), which has brought new insights into the problem that pure physiology and psychology-based studies could not bring.

1.3. Modern view of overtraining research

Recent literature has found that OT is a complex phenomenon that requires an understanding of many factors, both training and non-training related. Some authors have now emphasized that a holistic approach to study OT is crucial to understand athletes' adaptations to training (Kentta & Hassmen, 1998; Matos & Winsley, 2007; Meehan et al., 2004). Furthermore, Kentta and Hassmen (1998) outlined the importance of studying the athlete as an individual focusing on the athletes' perception of training and recovery. Through observation, case-studies and anecdotal reports, other researchers have also identified circumstances where the balance between training and regeneration is disturbed, or times where personal and situational variables (sport and non-sport related) are conducive to cause OT, serious illness or injuries (Gould, Guinan, Greenleaf, Medbery, & Peterson, 1999; Gould, Tuffey, Udry, & Loehr, 1997; Krane, Greenleaf, & Snow, 1997; Uusitalo, 2001).

1.4. Chronic Fatigue Syndrome and its similarities to Overtraining

Chronic fatigue syndrome (CFS) is a state that has been compared to overtraining. CFS has no obvious cause, is characterized by excessive complaints and feelings of fatigue that are disproportionate to the amount of physical activity being undertaken by the athlete, with a symptomology that has lasted for 6 months or more (Shephard, 2001).

This condition has been widely reported in high-performance athletes, and in non-sport individuals, although with subtle differences on the symptoms observed. Potential causes to CFS related to the high amounts of physical training but also to factors that relate to severe emotional stress, primary or secondary disorder of affect or personality (Abbey and Garfinkel, 1991), trauma, hormonal disturbances, suppression of immune function and more (Shephard, 2001). In athletes where this condition has been diagnosed the recommended treatment seems to be in breaking the vicious cycle of excessive exercise, through a combination of encouragement and a more balanced exercise programme (Shephard, 2001). In addition to the latter, the recovery of an athlete with CFS may however need to include other approaches that will deal with the psycho-emotional factors of the athlete in order to uncover other potential causes of the problem.

1.5. Overtraining incidence in adults and young athletes

In adults it is known that OT affects both endurance and non-endurance sports (O'Toole, 1998), but little empirical data is available regarding incidence rates both in adults and youth athletes. In adult athletes the incidence of OT in individual sports range from 10-64 % (Hooper et al., 1995a; Morgan et al., 1987a; Morgan et al., 1987b; O'Connor et al., 1989), and up to 50 % in soccer players (Lehmann et al., 1992). Also, approximately 10 % of collegiate swimmers and wrestlers become OT at least once during their careers (Morgan et al., 1987a), although rates of 21 % have also been reported in swimmers (Hooper et al., 1995b; O'Connor et al., 1989).

In comparison, little is known regarding the incidence in youth athletes. A multicentre survey in adolescent swimmers across Japan, USA, Sweden and Greece found that 35 %

had been overtrained at least once (Raglin et al., 2000). A similar incidence rate was found by Kentta and colleagues (2001) in older Swedish athletes with 37 % of the athletes overtrained at least once in their sports careers. Recently, Gustafsson et al. (2007) also found that approximately 10 % of competitive adolescent athletes reported high burnout (BO) scores.

1.6. Limitations of overtraining research

Unfortunately, the majority of previous research into overtraining has used cross-sectional studies, which can provide only limited information in regards what is actually occurring in athletes in the long-term, and more longitudinal studies are therefore required. In addition most of these investigations have focused primarily on training load as the main causative factor, ignoring other potential factors. It was thought that by increasing training load and then looking at the athletes' responses, the ones that showed signs of mal-adaptation were diagnosed as being overtrained. The problem is more complex however since overtraining involves training and non-training stressors, and unless researchers decide to study overtraining and burnout in its natural setting, our understanding of the problem will always be incomplete.

1.7. Aims and research questions of this PhD

With such little information available in young athletes it is imperative that more research is done on this phenomenon since it could potentially be affecting a great number of young athletes. In addition, not knowing which factors contribute to OT and BO (be it physical, psychological and sociological) leaves sport scientists and coaches unable to intervene in order to prevent and rehabilitate athletes suffering from it. As such, this PhD will investigate overtraining and burnout in young athletes by taking an integral perspective of the phenomenon, and it will attempt to answer the following questions:

1 – What is the incidence of overtraining in young athletes?

2 – What are the associated factors of overtraining and burnout in young athletes?

3 – What role does training load have on influencing overtraining and burnout?

4 – What are the most suitable diagnostic and monitoring instruments of overtraining / burnout in young swimmers over a competitive season?

5 – How does non-functional overreaching/ overtraining or burnout manifest in young swimmers after a 50 % increment in training load during a training camp?

6 – What does the profile of an NFOR, OT and/ or BO athlete look like seen through physiological, psychological and socio-cultural lens?

CHAPTER II

Literature Review

2.1. What is training and overtraining?

The physiological and metabolic adaptations of the healthy individual resulting from training or a consistent program of moderate physical activity have been well described (Astrand & Rodahl, 1986), as also have the precise exercise prescriptions for improving and maintaining physical fitness (ACSM, 1990). It is well known that for the average individual, 20 minutes of aerobic physical activity performed at moderate intensity 3 to 5 times a week for a period of six weeks minimum will result in a 15 to 20 % gain in aerobic fitness (ACSM, 1990). Furthermore, regular moderate physical exercise has consistently been associated with positive changes in mental health, including reduced anxiety and depression (Morgan & Goldston, 1987b), and has been recommended specifically for both healthy and clinical populations.

The type of physical activity described differs greatly from the training performed by athletes in competitive sports that require a high degree of aerobic/ anaerobic fitness. Typically endurance athletes already have acquired the physiological adaptations that result from moderate training, and more intense training is needed to keep improving performance. The most common example of this process involves periodic cycles of progressively intensified training, often referred as overreaching (OR) (Uusitalo, 2001). The traditional view of OR is to stress the athlete to the point where incomplete recovery occurs between training sessions (Harre, 1982), which is considered necessary for evoking a compensatory “physiological superadaptation” (*figure 2.1*) (Bompa, 1999;

Harre, 1982). The physiologic homeostasis of the body needs to be displaced by intensive training stimuli so that performance capacity can be improved, a process called supercompensation (Viru, 1994). Several days of intensive and intentionally heavy training are followed by days of less intense training (know as taper period) and rest to achieve supercompensation and an improvement in performance. Tapers are periods of recovery undertaken with the goal of eliciting peak performance, and they are initiated several days or weeks before the competition. It has been hypothesized that the improvements in performance that occur following tapers are the result of physiological supercompensations to overtraining (Harre, 1982), although compensatory responses have not been clearly identified (Neufer, 1989). This entire process of systematically increasing and reducing training has been referred to as periodization (Matveyev, 1981).

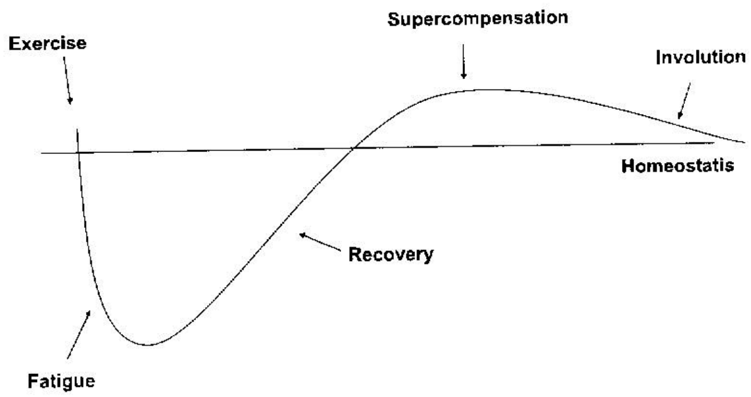

Figure 2.1 – The supercompensation cycle. Adapted, with permission, from T.O. Bompa, 1999, *Periodization: Theory and methodology of training*, 4th ed. (Champaign, IL: Human Kinetics), 16. Previously adapted from N. Yakovlev, 1967, *Sports biochemistry* (Leipzig: Deutsche Hochschule für Körperkultur.

The physiological consequences of this type of training have been investigated, but the findings have been inconclusive or contradictory (Kuipers & Keizer, 1988). There is some evidence, suggesting that performance improvements comparable to those gained with high intensity/ volume training can be achieved by training at low volumes but at a high intensity (Costill, 1985a), although these findings have been challenged (Councilman & Councilman, 1990). However, it has been contended that the external validity of research in support of reducing training volume is limited because of the use of non-elite athletes (Councilman & Councilman, 1990). Despite the limited understanding of the changes that occur during the training process significant improvements in performance have been observed following reductions in volume (Costill et al., 1985b). In resume, it is important to recognize that a balance between training intensity and volume during the overload phase is important, and that performance improvements will only occur if the athlete is given sufficient rest/ recovery after the overload period.

The time needed for supercompensation is essential. If an athlete is not given sufficient time before a new overloading is given, a greater and progressive imbalance in homeostasis will occur. Overreaching becomes OT when tapering the activity does not yield the desired supercompensatory effects, typically resulting in maladaptations and a decrement in performance (Kreider, Fry, & O'Toole, 1998; Kuipers & Keizer, 1988; Meeusen et al., 2006; Uusitalo, 2001). It is through these unbalances that athletes will progress in the "overtraining continuum" to a state of OT (*figure 2.2*) (Kentta, 2001a). The overtraining state, also called athlete's maladpatation state, includes performance decrements together with stress-related psychological, psychosomatic and physiological signs and symptoms that can vary in intensity from mild to severe (Uusitalo, 2001). A mild form is considered when the athletes show low-grade psychological and physiological symptoms like anger, tension, fatigue, loss of appetite, sleep problems, muscular fatigue, and/ or immune/ hormonal disturbances. A severe form includes symptoms such as depression, severe long-term insomnia, long-term muscle soreness, and abnormal sense perceptions (Armstrong & VanHeest, 2002; Morgan, Brown, Raglin, O'Connor, & Ellickson, 1987a; Uusitalo, 2001).

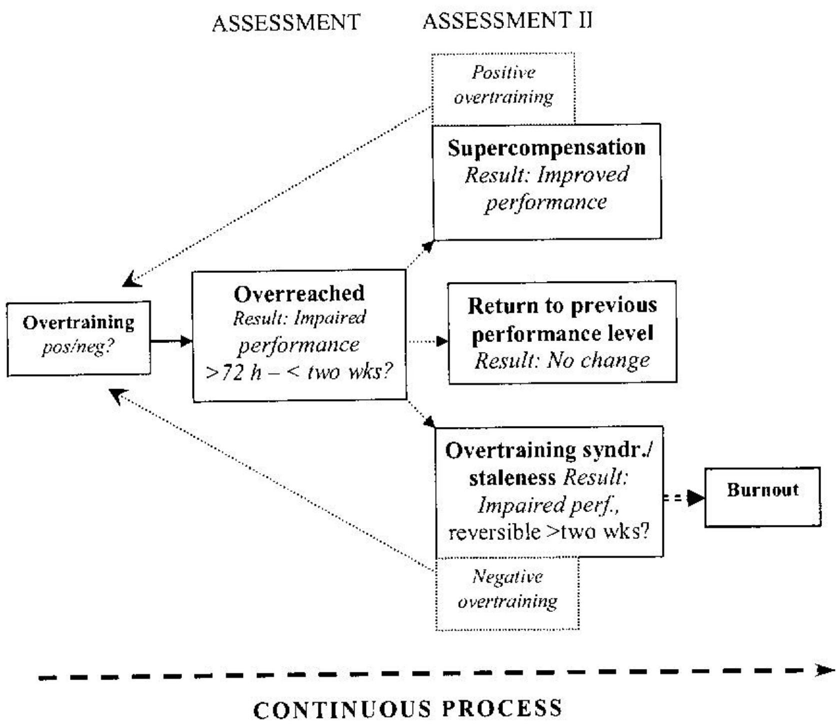

Figure 2.2 – The overtraining process (copied with permission from Kentta, 2001a).

2.2. Problems with the definition

In defining OT and due to its complexity researchers have given different terms to describe process and outcomes associated with OT (Kentta, Hassmen, & Raglin, 2001b;

Meeusen et al., 2006; Richardson, Anderson, & Morris, 2008). Since OT is a continuum in itself (Uusitalo, 2006), it has been hard to distinguish between overreaching - an accumulation of training and non-training stressors that result in short-term decrement in performance taking from days to several weeks to recover (Kreider et al., 1998) – and overtraining – an accumulation of training and non-training stressors that has a detrimental long-term effect on performance and a recovery period that may take several weeks to months (Kreider et al., 1998). However OR may develop into OT if sufficient recovery time is not given, indicating that OR and OT are just two points on the same continuum. As stated by several authors (Budget et al., 2000; Halson & Jeukendrup, 2004; Lehmann, Foster, Gastmann, Keizer, & Steinacker, 1999) the definitions suggests that the difference between OR and OT is in the duration of the performance decrement and in the amount of time needed to recover and restore performance and not the type or duration of training stress. In defining overtraining, many researchers have used many terms in different ways to describe both processes and outcomes related to training. Terms that have been used to describe or define OT include: *staleness*, *burnout*, *unexplained underperformance syndrome*, *non-functional overreaching*, *overwork*, *underperformance*, *underrecovery*, and *short*- and *long-term overtraining*.

2.2.1. Overtraining and Overtraining Syndrome

The problem with the word *overtraining* is that its definition varies depending on the author or researcher, and it can be used to describe a process, an outcome or both. In example, Steinacker and Lehman (2002) have used the word *overtraining* to describe both a process and an outcome; a process that can have sport-specific and non-sport specific stressors and an outcome because of a long-lasting decrement in performance, sports injuries, infections, mood disturbances, fatigue and depression (Steinacker & Lehmann, 2002). Similarly, Mackinnon (1995) and O'Toole (1998) outlined the different possible outcomes of OT, describing it as a process that will lead to negative adaptations like prolonged fatigue, depression, illnesses, injuries, and a long-term disruption of general psychological and physiological well-being. The same authors indicated that overtraining is a process, whereas overtraining syndrome is an outcome, representing the final end of the spectrum of the phenomenon (Hooper & Mackinnon, 1995a; O'Toole, 1998).

Other researchers have considered overtraining as a process and not an outcome, i.e. overtraining is viewed as a necessary part of training whereby coaches progressively prescribe intense physical training of a high absolute and relative intensity (Morgan et al., 1987a; Raglin, 1993). On the other hand, Kreider and colleagues (1998) did not differentiate overtraining from process or outcome and instead focused on overtraining as a state of stress accumulation (Kreider et al., 1998). In case the athlete experiences a long-term restoration of performance (several months) then it could safely be said that the he/ she is experiencing the *overtraining syndrome* (Richardson et al., 2008).

Lehman and colleagues (1999) also speak of short-term overtraining and long-term overtraining, referring to each as positive and negative terms, respectively. *Short-term overtraining* is considered a common part of the training process that leads to OR and is characterized by a transient loss in performance, which is reversible with a short-term recovery of one or two weeks. *Long-term overtraining* occurs when the extent to which the athlete overloaded himself lasts too long and the regeneration period is too short and does not allow full recovery. This state is associated with too many competitions and non-training stressors, leaving the athlete vulnerable to overtraining syndrome (Lehmann et al., 1999).

2.2.2. Staleness

Staleness can also be referred as the overtraining syndrome and is used when referring to the detrimental responses to training (Raglin, 1993; Raglin & Wilson, 2000). It has been regarded as an undesirable response that is a consequence or product of OT (Raglin, 1993). Silva (1990) described staleness as an initial failure of the body to cope with the psychological and physiological demands of training (Silva, 1990). It seems, nevertheless, that staleness is synonymous with the overtraining syndrome, hence adding this term just further adds to the already confusing lexicon used in OT research.

2.2.3. Unexplained Underperformance Syndrome

In an attempt to simplify the definition and criteria for diagnosis of OT, Budget and colleagues (2000) decided to reduce all the terms that had been previously used in regards overtraining to *unexplained underperformance syndrome* (UUS). This was forwarded on the basis that the term *overtraining* implies causation which is often difficult to prove (Budget et al., 2000) - many times it is not possible to determine accurately if an athlete is OT on the basis of frequent respiratory infections, depressed mood state, fatigue and a lack of performance. In the words of Budget et al., (2000) UUS "is a persistent unexplained performance deficit (recognized and agreed by coach and athlete) despite two weeks of relative rest." (p. 67). This definition has not been widely accepted by OT researchers, because it brings confusion instead of clarity, plus, the definition is too specific in that it actually specifies that just 2 weeks of a lack of performance are enough for the diagnosis to be met.

2.2.4. Overreaching – Functional and Non-Functional

Overtraining is fundamentally an imbalance between training fatigue and non-training stressors, and recovery. Furthermore, it is associated with a variety of symptoms that often vary considerably across individuals (Kentta, Hassmen, & Raglin, 2001). The latter has led to disagreements as to which signs and symptoms need to be present for an athlete to be defined as being overtrained or overreached (Meesuen et al., 2006; Uusitalo, 2006). To overcome the lack of common and consistent terminology a consensus statement taken by Meeusen and colleagues (2006) decided to separate overreaching (OR) into functional and non-functional overreaching (NFOR) as represented in *figure 2.3*. Functional overreaching will eventually lead to an improvement in performance taking from days to weeks to recover, whereas NFOR will lead to stagnation or decrease of performance and a recovery period that will last from weeks to months. If the OR becomes severe enough it is then called *overtraining syndrome*, with the difference being that OT will take months to recover leading to a significant decrease in performance. A recent position statement by the European College of Sports Sciences tried to provide clarity to the definition by recommending that overreaching was divided into two different stages, functional overreaching and non-functional overreaching, with the latter eventually leading to the OT syndrome (Meesuen et al., 2006). However, the statement did not provide guidance over the duration of each stage (Uusitalo, 2006), making it hard to distinguish which stage the athlete is in and also, when does functional overreaching turn into non-functional overreaching and ultimately OT.

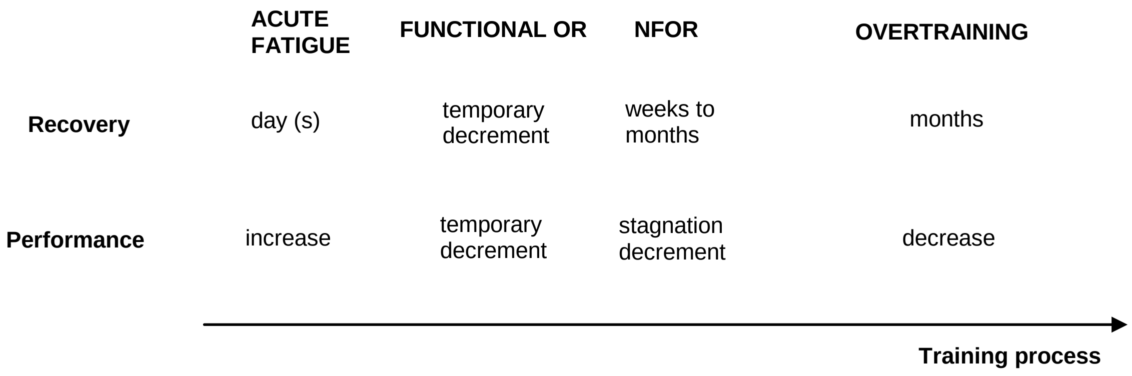

Figure 2.3 – Different stages of training represented according to Meeusen et al., (2006); OR – overreaching; NFOR – non-functional overreaching.

The definitions forwarded by Meeusen et al., (2006) will be used throughout the thesis (Figure 3).

2.2.5. Underrecovery

Recently, in an attempt to shift the attention away from training, overtraining and the confusion around these terms, Kellman (2002) has focused more on the recovery aspects of athletes' training. Under Kellman's (2002) definition to be overtrained is to experience *underrecovery*; coaches would not be overtraining their athletes but instead they would be underrecovering them. Also, is has been suggested that the main cause of an athlete becoming overtrained is because of a lack of recovery time between practice sessions (Kellman, 2002a). The problem with this definition is however that instead of focusing on both training and recovery, it only focuses on recovery. Furthermore, it only acknowledges recovery from training loads, i.e. physical recovery as the important factor and leaves psychological and emotional recovery completely disregarded.

2.2.6. Burnout

Burnout and *overtraining syndrome* have for many times been used interchangeably in the literature; both share many similarities. Foremost, they share diagnostic characteristics such as performance loss, mood disturbances and exhaustion (Fry, Morton, & Keast, 1991; Gould et al., 1996). Overtraining research has traditionally investigated signs and symptoms of maladaptive responses to excessive training (Fry et al., 1991; Kuipers & Keizer, 1988), whereas burnout research has focused essentially on psychosocial factors such as high external pressure, lack of control and feelings of entrapment (Gould et al., 1996; Raedecke, 1997). However, researchers acknowledge that non-training stressors should be recognized when studying the overtraining phenomenon (Kreider et al., 1998) and that OT has been suggested as an antecedent to burnout (Gould et al., 1996), which makes the boundaries between these two phenomena blurred.

Burnout denotes a negative emotional reaction to sport participation, while OT denotes a disorder combining affective and physiological maladaptive responses to training (Raglin & Wilson, 2000). While it is known that overtrained athletes can still maintain their motivation to keep training, it has been previously suggested that repeated episodes of OT may increase the risk of burnout (Raglin, Sawamura, Alexiou, Hassmén, & Kentta, 2000). Raglin (1993) suggests that the motivation to continue training during an OT episode is an essential factor to differentiate between the seriousness of the OT episode as the athlete may be very close to dropout from the sport. With this view in mind, an athlete suffering from OT can still be extremely motivated whereas a burned-out athlete will have no motivation to pursue his/ her activity (Gould et al., 1996). Thus, burnout and OT might be differentiated with regard to motivational aspects.

2.2.7. Chronic fatigue syndrome

There are suggested similarities between chronic fatigue syndrome (CFS) and OT. Chronic fatigue syndrome consists primarily of physical symptoms with some psychological symptoms (Schaufeli & Buunk, 2003). Furthermore, it is characterized by a fatigue that is disproportionate to the intensity of effort that is undertaken, has persisted for 6 months or more, and has no obvious cause (Shephard, 2001). Common symptoms of CFS are mild fever, muscle weakness, headaches, sore throat and joint pain (Fukuda, Straus, Sharp, Dobbins, & Komaro, 1994), which can also be present in OT athletes. According to Maslach et al., (2001) OT develops over long periods of time whereas CFS has an acute onset with symptoms very similar to an infection (Maslach, Schaufeli, & Leiter, 2001). Another difference is that the fatigue from CFS is unexplained whereas the fatigue from overtraining is thought to be explained through training load related factors (Kreider et al., 1998; Lehmann et al., 1999) or psychosocial stressors (Lehmann et al., 1999; Steinacker & Lehmann, 2002). Despite some differences and similarities, CFS and OT are considered distinct phenomena.

One thing seems clear, NFOR does not have the same seriousness as a state of OT (Meeusen et al., 2006). Because OT is regarded as a process (Uusitalo, 2006), the athlete may move negatively along a continuum so it is important to distinguish athletes who are at the beginning of this process from those that are at more advanced stages, as the recovery time is most likely to differ.

2.3. Physiological markers of Overtraining

Although underperformance is regarded as the main characteristic of an OT athlete, it is not clear how much performance has to drop to confidently indicate a state of OT. To complicate things further, performance decrements can be the result of OT or other precipitating factors like family problems, school work, exams, etc (Hollander & Meyers, 1995; Hooper & Mackinnon, 1995a; Raglin, 1993). Athletes, coaches and sport scientists have been interested in finding early and valid warning signs to detect subtle mal-adaptations to training. A considerable number of studies have investigated the common signs and symptoms reported in athletes from a range of different sports. Fry et al.'s (1991) review listed more than 90 different symptoms that are reported by overtrained athletes. Unfortunately, such a long list makes it difficult for a coach or an athlete to know which signs or symptoms to be concerned about, and further complicating the picture is the large interindividual variability in presenting symptoms found within athletes practicing the same sport (Verma, Makindroo, & Kansal, 1992).

As stated above, the main complaint from athletes is a decrease in performance (Budget, 1998), coupled with chronic fatigue and apathy (Armstrong and VanHeest, 2002). The symptomolgy of athletes with OT have essentially been investigated from 2 standpoints: physiological and psychological symptoms. Several physiological markers have been proposed as important and potential parameters for the diagnosis of OT such as: decreased salivary testosterone to cortisol ratio (Passelergue & Lac, 1999), increased salivary cortisol (O'Connor et al., 1989), decreased or suppressed levels of immunoglobulin A (IgA) (Gleeson et al., 1999a; Gleeson & Pyne, 2000; Ring et al., 2005), decreased heart rate variability (Hedelin, Kentta, Wiklund, Bjerle, & Henriksson-

Larsen, 2000a; Pichot et al., 2002), increased circulating catecholamines (Hooper, Mackinnon, Howard, Gordon, & Bachman, 1995a).

However, it is not advised to diagnose purely on the basis of a single marker due to the wide individual variability in many of these factors plus the inherent changes that can arise during the different stages of the OT process (Urhausen & Kindermann, 2002). For example, it has been proposed that a decrease in cortisol levels occurs in the chronic state of OT (Lehmann, Foster, Dickhuth, & Gastmann, 1998), whereas an increase would represent an acute higher physiological strain more representative of overreaching (Kirwan et al., 1988). There is no single practical, valid and reliable physiological marker that can be used to enable a clear and quick diagnoses of athletes who are entering this state (Kentta et al., 2001). Nevertheless, some symptoms appear to be more frequently reported than others; such as a higher incidence in infectious disorders (upper respiratory tract infections), losses of appetite, unexpected weight loss, sleep disturbances and emotional imbalance (Armstrong & VanHeest, 2002; Fry et al., 1991; Morgan, Brown, Raglin, O'Connor, & Ellickson, 1987; Raglin et al., 2000).

2.3.1. Neuroendocrine parameters

There are two predominant neuroendocrine systems under the control of the hypothalamus. The first is the sympathetic adrenomedullary (SAM) system, which involves the two catecholamines, adrenaline (ADR) and noradrenaline (NA) (Lundberg, 2000). The second is the hypothalamic-pituitary-adrenal (HPA) axis, which produces adrenocorticosteroids, primarily cortisol (*figure 2.3*) (Armstrong & VanHeest, 2002).

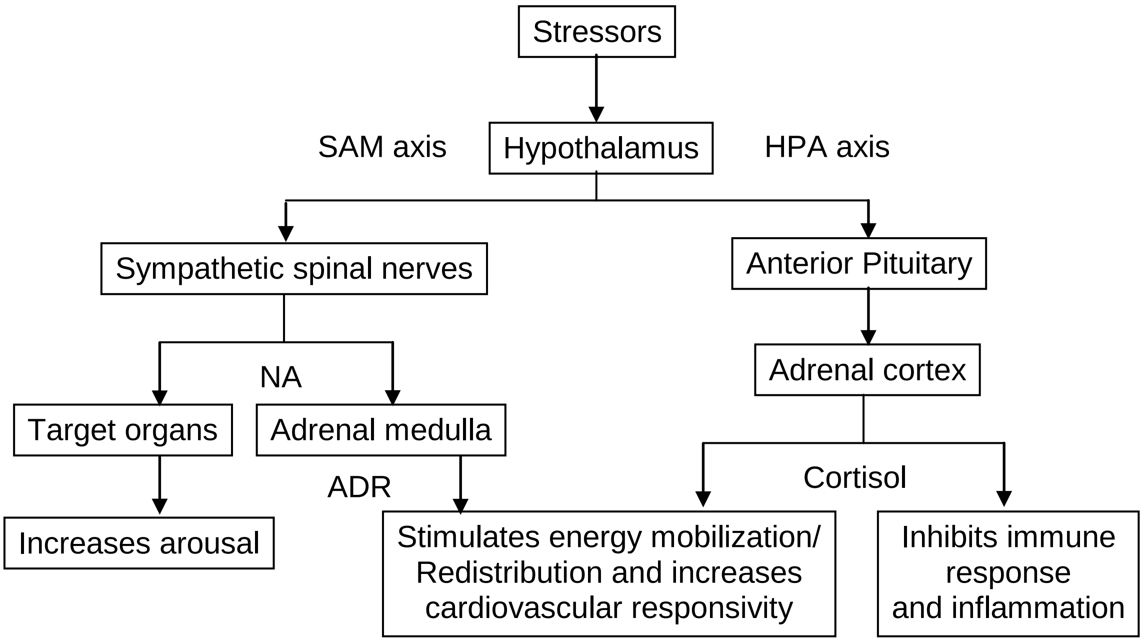

Figure 2.3 – The 2 predominant hormonal axis involved in the body's response to stressors. The sympathetic-adrenal medullary (SAM) axis involves the sympathetic branch of the autonomic nervous system. The hypothalamic-pituitary-adrenocortical (HPA) axis represents releasing factors (e.g. CRH, ACTH), produced by the hypothalamus and pituitary gland, which lead to responses in the adrenal cortex and other peripheral organs/ cells. ACTH - corticotrophin (adrenocorticotropin hormone); CRH – corticotropin-releasing hormone; ADR - adrenaline (also designated epinephrine); NA – noradrenaline (also designated as norepinephrine).

Activation of the SAM system prepares the body for aggression/ exercise and is activated through sympathetic innervations, which stimulate the adrenal medulla to release ADR and NA into the bloodstream, resulting in an increased release of stored energy through regulation of glucose and fat metabolism. The release of catecholamines also leads to an increased heart rate, cardiac output, peripheral vasoconstriction, stimulation of glycogenolysis in heart muscle and liver, increased attention and reduced sensitivity to pain (Burl, 2004; Chrousos & Gold, 1992). The SAM system has a very fast response and can be activated within seconds after an encounter with an unexpected threat (Kemeny, 2003).

The HPA system can be activated in response to a range of different stressors. The initiation of the stress response in the HPA system is mediated through the release of corticotrophin-releasing hormone (CRH). This hormone is released from the hypothalamus and, in turn, stimulates the anterior pituitary gland to secrete adrenocorticotropin hormone (ACTH). Through the bloodstream, ACTH is delivered to the adrenal cortex where the cortex is stimulated to release cortisol, which is a hormone known to affect the metabolism of cells, fat distribution and the immune function (Lundberg, 2005). This system is activated within a few minutes of an encounter with a stressor, and the peak level of cortisol secretion occurs around 20 to 40 minutes afterwards (Kemeny, 2003). Recovery and return to baseline levels of cortisol after an encounter occurs within 40 to 60 minutes (Dyckerson & Kemeny, 2004). By acting in concordance, cortisol and ADR connect the different actions of separate organs and systems, thereby coordinating the peripheral stress response throughout the body (Lovallo, 2005).

Encounters with stressful experiences can also alter different immune functions. Cortisol can reduce the production of certain cytokines (Kemeny, 2003), which are produced by the immune system and are a type of messenger that help mediate the generation of the immune response. When looking at psychological stress, it is important to recognize that, in many ways, the physiological and immune consequences of acute or chronic exercise parallel the effect of acute or chronic psychological stress, respectively. During melancholic depression, the resulting high circulating levels of cortisol lead to an impairment of natural killer cells and an increased plasma concentration of proinflamatory cytokines like interleucin 6 (IL6) (Clow & Hucklebridge, 2001). During strenuous exercise like a marathon race, tumour necrosis factor α (TNF-α) and interleucin 1β (IL-1β) can increase up to two-fold, whereas IL6 can increase up to 100-fold. On the other hand, the huge increase in IL6 triggers the release of cytokine inhibitors like IL-1ra and TNF-receptors, as well as the anti-inflammatory cytokine IL-10 (interleucin 10; Pederson et al., 2001). Interestingly, the immune system can also affect the autonomic nervous system and the HPA axis. By affecting the hypothalamus, cytokines can induce illness-related behaviour such as increased sleep, reduced movement and negative mood, as well as loss of appetite and sexual function (Lovallo, 2005). Since cytokines can induce a negative mood they might explain why depressive symptoms are frequently associated with stress (Maier & Watkins, 1998).

Adrenaline, noradrenaline and cortisol all serve to metabolize and redistribute metabolic fuels at different rates and to enhance the responsiveness of the cardiovascular system. The same responses prepare the athletes for action and exercise. If overreaching or overtraining stressors cause tissue injury and/ or trauma, cortisol restrains the inflammatory and immune responses so that they do not lead to permanent damage (Berne & Levy, 1996).

2.3.1.1. Cortisol hormone

In humans, cortisol is the most abundant and biologically active hormone of the glucocorticoid family. The glucocorticoids are steroid hormones (derived from cholesterol) that have catabolic effects on skeletal muscle and other tissues. Cortisol is the final component of the HPA and is synthesized and secreted by the adrenal cortex. It is a lipid-based hormone and consequently does not freely diffuse in the plasma of the blood (Hedge, Colby, & Goodman, 1987; Martin, 1985; McArdle, Katch, & Katch, 1996). Rather, upon secretion into the bloodstream, cortisol binds to transport proteins, primarily cortisol binding globulin (CBG), and it is mainly in this complex that it travels in the body. Approximately 90 % of the blood-borne cortisol is bound to both transcortin (75 %) and albumin (15 %), another blood protein. Only the remaining 10 % of unbound cortisol is biologically active; it can readily cross the lipid-based cell membrane of the muscle fibre so it can interact with intracellular receptors. When cortisol interacts with an intracellular receptor it forms a complex that is transported to, and interacts with, the DNA (deoxyribonucleic acid) of the cell. The latter increases the transcription of specific genes coding for enzymes that induce the catabolism of proteins within the muscle fibre. Cortisol induces the breakdown of cellular proteins, thereby liberating aminoacids which can then undergo gluconeogenesis in the liver (Hedge et al., 1987).

Cortisol diffuses very easily into the saliva, which enables the accurate measurement of free cortisol (Laudat et al., 1988). Furthermore, the salivary concentration of cortisol is highly correlated with free plasma cortisol ($r = 0.97$) and serum cortisol ($r = 0.91$) (Vining, McGinley, Maksvytis, & Ho, 1983). The simplicity of salivary cortisol collection in athletes makes this method of collection preferential, nevertheless, using salivary cortisol is still dependent on having a laboratory equipped with radio-immune assay techniques to determine the final concentration (Bricout et al., 2006).

2.4. Hormonal System, training and overtraining

Some of the most extensive research in the area of overtraining has involved studies looking at the metabolic-endocrine responses found in overtrained athletes. For several years it has been hypothesized that measurements of blood hormones could help find the adequate dosage of exercise load and regenerations periods (Adlercreutz et al., 1986; Urhausen, Gabriel, & Kindermann, 1995; Urhausen & Kindermann, 1992; Urhausen, Kullmer, & Kindermann, 1987). These speculations are based on observations that, depending on the intensity and volume of preceding physical exercise, anabolic and catabolic hormones, such as testosterone and cortisol respectively, show quantitative changes toward a catabolic or anabolic state (Flynn et al., 1994; Galbo, 1981; Kindermann et al., 1982). During periods of regeneration, catabolic effects are reversed by regenerative measures (Adlercreutz et al., 1986; Flynn et al., 1994; Hakkinen, Pakarinen, Álen, Kauhanen, & Komi, 1987; Urhausen et al., 1995; Urhausen & Kindermann, 1992; Urhausen et al., 1987). Furthermore, it has been speculated that a hormonal mediated central dysregulation occurs during the pathogenesis of OT; the hypothalamo-pituitary-gonadal and adrenal axis seems to play an essential role. These issues will be discussed next.

2.4.1. ACTH and Cortisol

The study of Kirwan et al., (1988) intensified training in competitive swimmers for a period of 10 days and found that the resting cortisol concentration significantly increased on days 5 and 11 compared to the first day of the study (Kirwan et al., 1988). Additionally, significant greater elevations in cortisol were observed as the training progressed. Similar elevations in resting cortisol have also been reported in runners (Stray-Gundersen, Videman, & Snell, 1986), and female swimmers (O'Connor et al., 1989) exposed to increments in training load. The results of the work by Hackney and Sinning (1986) are somewhat conflicting; college wrestlers were investigated at the peak of their training/ competitive season and then approximately 4 months later, after 8-10 weeks of inactivity, and resting cortisol was actually lower during the competitive season (Hackney & Sinning, 1986). Studies which compared untrained with endurance-trained males (Hackney & Sinning, 1988), and swimmers (Neisler, Bean, Pittington, Thomson, & Johnson, 1989) also found no differences in resting cortisol. Barron et al., (1985) determined the hormonal responses to insulin-induced hypoglycaemia in 4 overtrained athletes with 5 asymptomatic runners, and found lower plasma cortisol and ACTH concentrations in the four overtrained athletes. The same values were lower than their responses after a rest period of 4 weeks and lower than the responses of the asymptomatic runners, which led the authors to suggest that hypothalamic dysfunction may be present in OT athletes (Barron, Noakes, Levy, Smith, & Millar, 1985). Insulin-induced hypoglycaemia acts by altering the secretion of hypothalamic factors which have been shown to stimulate the release of ACTH (Barron et al., 1985). The same authors excluded pituitary dysfunction as a cause of overtraining and suggested instead that the dysfunction was purely hypothalamic.

Based on the available data it is hard to conclude on the effects that intense training, NFOR or OT may have on the HPA axis. The majority of investigations that monitor neuroendocrine responses to exercise have assayed both, resting (i.e. chronic) and exercise-induced (i.e. acute) hormonal levels. As such, the distinct responses between both types of studies need to be considered, since they have important physiological implications. Changes in the hormonal environment due to chronic adaptations involve a physiological regulatory mechanism to which the involved tissues are constantly exposed to. In contrast, the hormonal response to an acute exercise stress represent the systemic response and the system's ability to cope with the immediate demands of the exercise (Fry & Kraemer, 1997). To complicate things further, cortisol tends to be higher in the morning than in the evening (Dimitriou, Sharp, & Doherty, 2002), and its response to exercise is also influenced by the time of the day the test is done. It has been shown in resistance exercise-type research that the afternoon cortisol responses are greater compared to the morning responses (Dimitriou et al., 2002; Hakkinen & Pakarinen, , 1991; Thurma, Gilders, Verdun, & Loucks, 1995).

Furthermore, it is important to recognise that the HPA axis response will change depending on whether the athlete is FOR, NFOR or OT (Hackney & Sinning, 1988). In the NFOR state the HPA axis reacts by increasing the production of cortisol as a defensive mechanism. For example, an excess of cortisol increases hepatic glycogen breakdown and hepatic glucose production. Also, enhances lipolysis, increasing even more glucose re-uptake (Becker et al., 1980). On the other hand, elevated cortisol levels also lead to an inhibition of the immunological and inflammatory responses (Becker et al., 1980). It is possible however, that if cortisol levels remain elevated for long periods of time, an exhaustion of the HPA axis may occur, thus preventing the expected cortisol rise as a response to exercise (Fry & Kraemer, 1997).

Sufficient evidence for the changes in HPA axis function and pituitary sensitivity in the OT research is lacking, although it has been implicated in overtraining of endurance athletes (Barron et al., 1985). A very intensive training period during a normal training schedule seems to reduce maximal exercise-related concentration of ACTH and decrease maximal exercise-related cortisol concentration. In a study examining the pituitary hormonal response in overtrained endurance athletes, Urhausen et al., (1998) reported lower resting ACTH levels and lower exercise-induced ACTH released in overreached athletes (Urhausen, Gabriel, & Kindermann, 1998a). Similarly, no changes in resting serum cortisol concentration were observed elsewhere (Flynn et al., 1994;

Hopper, Mackinnon, Howard, Gordon, & Bachman, 1995; Mackinnon, Hopper, Jones, Gordon, & Bachman, 1997).

Also, reductions in salivary cortisol have been reported frequently. A study by McDowell and colleagues (1992) who tested adult males during 10 weeks of intensified training and compared them to a control group. Interestingly the authors found that both the high-intensity group and control had a reduction in cortisol concentrations, which led them to suggest that the decrease in salivary cortisol was not a function of the induced increment in training (McDowell, Hughes, Hughes, Housh, & Johnson, 1992). Also, maximal cortisol responses have been reported to decrease after a short period of intensified exercise; Uurhausen et al., (1998a) and Snyder et al., (1995) reported a decrease in plasma cortisol concentration following a period of intensified training that resulted in a state of overreaching. However, the authors concluded that the dysregulation of the HPA axis occurs during a state of increased training expressed by an impaired response of pituitary hormones to exhaustive short-endurance exercise (Snyder, Kuipers, Cheng, Servais, & Erik, 1995; Urhausen, Gabriel, & Kindermann, 1998a). The fact that McDowell and colleagues (1992) did not associate the decrements of cortisol to be a function of training could be because the training protocol used during the study was not sufficiently high to induce severe fatigue or a state of NFOR.

Recently, a two-bout protocol test has been developed by Meeusen et al., (2004) with interesting results. Their team showed differences between athletes before and after a period of high load training on cortisol and ACTH reactions to the exercise test. Furthermore, they also showed “hypersensitivity of the pituitary gland followed by an exhaustion” (p.145) in an OT athlete; i.e., the OT athlete evidenced an altered and dysfunctional hypothalamus-pituitary axis response to two bouts of maximal exercise performed within one day and 4 hours rest in between (Meeusen et al., 2004). Very similar results were reported by Nederhof et al., (2008) in a NFOR female athlete when using the same protocol (Meeusen et al., 2004); the athlete showed a slight increase in cortisol concentration after the first test and a large increase after the second exercise test. A similar responsive pattern was observed for ACTH, although a much larger percentual increase occurred after the 2nd exercise bout (Nederhof, Zwerver, Brink, Meeusen, & Lemmink, 2008), which allowed for the NFOR athlete to be distinguished from the 2 control athletes. This possibly reflects hypersensitivity of the pituitary gland and insufficient recovery after the first test in the NFOR female. Prolonged hyperreactivity in NFOR athletes who continue training may eventually lead to exhaustion of the pituitary gland suggested by Meeusen et al., (2004), although in an OT athlete the responses may be distinct compared to an athlete who is NFOR.

The literature on hormones and overtraining is still very confusing and contradictory. Decreases in exercise-induced plasma hormone concentration, especially cortisol, appear to be evident in NFOR athletes. However, these results are still highly variable, with some researchers showing increases (O'Connor et al., 1989; Stray-Gundersen et al., 1986), decreases (McDowell et al., 1992; Snyder et al., 1995; Urhausen, Gabriel, & Kindermann, 1998a) and no change (Flynn et al., 1994; Hopper et al., 1995; Mackinnon et al., 1997) in cortisol hormone after periods of increased training. It, therefore, remains difficult to draw conclusions about possible changes in hormone concentrations due to several reasons: different performance assessments; various types of modulations to exercise volume and intensity; different interpretations/ definitions of what a state of overreaching and/ or OT really is, which consequently led to distinct diagnosis; the hormonal concentrations are most possibly distinct depending on the state the athlete is, as FOR, NFOR, OT, and even burnout; and circadian variations of hormones.

2.4.2. Research in young athletes and study design issues

Very little research has been undertaken in young athletes to investigate testosterone and cortisol responses to exercise (Boisseau & Delamarche, 2000; Del Corral et al., 1994; Luigi et al., 2006); the remaining research in this age range has focused on healthy and clinical populations. The lack of knowledge on this area does not allow for scientists and coaches to be in a position to correctly and confidently interpret the variability of both physical performance and psychological responses in young athletes. Also, the fact that no data on young athletes pubertal development and the physiological responses to physical exercise are available, may impact negatively on sport and/ or the health of the athletes. As an example, the selection process young athletes are subjected to is essentially done based on chronological age (Helsen et al., 2000), with less attention being put on the physiological parameters that are linked with biological development and maturation (Leatt et al., 1987). The latter can mean that in the same practice group there may be healthy individuals with significantly different physiological and puberty-related hormonal patterns at rest (Di Luigi et al., 2006). A recent study investigated testosterone responses in young male athletes before (at rest) and after a single bout of exercise; they found a very high variability in the athletes' maturation status, which for as much obvious it may appear, is still of considerable importance. This study gave support to the development of new mechanisms of young athletes' selection that are more based on individual biological evaluations (Di Luigi et al., 2006).

Overall, there is a clear lack of research on hormonal responses to exercise in young athletes which, may be explained by the high variability and distinct maturational status that these individuals present with. Future studies that investigate hormonal responses in athletes, should aim at controlling the stage of pubertal development the individuals are (in case they are investigating young athletes), and clearly establishing which definition was used to indicate the mal-adaptation observed. Further, an effort to study these responses in the field should be made so that more out-of-lab evidence is accumulated and sports scientists and coaches can deal better with the challenges of real-life sport.

Key points:

- The HPA axis becomes disturbed during a state of overtraining;
- Active cortisol (salivary or unbound plasma cortisol) is suggested to be increased in the earlier stages of the mal-adaptation (i.e. NFOR), and depressed during the later stages (overtraining);

2.5. Immune System, training and overtraining

Overtraining has also been associated with illness or a depressed immune function in athletes, such as colds, allergic reactions, and upper respiratory tract infections (URTI) (Armstrong & VanHeest, 2002; Nieman, 1998; Steinacker & Lehmann, 2002). In contrast to findings that regular physical activity has positive effects on the immune system function, there is evidence that high training loads will increase the risk of infection. The relationship between exercise and susceptibility to illnesses has been modelled in the form of a “J” curve as illustrated in *figure 2.4* and the relationship between exercise load and immune function is modelled as the inverse (mirror image of the curve). This model suggests that while engaging in moderate activity may enhance immune function above that which is found in sedentary populations, excessive amounts of high-intensity exercise induce detrimental effects on immune function. However, although the literature provides evidence to the latter, little data is available to suggest that there is any clinically significant difference in immune function between sedentary and moderately active people. Thus, it may be more realistic to “flatten” out the curve representing this part of the relationship as illustrated by the dashed line in *figure 2.4.* Recently, Matthews and colleagues (2002) reported that regular performance of about 2 hours long, (moderate intensity exercise per day was associated with a 20 % reduction in infection risk in men and women compared with a sedentary lifestyle (Matthews et al., 2002). In contrast, it has been reported that there is a 100 – 500 % increase in risk of picking up an infection in the weeks following a competitive ultra-endurance running event (Nieman, Johansson, Lee, & Arabatzis, 1990; Peters, Goetzsche, Grobbelaar, & Noakes, 1996a; Peters, Goetzsche, Joseph, & Noakes, 1996b).

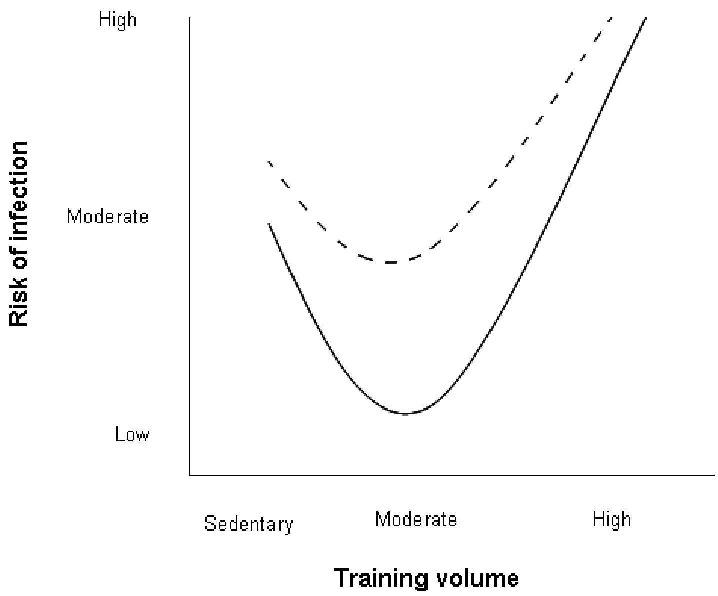

Figure 2.4 – The J-shaped model of the relationship between risk of upper respiratory tract infection and exercise volume. The dashed line may give a more realistic interpretation of the relationship. Adapted with permission from Nieman (1994).

It appears that prolonged, exhausting exercise taxes the immune system and may result in clinically significant alterations in immune function. The literature on exercise, immune function and illness is extensive, thus the following sections will purely focus on the changes in immunoglobulin A (IgA), heavy training loads and infection risk.

2.5.1. The immune system and Immunoglobulin A

The human being is permanently exposed to virus, bacteria, fungi, etc, that can attack different regions of the body such as the skin, mouth and the respiratory airways amongst others. To avoid and fight these infectious agents the human organism is equipped with a strong and efficient defence system known as the immune system (Guyton & Hall, 1996). The components of the immune system comprise cellular and soluble elements. All blood cells originate from the bone marrow from common stem cells. The latter are capable of differentiating into erythrocytes (red blood cells), megakaryocytes (precursors of blood platelets, important in blood clotting) and leucocytes (white blood cells). Leucocytes consist of the granulocytes (60-70 % of circulating leucocytes), monocytes (10-15 %) and lymphocytes (20-25 %). Various subsets of the latter include B cells (formed in the bone marrow), T cells (formed in the thymus) and natural killer (NK) cells (although a sub-family of lymphocytes and somewhat similar to the lymphocytes T, NK are considered to belong to the innate immune system) (Bishop, 2006; Klaus, 1996; McArdle et al., 1996).

The immune system can be divided in two general arms: innate (natural or non specific) and adaptive (acquired or specific) immunity, which work together synergically. The primary purpose of the adaptive immune system is to combat infections by preventing colonization of pathogens and keep them out of the body (immune exclusion), and to seek out specifically and destroy invading microorganisms (immune elimination). The lymphocytes are produced by the specific branch of the immune system, which has two different types of responses: cell-mediated and humoral. The former is responsible for the production of T-lymphocytes and the latter produces B-lymphocytes, which in turn produce the different classes of immunoglobulins (Bishop, 2006; Klaus, 1996).

The effector cells of the B-cell system are the terminally differentiated antibody-producing plasma cells. These constitute the basis for the so-called humoral (fluid borne) immunity, which is mediated by circulating antibody proteins or immunoglobulins (Ig) comprising five subclasses: IgA, IgD, IgE, IgG and IgM. The antigen-specific receptor on the surface of the B-lymphocyte is a membrane –bound form of Ig produced by the same cell. Engagement of surface Ig by the corresponding antigen will, in co-operation with T-helper cells initiate B-cells differentiation and clonal expansion. The resulting effector B cells can then transform into plasma cells that secrete large amounts of antibody with the same specificity as that of the antigen receptor expressed by the progenitor B lymphocyte. Whereas IgM and IgG dominate systemic humoral immunity, IgA is normally the dominating antibody class of mucosal immunity, working through exclusion, neutralization and elimination of the viral pathogenic agents (Bishop, 2006). The mucosal immune system is arguably the largest immune component in the body. It not only defends the intestine against invasion by infections, but also plays a similar role in the respiratory system, mouth, eyes and reproductive tract. Mucosal immunity can be viewed as the first line of defence that reduces the need for systemic immunity, which is principally pro-inflammatory and potentially tissue damaging (Bishop, 2006; Klaus, 1996).

2.5.2. URTI's and overtraining research

Upper respiratory tract infections, including viral rhinitis (common cold), pharyngitis, and sinusitis, are among the most common medical complaints in most training room clinics. They are extremely common amongst adults, who can evidence multiple URTI's each year (Kane, 2002). However, there are surprisingly few studies to directly address the issue of incidence of URTI's in OT athletes (Foster, 1998; Mackinnon & Hooper, 1996b; Pyne et al., 1995), despite the well-accepted belief that OT athletes are susceptible to illness. A study with 24 competitive swimmers after an increase in training over 4 weeks, resulted in 8 (33 %) of the swimmers showing symptoms of OT (Mackinnon & Hooper, 1996b). Of the 24 swimmers, 10 (42 %) exhibited self-reported symptoms of URTI's during the 4 weeks. Unexpectedly, the rate of URTI's among the mal-adapted swimmers (12.5 %) was significantly lower than that in the well-trained swimmers (56 %). It was therefore, suggested that increased risk of URTI's may not necessarily accompany NFOR or OT, but may instead, be a consequence of intense training in all athletes (Mackinnon & Hooper, 1996b). It was later suggested that the higher rate of URTI's among the well-trained swimmers may actually have protected them against not becoming OT. That is, the appearance of the mild URTI's symptoms may have led the athletes, unconsciously or consciously, to reduce their training for a few days and have more time to rest and regenerate and, consequently, have them more protected against NFOR or OT (Mackinnon, 1999). Another study on elite athletes found no association between incidence of URTI's and increased training loads over an 12-week season (Pyne et al., 1995). In contrast, a study with 25 athletes that has investigated infection risk and high training loads found that a high proportion of illnesses occur when training exceeds thresholds identified for individual athletes, based on a combination of training volume and training monotony (Foster, 1998).

Nieman (1997) stated that "the epidemiological data suggest that endurance athletes are at increased risk for URTI during periods of heavy training and in the 1 – 2 week period after marathon-type race events" (p. 334) (Nieman, 1997). Later, Nieman (1998) gave the same warning for the "1 – 2 week period following prolonged and intense aerobic exercise" (p.193) (Nieman, 1998). This 1- to 2-week period of risk may derive from the "open window" that may last from 3 to 72 hours (depending on the immune measure) of acute immune system changes following heavy bouts of exercise that may allow for infections to take hold, incubate, and manifest in the next week or so (Nieman, 2000). The open-window hypothesis is based on several components of the immune system that exhibit changes after long bouts of heavy exercise. For example, high intensity endurance exercise induces changes in cytokine concentrations, body temperature, increases in blood flow, lymphocyte apoptosis, dehydration, and a significant elevation of cortisol above normal levels for several hours (Nieman, 1997a). Furthermore, IgA concentrations in nasal secretions are decreased nearly 70 % for at least 18 hours after strenuous long exercise, decreasing the level of IgA-mediated immune response protection at the mucosal surface (Steerenberg et al., 1997). Nasal mucociliary transit time is significantly prolonged after marathon running for several days due to abnormal function of the ciliated cells, suggesting that host protection in the upper airway passages is suppressed for a prolonged time after the race (Muns, Singer, Wolf, & Rubinstein, 1995). Finally, natural killer cells activity (NKCA) has shown to be decreased 40 – 60 % for at least 6 hours after prolonged endurance exercise (Muns et al., 1995); however, it has not been determined whether the decreased NKCA in the blood compartment represents what is occurring in other lymphoid tissues or if it linked with URTI risk. This open-window hypothesis, although intuitively attractive, has not yet been studied extensively and needs further research.

As such, the few studies published on this issue do not support the concept that OT itself is associated with an increased risk of URTI’s. There is, however, good evidence showing increased risk of URTI’s among endurance athletes and a dose-response relationship between training volume and incidence of URTI’s (Mackinnon & Hooper, 1996b; Nieman, 1997, 1998). Taken together, it appears that, in athletes, both OT and URTI’s result from a common cause: excessive training with insufficient rest. Nevertheless, the risk of URTI’s is elevated in athletes during periods of intense training, regardless of whether such training leads to symptoms of OT. Recently, Gleeson (2007) stated that elite athletes are not clinically immune deficient and that due to the effects of training they may undergo small changes in certain immune parameters that can compromise resistance to several common illnesses. However, this may be a small price to pay as the anti-inflammatory effects of exercise are actually likely mediators of many of the long-term health benefits of regular exercise (Gleeson, 2007). Recent research has shown that, not only a considerable proportion of URTI's are not associated with identification of a respiratory pathogen and instead are related with either virus of bacterial infection (Cox et al., 2008); many URTI episodes could have been wrongly described in athletes because they were not caused by a respiratory pathogen. As such, it is important to understand that any URTI episode does not necessarily imply an external pathogen infection that will activate the athlete's humoral defences.

2.5.3. Immunoglobulin A and overtraining research

Salivary IgA is the first barrier to colonization by microorganisms causing URTI's (Tomasi & Plaut, 1985). Salivary concentrations of IgA have been shown to correlate more closely to URTI's than do serum antibodies or other immune parameters (Mackinnon & Jenkins, 1993). In addition, low resting levels of IgA have been correlated with an increased risk of URTI's among competitive swimmers (Gleeson et al., 1999b).

Previous studies looking at the acute responses of salivary IgA to heavy training have produced conflicting results. Several studies have described low concentrations of salivary IgA following various modes of intense exercise, including swimming (Gleeson et al., 1999b; Tharp & Barnes, 1990; Tomasi & Plaut, 1985), interval training (Mackinnon & Jenkins, 1993), repeated Wingate tests (Fahlman, Engels, Morgan, & Kolokouri, 2001), tennis (Novas, Rowbottom, & Jenkins, 2003), football (Moreira et al., 2009), and running (Nieman et al., 2002). Some have reported no change in salivary IgA levels after acute and chronic weight training (McDowell, Weir, Eckerson, & Wagner, 1993), or treadmill running of varying intensity (McDowell et al., 1992). In contrast, a study on basketball players reported increased salivary IgA levels following basketball games (Tharp & Barnes, 1991).

The reasons for such discrepant findings are not completely understood. However, the specific method of IgA expression used in each study is an important factor to be considered. Some studies have expressed their findings using only the raw concentration of IgA (Tharp & Barnes, 1990, 1991), without considering the potential for exercise-induced drying of oral surfaces. Others have attempted to account for the drying effect of exercise by expressing IgA as relative to total protein (IgA-Pro) (Fahlman et al., 2001; Nieman et al., 2002). Some have suggested that IgA relative to salivary osmolality (IgA-Osm) is the preferred method for determining the impact of exercise on mucosal IgA (Blannin et al., 1998), whereas others still have suggested expressing IgA content as a secretion rate (s-IgA) (Reid, Drummond, & Mackinnon, 2001). Moreover, it is known that the levels of secretory immunoglobulins such as salivary IgA (s-IgA) vary widely between individuals, which adds more problems on the interpretation of the findings (Tomasi & Plaut, 1985).

Several longitudinal studies have monitored immune function in high-level athletes over a course of a competitive season. One study measured the impact of long-term training on systemic and mucosal immunity in a cohort of elite Australian swimmers over a 7-month competitive season (Gleeson et al., 1995). The results indicated a significant suppression of resting serum IgA, IgG and IgM during the 7 months, and salivary IgA concentration was associated with long-term training at an intensive level. Furthermore, resting saliva IgA concentrations at the start of the training period showed significant correlations with infection rates (URTI), and the number of URTI's observed in the swimmers during the training period was predicted by the pre-season and mean pre-training IgA levels (Gleeson et al., 1995). Comparable results were obtained in a similar study which followed a team of Australian elite-level swimmers during 7 months and demonstrated a relationship between suppression of mucosal IgA levels and increase in the number of URTI's (Gleeson et al., 1999b). In a recent study with American football players, the incidence of URTI's was increased during intensive training, and it was reported that secretion rate of s-IgA was significantly and inversely related to URTI incidence (Fahlman & Engels, 2005). Despite the low levels of serum immunoglobulins, the ability to produce antibody responses to antigenic challenge has been reported to be normal in swimmers (Gleeson et al., 1996), and triathletes (Bruunsgaard, Hartkopp, & Mohr, 1997). These studies on mucosal immunity in athletes are representative of a very small number of studies that have established a relationship between some surrogate measure of immune function and infection incidence in athletes.

In conclusion, it seems that illnesses might be both a contributor to and an outcome of OT. When athletes are in a state of stress-recovery imbalance, they become more susceptible to infections and illnesses, which further stress their bodies, leading to higher risk for greater imbalances and OT. The initial stress-recovery imbalance is part of the OT process, and the interaction of this OT process with illness is circular, i.e., each one may contribute to and be an outcome of the other. Gotovtseva and colleagues (1998) made a clear statement that illness is part of the OT aetiology, stating that apart from the classical symptoms of OT, immune dysfunction and frequent URTI’s have been found both in overreached and OT athletes, which makes them markers of this pathology (Gotovtseva, Surkina, & Uchakin, 1998). Thus, with chronic periods of heavy training, several aspects of both innate and adaptive immunity are depressed, but athletes are not necessarily immune deficient. In other words, exercise-induced immune dysfunction does not put athletes in danger of serious illness, but it could be sufficient to increase the risk of picking up common infections such as URTI’s or influenza (Gleeson, 2007).

2.5.4. Research in young athletes

In relation to young athletes and their immune responses to exercise, very little data is available. Only 2 studies have looked at young athletes’ immune system responses to exercise. In 2005, Matos and colleagues tested a sample of national-level swimmers over an aerobic and an anaerobic protocol. It was found that after both protocols IgA concentration increased significantly, although the increment was higher for the anaerobic test (Matos, Teixeira, & Rama, 2005). Similar results were obtained by Dimitriou and colleagues (2002) after an aerobic swimming protocol, although they tested adults and the increment was not significant (Dimitriou et al., 2002). In contrast, it was observed that healthy young athletes experience smaller overall perturbations to the immune system in response to an acute bout of exercise as compared with adults, and also they demonstrated a faster recovery of the immune system following exercise (Timmons, 2007).

Key points:

- The relationship between exercise and the incidence of URTI’s in athletes is still not clear. However, it is evident that any type of intense exercise will increase the risk of contraction of a URTI;
- The relationship between exercise and IgA levels is still not well understood, but it seems that intense chronic exercise will lead to a decrement of the concentration of IgA;
- Overtrained athletes tend to show a higher incidence of URTI’s and low concentrations of IgA.

2.6. Autonomic Nervous System

Chronic exposure to intense training loads is known to influence the autonomic nervous system (ANS). However, it is still not clear how it is affected by exercise and which methods of evaluating those physiological responses are valid to help coaches and athletes prescribe training and possibly prevent OT. Among those methods that can be used to evaluate the ANS responses to exercise, heart rate (HR) is a commonly used tool. However, results from studies have provided equivocal results in athletes under different training states, like NFOR or OT (Hooper et al., 1995b). Hence, understanding the interactions between cardiovascular function, the activity of the ANS and exercise is challenging. Another recent tool used to study the responses of the ANS to exercise that has gained popularity is the analysis of heart rate variability (HRV); by using HRV it is possible to evaluate the activity of the ANS and its sympathovagal balance (Yamamoto, Hughson, & Peterson, 1991).

2.6.1. The autonomic nervous system: control of heart rate

The human cardiovascular system, the heart and circulation are predominantly controlled by higher brain centres, also known as central command. In addition, the cardiovascular control areas in the brain stem are mediated by the activity of the autonomic nerves, comprised by the sympathetic and parasympathetic nerves. This control is also affected by the activity of the baroreceptors, chemoreceptors, muscle afferent bodies, local tissue metabolism and circulating hormones (Aubert, Seps, & Beckers, 2003). As such, the organic function of the body is a result of continuous, dynamic interactions between multiple neural, hormonal, mechanical and sub-cellular control systems (HeartMath, 1996).

The ANS comprises the sympathetic nervous system (SNS) and the parasympathetic nervous system (PNS); the cardiac nerves that are part of the PNS are also known as vagal nerves. Each of the systems acts in a complementary way, concerned predominantly with the regulation of bodily functions; in example, the sympathetic nerves increase heart rate, constrict blood vessels, decrease gastrointestinal motility and constrict sphincters, whilst the parasympathetic nerves act inducing the opposite responses (Aubert et al., 2003).

Heart rate is not fixed and regular but is constantly being adjusted by a variety of internal and external stimuli, resulting in a dynamic and responsive rhythm. Accordingly, by measuring HR over a 1-minute interval a standard deviation around the mean HR indicates an evident physiological variation caused by the synergistic action between the two branches of the ANS. This balance happens to adjust HR in response to the actions of ventilation, blood pressure control, thermoregulation and the renin-angiotensin system; the net effect is an increase or decrease in HR resulting from the activity of the SNS and PNS, respectively (Aubert et al., 2003; HeartMath, 1996; Tarvainen & Niskanen, 2005; Winsley, 2002).

2.6.2. Physiological mechanisms affecting HR

Although cardiac automaticity is intrinsic to various pace maker tissues (sino-atrial (SA) node and atrio-ventricular (AV) node), HR is largely controlled by the ANS (Malik et al., 1996). Without any hormonal or neural input the heart, due to the intrinsic rhythm of the SA node, can produce a rate from 100 to 120 bts.min^{-1} (McCraty & Watkins, 1996). In brief, the heart's enervation is structured as follows: the parasympathetic nerve impulses reach the heart via the right and left vagus nerves, innervating the SA node, AV node and the atrial myocardium (McArdle et al., 1996). The response time of these nerves is very short and the effect is an immediate response within one or two heart beats after its onset. Therefore, any sudden changes in HR are due to parasympathetic modulation, mediated via the release of the neurotransmitter, acetylcholine (ACh) by the vagus nerve. The SNS branches innervate the heart at the SA node, the AV node, the myocardium of atria and the ventricles (McArdle et al., 1996); the influence of the SNS on the heart is also affected by the hormonal system, so that the regulation of the HR is made through a combination of neural and hormonal pathways (De Meersman, 1993).

The SNS acts by releasing the neurotransmitters, NA (through post-ganglionic fibres) and ADR (at the adrenal gland). These catecholamines, which have both a chronotropic and inotropic effect on the heart, facilitate the influx of Ca^{++} ions into the myocardial cells, speeding the depolarization-repolarization rate and increasing the availability of Ca^{++} (calcium) ions for the actin-troponin complexes of the myocardial cells

(Silverthorn, 1998). The effect of the SNS on the heart is both an increase in HR and contractility. The release of ACh from the vagus nerves causes these neurotransmitters to bind to muscarinic receptors, resulting in an outflow of potassium (K^+) ions and reduce influx of Ca^{++} ions into the cell. Consequently, by an efflux of positive ions (potassium) and a lower influx of Ca^{++} ions, the cell becomes even more negative, lowering the cell's membrane potential even more (cell becomes hyperpolarized). The net result is a slowing of the rate of depolarization and therefore HR (Levy & Martin, 1981).

Sympathetic activity tends to increase heart rate, taking from 2 to 5 seconds to trigger the effect, whilst the parasympathetic nervous system decreases HR taking only 0.2 to 0.6 seconds for the effect to be seen (Berntson et al., 1997). The quicker response seen with the PNS is due to the rapid activity of the enzyme acetylcholinease, which rapidly removes ACh from the synapse, making the effects of the PNS very short lived. When the PNS activity is more dominant, its effects on slowing HR are transient and paradoxical, since HR is slow but displaying a high degree of variability. In contrast, 5 seconds after the initiation of the sympathetic stimulus, it may take an additional 20 seconds for HR to respond completely, with an even slower decline in HR after the impulses are terminated (Hainsworth, 1995; Rowell, 1993). The heart rate's slower decline and the longer effects of the SNS on HR are essentially due to the slower secondary messenger process that involves a slower clearance of NA (Mokrane & Nadeau, 1998). The re-uptake of synaptic NA is made through the same axon that released it through the actions of the enzymes methyltransferase and monoamine oxidase. Because the effect of these enzymes is much longer (up to 9 seconds) (Mokrane & Nadeau, 1998) in comparison with acetylcholinease, the effects of NE are also longer lasting. Consequently, HR stays elevated for longer periods and shows less variability (Winsley, 2002). The response of the heart to sympathetic stimulation is, therefore, in direct contrast to vagal stimulation, enabling sympathetic and parasympathetic activity to be independently measured (HeartMath, 1996).

2.6.3. Heart rate variability (HRV)

Heart rate variability refers to changes in the heart beat interval that is a reciprocal of heart rate. The variations of consecutive heartbeats (mentioned above) constitute the so-called heart rate variability (Tarvainen & Niskanen, 2005). It is the HRV signal or waveform that contains the oscillations or changes of varying speeds and shapes due to autonomic control of the heart (HeartMath, 1996). When analysing HRV it is important to be aware that it is influenced by a variety of factors like the body's thermoregulation mediated by the hypothalamus, the renin-angiotensin system, the already mentioned barorecepors, the chemoreceptors, the atrial stretch receptors and finally ventilation. Ventilation, the most conspicuous component of HRV analysis, is the so-called respiratory sinus arrhythmia (RSA) (Tarvainen & Niskanen, 2005).

- A variation in body temperature, either increase or decrease, triggers the hypothalamus to increase the efferent adrenergic sympathetic nervous tone or cholinergic sympathetic tone for vasodilation or vasoconstriction, respectively, with a consequent effect on thermoregulation and HR (Silverthorn, 1998).

- The renin-angiotensin system acts by increasing the activity of the cardiovascular control centre of the brain, which result in an increase in the activity of the SNS.

The higher sympathetic outflow leads to an increase in HR, cardiac output and thus, helps maintain blood pressure (Silverthorn, 1998).

- The baroreceptors that influence HR are located in the aortic arch and carotid sinus. An increase in blood pressure triggers the baroreceptors to increase the afferent information to the brain which, in turn, causes a reciprocal increase in efferent vagally-mediated activity. As such, HR slows down and cardiac output and blood pressure are consequently reduced. Due to its vagal pathway, the response is very quick, so that HR may be influenced on a beat-by-beat basis (Hainsworth, 1995). Still, blood pressure is not solely vagally modulated and the SNS efferent impulses are also involved in this process (McCraty & Watkins, 1996).

- The aortic and carotid bodies also have chemoreceptors that sense changes in blood gas concentrations and pH - hypoxia, hypercapnia and academia (Hainsworth, 1995). The reason why the stimulation of the carotid bodies causes HR to decrease, and that of the aortic bodies causes tachycardia is, however, not clear (Winsley, 2002).

- Heart rate can also be increased by a direct stimulation of the atrial stretch receptors, which sense differences in pressure. For example, an increased venous return distends the atria, triggering an increase in efferent sympathetic impulses (the Bainbridge reflex), and a consequent increase in HR (Silverthorn, 1998).

- Respiration exerts a high effect on heart rate (RSA), which corresponds to the fluctuations of HR with respiration, so that HR increases during inspiration and decreases during expiration (Winsley, 2002). During inspiration, airway stretch receptors are activated, reducing the efferent vagal tone, with a consequent increase in HR with expiration, the vagal tone is re-established and HR slows again (De Meersman, 1993; Hainsworth, 1995). A high parasympathetic influence has been shown if an individual is breathing at a rate below 7 breaths per minute (Tiller, McCarthy, & Atkinson, 1996), which may confuse the interpretation of this band. More recently, Williams and Lopes (2002) found that respiration significantly influenced HRV in 16 years olds, by altering the mean RR intervals. Repeated modulation of the HR is primarily exerted by the PNS, so evidence of RSA can also be used as an indicator of parasympathetic activity (Gregorie, Tuck, Yamamoto, & Hughson, 1996; Hojaard, Holstein-Rathlou, Agner, & Kanter, 1998)

The starting point of HRV analysis is the electrocardiogram (ECG) recording from which the HRV time series can be extracted. Another form of analysis is the HR tachogram that shows a sequence of time intervals between R-waves (Malik et al., 1996).

2.6.4. Methods for the analysis of HRV

HRV can be assessed by frequency domain, time domain analysis and nonlinear methods; either method enables the study of the time intervals between consecutive normal QRS complex (HeartMath, 1996; Tarvainen & Niskanen, 2005). Because the majority of the studies on HRV and exercise/ overtraining have focused their research on frequency-domain data (Hedelin, Kentta, Wiklund, Bjerle, & Henriksson-Larsen, 2000a; Hedelin et al., 2000b; Iellamo et al., 2006; James, Barnes, Lopes, & Wood, 2002; Kiviniemi, Hautala, Kinnunen, & Tulppo, 2007).

By definition, spectral analysis decomposes any steady, stationary, fluctuating time-dependent signal into its sinusoidal components and is commonly known as power spectral density (PSD) analysis. This process allows plotting the power of each such component as a function of its frequency and the computation of power defined under distinct frequency areas. Spectral analysis of HRV data confers information on how the power is distributed as a function of frequency, providing a means to quantify autonomic balance. Although based on indirect markers, exploring the frequency domain might disclose a unitary vision hard to reach through other methods of analysis (Malliani, Pagani, Lombardi, & Cerutti, 1991). One of the methods employed to run a PSD analysis is the autoregressive modelling (AR) (Aubert et al., 2003). An example of an analysis performed by AR modelling is shown in *figure 2.5*.

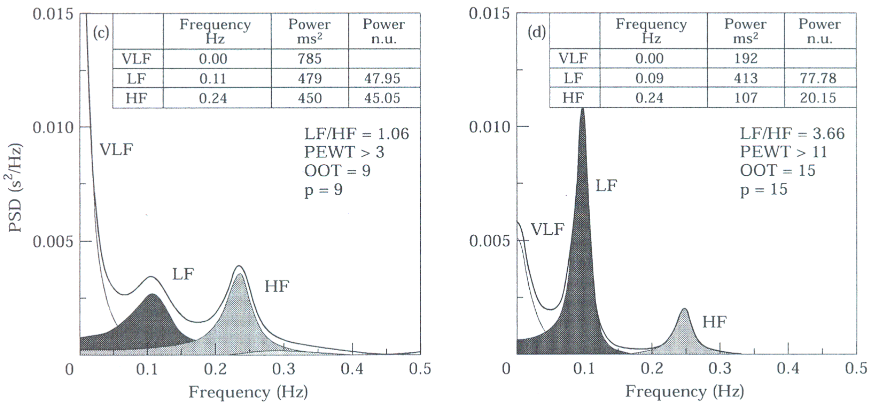

Figure 2.5 - HRV power spectra calculated by Autoregressive model in a young male endurance swimmer under resting conditions and laying supine (taken from Kubios HRV software version 2.0 beta 4).

For short-term recordings, the HRV power spectrum can be divided in three frequency ranges or bands: high frequency (HF) band (ranging from 0.15 to 0.4 Hz), low frequency (LF) band (ranging from 0.04 to 0.15 Hz), and the very low frequency (VLF) band (ranging from 0.033 to 0.04 Hz). Unlike the HF and LF bands, the physiological mechanisms involved in the generation of the VLF band are not well understood. According to Berntson and coworkers (1997), apart from the autonomic influences, the detects ultra slow changes in HR due to long-term regulation mechanisms like hormonal factors, thermoregulatory processes and the renin-angiontensin system (Berntson et al., 1997). Because VLF data can only be detected through long-term recordings it will not be used in this work since only short-term recordings were employed. While absolute power units (milliseconds squared) of HRV are used to assess autonomic activity in the VLF, LF and HF bands, the LF and HF components can also be expressed in normalised units: HFnu and LFnu. These values of LF and HF bands result from dividing the total power minus VLF and multiplied by 100 (expressed as a percentage); thus,

$$LFnu = LF/ (LF+HF) \text{ and } HFnu = HF/ (HF+LF)$$

The ratio between LF and HF bands (ratio LF/HF) can be used to quantify the overall balance between the sympathetic and parasympathetic – sympathovagal balance – and is calculated by dividing LF and HF expressed in normalised units. A high ratio LF/ HF will indicate an increased sympathetic activity or reduced parasympathetic activity (HeartMath, 1996).

2.6.5. Physiological correlates of HRV components

Different studies have been performed in order to measure the amount of activity from each branch of the ANS expressed by the frequency components of the PSD analysis. There is consensus in that the HF component is predominantly vagally modulated as the sympathetic receptors, at the sinus node, have a slower response than the parasympathetic one; therefore, sympathetic activity is reflected as a frequency of 0.15 Hz, meaning that anything occurring more frequently must come from parasympathetic origin (Winsley, 2002). Due to the vagal contribution to the LF power spectrum, the interpretation of the LF component has yielded controversial results, with some studies demonstrating the LF band to be of sympathetic origin (Malliani et al., 1991; Montano et al., 1994), and others, which used beta-blockade drugs to block the receptors of the SNS, demonstrating a decrease in the LF component (Japundzic, Grichois, & Zitoun, 1990).

To induce an increase of the sympathetic activity, a simple autonomic provocation is made by simply changing the posture from supine to standing, resulting in a shift of the blood away from the chest to the venous system below the diaphragm, usually referred to as venous pooling; this will create an increase in HR in the great majority of healthy individuals. When standing, the regulatory system increases HR, cardiac contractility and vascular tone by a decrease in vagal tone (Aubert et al., 2003). Experiments using a change in position from supine to standing observed an increase in LF power, showing an association between the LF band and sympathetic activity (Akselrod, 1995). Also, in long-term recordings, the LF band represents a fair approximation of sympathetic activity (HeartMath, 1996). Recently, however, evidence of the presence of both sympathetic and parasympathetic stimulation has been observed; a high dose of atropine, blocking the SA node responses to the release of ACh by the vagus nerve, abolished nearly all RR-interval spectral power in LF and also in the HF band. Based on these results, Eckberg (1997) suggested that vagal contributions to baseline LF power are great (Eckberg, 1997). In resume, there is some disagreement in regards the extent to which the LF power is solely regulated by the SNS activity, and it seems that both, the PNS and SNS affect the LF band, although the extent to which the influence occurs is not clear.

2.7. Overtraining and the ANS

As described previously, the mechanisms underlying overload and OT seem to be related, among others, to factors that affect the functioning of the ANS. Since HRV will also be affected by changes in the autonomic nervous system, it may indicate early stages of NFOR and OT (Kreider, Fry, & O'Toole, 1998; Pichot et al., 2000; Uusitalo, Uusitalo, & Rusko, 2000).

2.7.1. Sympathetic and parasympathetic types of Overtraining

There have been suggestions in the literature that OT can be broken into 2 classifications: sympathetic (Basedowoid) and parasympathetic (Addisonoid) types (Israel, 1958; Kellman, 2002a; Lehmann et al., 1993). Kuipers and Keizer (1988) hypothesized that during the early stage of the mal-adaptation (NFOR), the sympathetic system is overstimulated, whereas in an advanced state of OT, the parasympathetic nervous system activity would become dominant due to an inhibition of the SNS activity. Sympathetic OT has been associated with characteristics such as increased resting HR and blood pressure, decreased appetite, loss of body mass, disturbed sleep and irritability. Parasympathetic type of OT has been associated with such patterns as low resting HR and blood pressure, excessive periods of sleep and depression (Kellman, 2002a; Lehmann et al., 1993; Mackinnon & Hooper, 1994). The sympathetic type of OT has been linked with power and speed sports like weight lifting and speed running, whereas the parasympathetic type of OT has been associated with endurance sports (Kellman, 2002a; Lehmann, Dickhuth, & Gendrisch, 1991; Van Borselen & Fry, 1992).

However, it is not clear that these distinctions between aerobic and anaerobic types of OT add clarity to the understanding of the problem. Fry (1998) stated that because the training adaptations in endurance and power sports are different, therefore it follows that OT may manifest itself in different ways in those 2 types of sports. As such, it is important to be wary of using the endurance OT literature to infer what happens during OT in power sports (Fry, 1998). For example, a study looking at increased volume training in judo national-level athletes found that after 6 weeks of intensive anaerobic training and concomitant decrement in performance, the expected changes in the SNS did not occur; also, there were no significant increases in HR and blood pressure (Callister, Callister, Fleck, & Dudley, 1990).

Diagnosing athletes in relation to HRV responses during training and OT has not been an easy task. There is evidence to support that different types of ANS responses are observed during either the early stages of OT or the later ones. This is aggravated by the fact that different types of sports, be it endurance or anaerobic may lead to a mal-functioning of both, the SNS and PNS. As a result, the short-term protocols that have been used in the majority of the studies have brought confusing results in regards the actual stage of response to training the athletes are under. Two studies are available that have investigated the ANS responses during training of a previously diagnosed OT athletes. Hedelin et al. (2000b) studied the HRV responses of a cross-country skier and found that the athlete presented with increased HRV and reduced resting HR, suggesting a cardiac autonomic imbalance with extensive parasympathetic modulation and depressed SNS modulation (Hedelin et al., 2000b). This is an extremely important finding because coaches aim their athletes to have an ANS profile that shows high parasympathetic activity and a low resting HR. As such, they may misinterpret the data from an OT athlete and wrongly prescribe training, worsening the athlete's state. In contrast, 7 OT athletes were also studied in relation to their HRV profile in comparison with healthy trained athletes and a control group. The investigators found that the indices of HRV were significantly higher in the well trained group compared with the OT and control groups (Mourot et al., 2004). As such, there is insufficient evidence to confidently state that there are differential responses between endurance-overtrained and power-overtrained athletes.

2.7.2. Heart rate variability, training and overtraining

Experiments that have investigated HRV in athletes following periods of intensified training showing either no changes or inconsistent changes in HRV profile. Hedelin and co-workers (2000a) followed nine canoeists during a 6-day training camp where the training was increased by 50%; all HRV indices remained unchanged, either measured at rest or in the tilted position. The authors concluded that HRV did not seem to be affected by short-term overtraining (Hedelin, Kentta, Wiklund, Bjerle, & Henriksson-Larsén, 2000a). Similarly, Uusitalo and colleagues (1998c) reported no change in intrinsic heart rate and autonomic balance, in female athletes following 6-9 weeks of exhaustive endurance training (Uusitalo, Uusitalo, & Rusko, 1998c). A study conducted on sedentary and active females during 2 weeks (training 7 days per week) of an overloading protocol failed to find any significant change in the HRV variables, although a trend was observed towards an increase and decrease of the LF and HF power, respectively (Winsley, Battersby, & Cockle, 2005). The sedentary group showed a significant increase in the LF power and a decrease in the HF power; therefore, it was suggested that sympathovagal balance changes more in sedentary people than in active individuals (Winsley et al., 2005).

All of these studies are, however, of very short duration due to their interventionist nature, and most of them use overloading as the premise to induce a state of OT. However, the limited time of evaluation may not be sufficient to provide valid information regarding the autonomic responses of the body to exercise. In that sense, longitudinal studies have provided more valuable information into the changes of the ANS in response to long periods of intensive training. The majority of research suggests that heavy training changes the cardiac autonomic balance towards a dominance of the sympathetic over the parasympathetic drive (Earnest et al., 2004; Garet et al., 2004; Iellamo et al., 2002; Kiviniemi et al., 2007; Pichot et al., 2000). In addition, the results provide support for the use of HRV as a tool to design and control training for optimizing individual training profiles (Kiviniemi et al., 2007).

Interesting results have been reported regarding the ANS responses to an orthostatic challenge. Hedelin and colleagues (2001) examined the relationship between HRV and performance before and after a training period of seven months, both in cross-country skiers and canoeists; despite HF and total HRV not having changed proportionally to the performance or aerobic capacity, the improved measures of both peripheral and central work capacities were associated with a reduction of the LF power in the tilted position (Hedelin, Bjerle, & Henriksson-Larsén, 2001). Furthermore, a study by Mourot and colleagues (2004) found that healthy trained athletes showed greater changes in HRV induced by the upright posture compared to OT athletes (Mourot et al., 2004), and a similar trend response was also observed elsewhere (Hynynen, Uusitalo, Konttinen, & Rusko, 2008).

Key points:

- The 2 different types of sympathetic and parasympathetic OT have not been confirmed;
- The relationship between OT in endurance and power-type sports is also not clear;
- Athletes commonly present greater HRV than sedentary people;

2.8. Other physiological markers

Due to their easy application and low cost, other parameters to monitor athletes' responses to training and OT have been applied in the field. The most commonly used field measures being blood lactate and RPE response profile, however muscle glycogen has also been assessed in relation to OT.

2.8.1. Glycogen

It has long been assumed that the fatigue and underperformance coming from overloading athletes is at least partly attributed to a decrement in muscle glycogen levels. Low muscle glycogen levels can impair exercise performance at intensities primarily between 65 and 85 % of maximal oxygen consumption (Sherman & Lamb, 1991). Runners who ate a low carbohydrate (CHO) diet (40 % of total calories) over a 3-day increment in training often experienced a day-to-day decrease in muscle glycogen. In contrast, when the same athletes consumed a high CHO diet (70 % total calories), their muscle glycogen levels recovered almost completely within 22 hours of the training bouts (Costill, Bowers, Branam, & Sparks, 1971). Costill and colleagues (1988) investigated the effects of 10 days of increased training volume on performance and muscle glycogen levels. From the 12 swimmers participating in the study, four were not able to tolerate the training and forced to swim at significantly lower speeds during the latter training sessions. It was later found that these swimmers had reduced muscle glycogen levels, a result of their lower CHO intake (Costill et al., 1988). These findings led Snyder et al., (1995) to investigate performance responses to a 15-day intensified training period with the addition of sufficient CHO in the athletes' diet to determine if a state of NFOR would occur in the presence of normal glycogen levels. After the intensified training 4 out of 8 cyclists demonstrated a decrement in performance and were classified as NFOR. The authors concluded that a mal-adaptation to training can occur even when resting muscle glycogen levels are maintained (Snyder et al., 1995). Nevertheless, it seems that keeping an adequate diet with sufficient ingestion of CHO is important to avoid the potential consequences of glycogen depletion through training.

2.8.2. Blood lactate

The production of intramuscular lactate leads to its accumulation in the blood where it can easily be measured (Armstrong & Welsman, 1997). According to Olbrecht (2000), using lactate as a tool to monitor training intensity gives the coach a greater understanding of how the two energy systems (aerobic and anaerobic) interact and how they can be combined to improve velocity (Olbrecht, 2000). This marker has been used to monitor training and diagnose overtraining, specifically when looking for a reduction in plasma lactate levels during submaximal and maximal exercise. While lower lactate levels during submaximal exercise generally indicate improved endurance capacity (Foster, Snyder, Thomson, & Kuettel, 1988; Jacobs, 1986), in overtraining, lower maximal and submaximal lactate values have also been reported (Jeukendrup, Hesselink, Snyder, & Kuipers, 1992; Lehmann, 1988).

Jeukendrup and colleagues (1992) studied amateur cyclists and investigated the effects of a period of intensified training on blood lactate levels. After 2 weeks of extremely heavy training (13 intensive interval training sessions of 2-3 hours over 15 days) maximal as well as submaximal plasma lactate concentrations were significantly decreased; the maximal lactate levels dropped by 50 % and submaximal lactate levels by 40 % when cycling at 300 watts (Jeukendrup et al., 1992). A study that tested a young amateur cyclist (19 years old) twice over a period of 2 months found that there had been a rightward shift in the lactate curve (submaximal test). However, at the end of the study the authors found that the maximal lactate level was lower compared to 3 months before. Together with other criteria (complaints of deteriorating performance, irritability and sleep disturbances) the athlete was diagnosed as OT (Jeukendrup, Matthijs, & Hesselink, 1994). As such, a curve that could easily be interpreted as improved endurance capacity was in fact a case of OT. Decreased submaximal lactates, in combination with decreased maximal lactate concentrations can help in the diagnosis of OT (Jeukendrup et al., 1992; Jeukendrup et al., 1994). For that reason lactate curves should be interpreted with caution. In contrast Urhausen et al. (1998) found no changes in submaximal and maximal lactates after acute short-term exhaustive tests performed 5 times during a complete season in cyclists and tri-athletes (Urhausen, Gabriel, & Kindermann, 1998a).

Several mechanisms have been proposed to explain the decrements seen in lactate, and it is not clear what the causes are. Some evidence seems to point to a delay in the resynthesis of glycogen with a decrease in substrate availability (Costill et al., 1988), and a consequent alteration of the blood lactate response to exercise (Maassen & Busse, 1989). However, Snyder and colleagues (1995) have clearly shown that a decrease in lactate concentration can also occur in athletes who have been exposed to 15 days of intensive training with normal glycogen concentrations at rest (Snyder et al., 1995). This suggests that the capacity to mobilize available substrate is a more critical factor than substrate availability. In this respect, a blunted response from growth hormone and cortisol has been observed after an insulin-induced hypoglycaemia in five OT marathon runners (Barron et al., 1985). This implies that an exercise hypoglycaemia independent of muscle glycogen stores can occur during OT, decreasing the capacity of the muscle to produce lactate (Bosquet, Léger, & Legros, 2001). Importantly, and from a coaching/ research perspective, if lactate curves are to be used as training indicators, maximal lactate values should be determined for each test, together with the athlete's maximal work capacity. If glycogen levels are in fact reduced and/ or being less utilized, it should be easy to detect and therefore correct training.

2.8.3. Rates of Perceived Exertion

Borg's RPE (rates of perceived exertion) scale (Borg & Noble, 1974; *appendix 1*) is used in sport research to measure how athletes perceive their own exertion. Morgan (1994) stated that this scale is accurate in estimating the intensity of exercise (Morgan, 1994). Perceived exertion has also been studied in the context of OT. The direct relationship between training load and perceived exertion has been well documented in the literature (Borg, 1998; Noble & Noble, 1998; Noble & Robertson, 1996). A study by O'Connor and colleagues (1991) used the scale on a team of swimmers during their standardized training (90 % of $\dot{V}O_2$) and found that the perception of physical effort during a bout of submaximal exercise is sensitive enough to short-term increases in training volume (O'Connor, Morgan, & Raglin, 1991). Also, higher RPE values have been reported in OT athletes after 10 minutes of intensive exercise (Urhausen, Gabriel, Weiler, & Kindermann, 1998b). The scale is normally chosen for use because of its simplicity and because involves no costs. However, it only represents one dimension of stress and recovery, making its interpretation from a biopsychological perspective limited. The POMS (profile of mood states) however, with its multidimensional approach, takes more dimensions into account (Kellman, 2002b).

2.8.4. The La/ RPE ratio

Physiological parameters are often used to appraise training effects, whereas athletes' feelings during exercise are overlooked. Nevertheless, numerous studies have shown that the use of the RPE scale (from 6 to 20) described by Borg in 1970, is a good indicator of physical stress and physical working capacity (Borg & Noble, 1974; Eston, Davies, & Williams, 1987). This scale is used for clinical, ergonomic, pedagogical and sporting applications (Okura, Ueno, & Tanaka, 1998). Because subtle changes in athletes' feelings whilst exercising can have substantial effects upon their performance, it seems interesting to focus on athletes' feelings during exercise in order to appraise and check training responses.

Foster and colleagues (1990) noticed that the ratio of blood lactate to RPE during exercise indicated an athletes' degree of tiredness and/ or state of OR and OT. That is, with intensive training, as the blood lactate concentration is reduced and the RPE stays the same, the ratio of the two (multiplied by 100) becomes less than 100 (Foster, Snyder, & Thomson, 1990). The use of this measure has been confirmed and advised as it can easily be applied in the field (Garcin, Fleury, & Billat, 2002; Snyder, Jeukendrup, Hesselink, Kuipers, & Foster, 1993). More recently, another study performed on young high-level middle distance runners, also suggested the use of the La/ RPE ratio because it allows for early detection of changes in athletes. In contrast, it has been stated that using the La/ RPE ratio provides little additional information compared to lactate concentration alone (Bosquet et al., 2001).

2.9. Psychological markers for overtraining

People experience stress differently; one athlete might believe competition to be stressful whereas an opponent might not feel any stress at all. According to Lazarus (1966), the reason for this is that individuals interpret situations differently; their appraisals diverge (Lazarus, 1966). Lazarus and Folkman (1984) define 2 forms of cognitive appraisal: primary and secondary. Primary appraisal is the initial conclusion an individual makes about a situation – is the event irrelevant, benign or positive, harmful and a threat, or harmful and a challenge. The second appraisal involves the individual determining what coping resources or behaviours are available for handling the threat. In this process, the individual is constantly acquiring new information and re-evaluating the situation. Thus, both the environment and the athlete's appraisal will affect whether the situation is interpreted as stressful.

Whether or not an individual perceives a situation as a threat or a challenge will have significant physiological implications. The situation must exceed the athlete's resources, and he or she must interpret the situation as stressful (i.e., as a threat). When the resources are perceived as approximating or exceeding the demands, the situation will be interpreted as a challenge instead of a threat. In both conditions the athlete will experience increased arousal, but experiencing the situation as a threat (demands of the situation are perceived to outweigh the resources) instead of a challenge (resources are perceived to approximate or exceed the demands) is associated with different ANS alterations, which then can have essential health implications. For example, when an individual faces a challenge there is an increase in sympathetic arousal coupled with reduced or unchanged peripheral resistance to blood flow. In contrast, a threat although triggering an increase in arousal due to sympathetic activation, is associated with an increased peripheral resistance, leading to increase blood pressure (Kemeny, 2003). The fear of failure or a threat to the individual's self-esteem elicits HPA axis activation, but these effects are reduced when self-esteem is not at stake (Dickerson, Gruenewald, & Kemeny, 2004). In addition, the perception of control will greatly influence how we experience a situation (Karasek & Theorell, 1990). These circumstances and its interpretation will then lead to greater physiological activation.

In order to understand stress and stress reactions, the concept of coping must be included. The most common definition of coping states that the "constantly changing cognitive and behavioural efforts to manage specific external and/ or internal demands that are appraised as taxing or exceeding the resources of the person" (p.141) (Lazarus & Folkman, 1984). Lazarus and Folkman (1984) also differentiated between problem-focused and emotional-focused coping. The former coping is directed at managing the problem and situation, whereas the emotional coping is directed at managing cognitions or emotions. These two forms of coping are not reciprocally exclusive, but are instead often used together or sequentially to handle stress (Liegey-Dougall & Baum, 2003). A person's choice of coping can be influenced by his or her perceived level of control over the situation and many other factors, such as personality characteristics and the character of the event (Anshel & Eom, 2003). The efficiency of coping skills has important influence over the stress reactions found in different individuals.

2.9.1. Psychological instruments used in overtraining research

The interindividual differences existent amongst athletes in different recovery rates, exercise capacity, non-training stressors and stress tolerance may explain the different degrees of vulnerability experienced by athletes under normal training conditions (Lehmann et al., 1993). Therefore, it is necessary to evaluate athletes individually, monitoring them regularly and, if possible, comparing the data longitudinally (Froehlich, 1993). The psychological research on OT has added an additional depth of understanding to the OT phenomenon. Initially, the relationships between mood (measured by the POMS; Profile of Mood States), training load and subjective ratings of well being have been investigated. It was suggested that increased mood disturbances and self-reports of decreased well-being may be valuable indicators of impending OT (Hooper, Mackinnon, & Hanrahan, 1997; Hooper et al., 1995b; Morgan, Costill, Flynn, Raglin, & O'Connor, 1988a).

2.9.1.1. Profile of Mood States

The relationship between training and emotional state and mood has been widely researched. Mood states are comparable to emotional states, but they are more persistent, less dynamic and less specific than emotions (Carver & Scheier, 1990). Still, they are more transient and fluctuating than personality characteristics. Mood states, emotions and stress should be measured at different levels, which again encompass physiological, subjective-verbal, behavioural, cognitive and social aspects (Kellman, 2002b). Research on emotional states is based mostly on the POMS (McNair, Lorr, &

Dropplemann, 1971), which is a self-assessment questionnaire for mood and affective states; it is a 65-item likert-format questionnaire that is rated on a scale of 1 (“not at all”) to 4 (“extremely”) that measures of total mood disturbances and six mood state constructs (tension, depression, anger, vigour, fatigue and confusion).

Athletes in a mentally healthy state will tend to show an iceberg profile on the POMS, especially during the start of the season (Morgan et al., 1988a). However, when engaging in intensive training athletes will tend to worsen their mood states and their POMS profile is accompanied by diminished mental health profile. After the training intensity is significantly reduced athletes will return back to exhibiting the original iceberg profile (Morgan et al., 1987a; Raglin, Morgan, & O'Connor, 1991). A dose-response relationship between mood and training intensity has therefore been claimed (Kentta, Hassmen, & Raglin, 2006; Morgan et al., 1987a; O'Connor, 1997; Raglin, 1993), with depression, anger and fatigue being the constructs that are most affected in athletes under overtrained states (Morgan et al., 1988). As such, it was suggested by Morgan and colleagues (1987a) that monitoring mood states during a given period offers a potential method of quantifying distress and titrating training loads on an individual basis (Morgan et al., 1987a). What tends to happen with POMS and training load variations is that when the load is increased, scores on the negative POMS subscales will tend to increase, whereas scores on vigour tend to decrease. The POMS becomes an interesting tool if some of the athletes in the group are undergoing maladaptations to training (NFOR or OT). In these cases, after the training load has been raised for a prolonged period, when load is reduced again, the profile of the athlete under NFOR or OT still remains negative, whereas the well-adapted athletes show the normal response returning to a positive score profile (Hooper et al., 1997; Morgan et al., 1987a; Morgan et al., 1988a; Morgan, O'Connor, Ellickson, & Bradley, 1988b; Raglin, Morgan, & Luchsinger, 1990). However, other studies (Murphy, Fleck, G., & Callister, 1990; Verde, Thomas, & Shephard, 1992), have reported no links between the POMS scores and performance. Richardson and colleagues (2008) have suggested that if POMS is not related to performance, then any changes in POMS during training periods are relatively meaningless (Richardson et al., 2008). The time frame together with the low increments in training load could have hidden possible negative changes that were not reflected in the POMS. In an attempt to clarify some of these issues Martin and colleagues (2000) have recently studied competitive cyclists and tried to relate POMS scores to training load and performance. After an increment of training intensity for a period of 6 weeks in 11 cyclists, followed by a taper period, there were no reported significant changes in mood scores. Furthermore, the POMS profile of 2 cyclists who were classified as OT because they did not improve their performance compared to their colleagues during the taper period were not distinctly unique when compared with the cyclists who did improve performance (Martin et al., 2000). However, the latter study was of short duration and used a small pool of subjects, which then leaves the study vulnerable to criticism.

A number of previous psychologists work (Kentta et al., 2001b; W. Morgan et al., 1987a; O'Connor et al., 1989; Raglin, Koceja, & Stager, 1996; Raglin et al., 1990; Raglin, Sawamura, Alexiou, Hassmén, & Kentta, 2000b) argue that the majority of athletes who are prone to develop NFOR/ OT, will report significantly higher mood disturbances during periods of hard training compared to healthy athletes. Finally, the fact that at the individual level certain athletes may not show the expected mood-training relationship seen in groups (Martin et al., 2000), may be used to modify interventions in terms of needs/ weaknesses/ strengths of the individuals.

2.9.1.2. Training Distress Scale

Recently, a reduced version of POMS has been developed called the Training Distress Scale (*appendix 2*). This is a 7-item scale developed by Raglin and Morgan (1994) using data from swimmers (Raglin & Morgan, 1994). Data were obtained over a 4-year period; the athletes were asked to routinely complete the POMS on a monthly basis. They found that the 7-item subset of POMS items derived from discriminant function analysis was effective in identifying collegiate swimmers and track and field athletes who exhibit signs of distress resulting from intensive training and/ or mal-adaptations to training. The resultant 7 items all derived from POMS items related to depression and anger. Raglin and Morgan (1994) stated that the scale could be useful in identifying swimmers in the initial phases of distress and also that it could be easily used in field settings, so it looks like a promising and easy-to-use instrument in training monitoring and OT research. If the TDS scores are low the athlete is thought to show no distress. On the other hand, if the athlete starts showing signs of chronic distress the scores on the questionnaire will increase.

2.9.1.3. Athlete Burnout Questionnaire

Research on athlete burnout has been hampered due to a lack of validated instruments (Raedeke & Smith, 2001). Recently, a new instrument has been developed: The Athlete Burnout Questionnaire (ABQ; *appendix 3*) (Raedecke, 1997; Raedeke & Smith, 2001). This instrument was initially developed based on the Eades Athlete Burnout Inventory (11 of 21 items are identical), but is more closely related to the burnout dimensions proposed elsewhere (Maslach & Jackson, 1984; Maslach, Jackson, & Leiter, 1996). The most recent version of the ABQ consists of 15 items and is related with the following burnout dimensions: Physical/ emotional exhaustion, reduced sense of accomplishment and sports devaluation. It has been validated by Raedecke and Smith (2001) and Cresswell and Eklund (2006), showing good convergent and discriminant validity, and appears to be a promising tool for measuring and monitoring burnout (Cresswell & Eklund, 2006; Raedeke & Smith, 2001). Even though the ABQ shows more advantages compared to other instruments that also measure burnout, like the Recovery-Stress Questionnaire (Kellman & Kallus, 2001b), the latter lacks the absence of a devaluation dimension. So far, only one study has used the ABQ to investigate the prevalence of burnout in young competitive athletes; the authors found that the incidence of burnout ranged between 1 and 9 % of the adolescent elite athletes and suggested that factors other than training load must be considered and investigated when athletes are at risk for burnout (Gustafsson, Kentta, Hassmen, & Lundqvist, 2007). As such, more research with the ABQ is needed both in young and adult populations.

2.9.1.4. Daily Analysis of Life Demands for Athletes

The Daily Analysis of Life Demands for Athletes (DALDA; *appendix 4*) is a self-report inventory of sources of life-stress and symptoms of stress. The questionnaire is divided in part A (sources of stress) and part B (symptoms and manifestation of stress). The total "a" scores for each day can then be graphed and an indication of fatigue levels determined. When scores remain elevated for more than 4 consecutive days, a period of rest is advised (Halson & Jones, 2002). This tool can be used to determine the nature of an athlete's response to training, particularly, his/her capacity to tolerate training loads. Also, it provides insights into training responses, like the ideal amount of stress required to promote a near-to-optimum training response, the influence of outside-of-sports stresses, and preliminary features of overtraining (Halson & Jones, 2002; Rushall, 1990).

4.9.1.5. Stroop test

This test and other psychometric tests have been used on research that has looked at depression (Nederhof et al., 2006) and, more recently, on research looking at NFOR and OT in athletes (Nederhof et al., 2007; Nederhof et al., 2008). The use of the test is based on data that has consistently shown that depressed patients present higher reaction times compared with healthy participants (20 - 26% slower reaction times than healthy controls) (White, Myerson, & Hale, 1997). Athletes who are overtrained typically show concentration problems, attentional dysfunction, cognitive and memory complaints, which then results in a poorer performance on a psychometric task (Nederhof et al., 2006). Because assessment is computerised, it is objective and not manipulable. Furthermore, it is a simple task that can be performed in a quiet room on a laptop and therefore can be easily integrated into any investigative study or even a training programme, in order to monitor and prevent the development of NFO and/or OTS.

Recently, Hynynen et al. (2008) compared 12 overtrained athletes with 12 healthy athletes of the same sex and age on the Stroop test. The overtrained athletes experienced underperformance even after a recovery period of at least 3 weeks and underperformed on the cognitive task; the overtrained athletes clearly made more mistakes on the Stroop test compared with the healthy athletes. Nederhof and colleagues (2007) also tested overreached cyclists to determine if they show psychomotor slowness after a period of very intense training. At the end of the study 5 of the cyclists were diagnosed as FOR and the other 7 were classified as well-trained. Nederhof’s research group (2007) found a trend towards psychomotor slowness for the FOR cyclists, although differences were not significant. As such, it seems that using a psychomotor cognitive task like the Stroop test can be useful to differentiate between athletes with positive adaptations to training and others that show early signs of NFOR and/ or overtraining. Similarly, Nederhof et al. (2004) found that healthy, high-level rowers who were under more stress performed worse on the Vienna Determination test (reactive stress tolerance), whereas rowers who perceived lower levels of regeneration performed worse on the finger pre-cuing task (reaction time test).

Preliminary evidence for psychomotor speed as an early marker for NFO and/or OTS is promising. However, it is necessary to conduct more studies over complete training seasons to get more insight into athletes' psychomotor speed; this may potentially lead to using the Stroop test as a simple task for early detection of a mal-adaptation.

2.10. Overtraining risk factors

Risk factors in OT have not been well researched. However, some researchers have made anecdotal comments on potential OT risks and have presented some qualitative data. These data have provided insights into other factors that do not only relate to training but instead involve all other aspects of the athletes' lives. When looking at the research done and their anecdotal nature, one comes to realise that these factors relate to training, personal, environmental and situational factors (Richardson, 2005). In other words, they involve perspectives that point to external objective and internal subjective reasons that accompany the individual at all times and are therefore said to be ever-present. The same line of thought applies when the perspective one is taking is now investigating the collective; there is no longer the individual being studied on its own, but a group of individuals that make up a collective. As such, the collective can also be investigated with 2 essentially different perspectives, one that considers its exterior inter-objective aspects and one that acknowledges its interior and therefore, inter-subjective reality (Wilber, 1997). In resume, the extremely well achieved resume of risk factors presented by Richardson (2005), all fall into these 4 essential and ever-present categories and will be discussed bellow.

Krane, Greenleaf and Snow (1997) reported the story of an elite female gymnast who was OT; she was characterized by disordered eating, high levels of ego-involved goal orientation, perfectionism, a win-at-all costs attitude, maladaptive responses to lack of success (e.g., increasing the training load even more), and an inability to rationalize what represented excessive training. Furthermore, she was also surrounded by parents and coaches who put enormous pressure over her in order to succeed and train hard, even supporting maladaptive behaviours like training when injured, or lack of rest/ recovery (Krane et al., 1997). This example is one of countless that underlines how different situational factors can interact to lead athletes to develop OT. It is not just the training load alone, but a combination of the physical and psychological training-related factors with the cultural ones that relate to identity, communication, relationship issues and more.

2.10.1. Training related

Gould and colleagues (1997) investigated burnout in young elite tennis players and found similarities between 2 tennis athletes who showed signs of excessive training although for different reasons. One of the athletes was characterized by both, high levels of perfectionism and a tendency to create unrealistic expectations in regards her future in tennis. Further, she was strongly criticised by her parents who created high expectations on the daughter and overemphasized winning. Her personality traits directed to perfectionism and her unconscious need to please her parents led her to create a mentality based on high training loads. With the other athlete who also showed high training load levels the causes seemed to be slightly different; he believed that success would come not from talent but from a strong commitment to training combined with "super-motivation" and unrealistic goals. This case clearly shows that the reasons athletes decide to train "too much" can be different, but have a common ending: they will lead athletes to train more than they are physically and psychologically capable of and consequently, overtrain and eventually burnout. Fry, Morton and Keast (1991) stated, "lack of recovery time in the training schedule is the most important risk factor for OT" (p.123). There are, however, many factors that can affect recovery. For some athletes, the training stimulus may be the most important factor affecting recovery, if the workload is of a high volume and intensity (Kuipers and Keizer 1988; Lehmann, Foster et al. 1993; Budget 1998). For others, factors outside of training may impede adequate recovery, such as work, school or family commitments. Lehmann and colleagues (1993) suggested that it is important to look at each athlete individually, stating that "inter-individual differences in recovery potential, exercise capacity, non-training stressors and stress tolerance may explain the different degrees of vulnerability experienced by athletes under identical training conditions" (p. 25). There also may be subtle differences on attitudes towards, and behaviours surrounding recovery, such as parental input, sport culture, pressures, or attitudes of peers, training partners, and other athletes. In this regard, Brustad and Ritter-Taylor (1997) noted that coaches and others, frequently endorse attitudes, such as *no pain no gain* and the *more is better* philosophy, which create cultural risks (Brustad & Ritter-Taylor, 1997) because it allows a certain type of mentality to be accepted unquestioningly, and blocks the development of self awareness (Brustad & Ritter-Taylor, 1997; Kentta & Hassmen, 2002). Furthermore, sudden increases in training load, due to both a lack of periodization (Armstrong & VanHeest, 2002; Budget, 1998), and/ or athlete and coach awareness, can lead to an excess in motivation from the athlete (Budget, 1998; Hollander & Meyers, 1995), only adding to the total stress the athlete experiences in his/ her life. This can reach a level where a person experiences a lack of recovery, which shows how OT can develop even with moderate levels of physical activity, if coexisting high-levels of psychological stress are present (Kentta & Hassmen, 2002).

Botterill and Wilson (2002) emphasized how when some athletes become extremely guilty about not working hard enough can be another important factor on the development of OT, impeding recovery and rehabilitation. Circumstances, such as the lead up to, or the time following big competitions, may also increase the risk to OT, most possibly due to the addition of heightened mental and emotional demands to the already existing physical demands of preparing for, and performing in competitions (Botterill & Wilson, 2002). Finally, the same authors also recognised the potential harm of emotional build up, commenting that “repressed denied or unprocessed emotions” can be sources of conscious and unconscious conflicts and personal stress (p. 150) (Botterill & Wilson, 2002).

Similar to comments by Fry et al. (1991) about lack of recovery, Hanin (2002) also described risk factors in terms of barriers to effective recovery and rest. He suggested that athletes and coaches may underestimate the importance of systematically matching the workload with adequate rest, and pointed out that this underestimation may be reinforced by the values held by some sport cultures, subcultures and athletes, where quantity (intensity and volume) is emphasized over quality (Hanin, 2002).

2.10.2. The athlete's psychology and environmental stressors

Simple changes in environment like an athlete's accommodation being close to a noisy place outside, may affect the rest the athlete can have during day and night. In contrast, the athlete who is used to living in a loud area may struggle to sleep in a very quiet place and become irritated. Furthermore, emotional disturbances such as family and relationship conflicts can alter the sleep of the athlete. Kellman (2002a) recognized that although athletes can compensate for a lack of sleep or other recovery activities in the short term, without addressing the factors that explain the lack of recovery, they will eventually risk developing OT in the long term (Kellman, 2002a).

In many sports, competitive environments and intra-team rivalries can lead to disruptions in recovery. Sometimes, athletes get a day of recovery during the week and may decide to do some type of sports activity with their team mates that had the intention to be something relaxing, but can end up becoming a competitive race. With fear of telling the coach what had been done during the recovery day, the athlete will continue practice as if recovery had taken place, adding a new physiological stressor to the training (Kellman, 2002a). Kentta and Hassmen (2002) stated that although the athletes may have experienced some social relaxation, their competitiveness resulted in an added physiological stressor that could disrupt the training programme prescribed by the coach.

Athletes' responses to their own performances can affect how they balance training and recovery, potentially motivating them to push excessively in training (Hanin, 2002). When an athlete performs poorly, he/ she can end up continuing to work intensely or even increase the amount of training in an effort to enhance self-confidence and self-esteem. In contrast, an athlete who is performing very well, can become over-enthused with their own performance and consequently may start to train even more in the belief that this will improve performance even further and/ or not notice the signs of fatigue (Hanin, 2002). Hawley and Schoene (2003) noted how athletes might display maladaptive responses to poor performance, where frustration may lead them to train harder in response to plateaus or declines in performance. The problem with increasing training when the stress loads are already high is that it increases fatigue and results in further decrements in performance, thus initiating a vicious cycle of heavy training, chronic fatigue, poor performance and frustration. To make things worse, coaches can also promote the *more-is-better* philosophy, whilst being unaware of the risks for developing OT, by implementing aggressive approaches to training and thinking that "if 5 is good then 50 is better" (p.26) (Gould & Dieffenbach, 2002).

Further, communication problems with coaches also stand out as another contributing factor. A lack of good and healthy communication between athlete and coach seems to be essential to maintain a healthy sports atmosphere; this aspect together with poor timing of selections processes were cited by several Olympic athletes as common factors that contribute to the development of a mal-adaptation (Gould et al. 1999). If athletes are unable to communicate to the coach how they are feeling about performing at training and competition, or about other non-sport issues that are naturally and logically brought into training the coach will simply not be aware of crucial aspects that will affect how he/ she is performing. As such, it is important that coaches make an effort to improve communication within their team so that they know which issues are most likely to affect their athletes' performances. Some athletes however, are scared of expressing their honest thoughts to their coaches and may take unfavourable decisions. An example of the latter was described by Kellman (2002) in a study with a Canadian male speed skating team. As part of their training schedule, there was a day off for purpose of recovery. However, because the coach did not know their athletes with enough depth, he did not know that some of the athletes could use that day to go for a bike ride in the mountains. Even worse, these athletes ended up competing with each other and the bike ride turned into a race. In the end, these athletes did not rest and when the coach assessed them later in the week he was surprised by the performance decline (Kellman, 2002). This example shows how coaches may be completely unaware of their athletes behaviours and the decisions they take outside sport.

Coaches play a crucial role for their athletes' development and if they lack self-awareness and do not think it is important to worry about how their athletes develop inside and outside sport, it is very likely that overtraining will develop and that many athletes will end up burning out. The coach is the one prescribing training and therefore has a huge responsibility on that role. As such, they influence how athletes push themselves in training, what they do inside and outside the sport in terms of recovery, and how they feel about themselves from an emotional, psychological and physical point of view. Even at times where the athlete may agree that his/ her coach pushes him/ her too hard, they will still engage in the prescribed practice (Gould and Dieffenbach, 2002; Krane et al., 1997). Other times, coaches may not individualize training appropriately as exemplified in the following quote: "I think the coach failed to see the individual needs of players. Some people just couldn’t practice for 3 hours in 90-degree heat. It got to them. Quite a few were sick, off and on, and half of our team was injured” (Wrisberg and Johnson, 2002; p. 264).

Some coaches even use abusive behaviours with their own athletes because they believe this is the best way to push them to their highest potentials, with the athletes “consent”; athletes also believe this is the best way for them to become better so they engage unquestioningly on the practices prescribed. Krane et al. (1997) has provided evidence of a gymnastics coach that used to put Pepsi bottles on the bottoms of their athletes’ feet in case they would fall on their heals so that they would not do it again. One of her athletes described her as “…excruciating, die-hard; she was wonderful. You either love her or hate her. I was a person who loved her because she was good, and that’s why I liked her” (p. 59). Another example was given by Wrisberg and Johnson (2002) who provided evidence of how verbally abusive coaches can be: “She made us feel like we were fat… real big. She called me names and told me how mentally retarded I was” (p. 264). In other situations coaches will push their athletes to keep training even though they know they are injured, which is another extremely risky behaviour: “When I had a groin injury [the coaches] made me scrimmage anyway… I mean, I had no business being out there” (p. 258; Wrisberg and Johnson, 2002).

How parents see their kids in sport and how much involvement they get is also a crucial factor that will influence how well they adapt to training. Some parents get overly involved in their kids’ sport and from this a huge amount of pressure can result for the athlete. Further complicating things, because the athletes are very young they have no cognitive ability to understand that these behaviours are not appropriate and therefore they “allow” them to develop. Gould et al. (1997) provided evidence for the latter: “…you wouldn’t talk about anything else but tennis whether we were eating or if there was a match on television everyone had to watch it and he’d comment, and whether ot not you agreed with him, it didn’t matter cause you know, he was always right” (p. 265).

There are many more examples of how situational stressors can act to leave athletes under stress within their sport. What is trying to be stressed here is the complexity of factors that are dependent on every individual (physical and psychological), every coach, every parent, the cultural and social context that the athletes are emerged in, and how they all interact with each other to influence the development of overtraining and eventually lead athletes to burnout. The available data indicates that understanding what puts athletes at risk for OT strongly requires looking into several different aspects of athletes’ lives; the perspectives that should be taken into account should investigate how the athlete reacts individually and when socially surrounded, from 2 points of view, physical and mental (Wilber, 1997). Hence the complexity of the phenomena known as overtraining and burnout.

2.11. Overtraining or depression?

It has been recently recognised that the OT signs and symptoms are actually very similar to the ones encountered in the condition known as depression (Armstrong & VanHeest, 2002). According to the American Psychiatric Association, there are two sub-types of this condition, but concerningly the one that most closely resembles OT syndrome is known as major depression (Yudofsky & Hales, 1992). Major depression affects an individual’s thoughts, feelings, physical health, behaviour and ability to function on daily activities. Furthermore, it involves at least two weeks of depressed mood or lack of interest on nearly all life activities, with individuals reporting similar signs and symptoms to the ones seen in OT - problems with sleep, lack of appetite, irritable mood, loss of body weight, loss of motivation (Yudofsky & Hales, 1992). Finally, OT syndrome shares similar brain related dysfunctions, altered endocrine pathways and immune responses to the ones reported for major depression (Morgan et al., 1987; O'Connor, Morgan, & Raglin, 1991). In fact, Morgan and colleagues (1997a) reported that approximately 80% of athletes with OT had a psychopathology similar to people with psychological depression.

The frustration due to the lack of performance typically drives the athlete to further increase the amount of training that he/ she is doing, which just exacerbates the situation by increasing physical and emotional fatigue, with a consequent worsening in performance (Kentta et al., 2001). This cycle (process) manifests itself by changes in mood, sleep disturbances, losses in appetite and body weight, and an increase in depressive symptoms, eventually leading to depression (Armstrong & VanHeest, 2002). Nevertheless, it is unlikely that all athletes with OT will develop major depression. Athletes who are OT state may present with some symptoms that match those of depression but they are not necessarily depressed.

2.12. What is the prevalence of OT in adults?

OT syndrome has been extensively studied in adult athletes. However, little empirical data has been produced regarding incidence rates (*table 2.1*). Signs and symptoms of OT appeared in more than 50 % of professional soccer players during a 5-month competitive season (Lehmann, Schnee, Scheu, Stockhausen, & Bachl, 1992), and 33 %

in basketball players during a training camp of 4 weeks (Verma et al., 1992). In two separate research studies in elite US distance runners, Morgan and colleagues (1987, 1988) found that 60 % of women and 64 % of men reported being overtrained at some point in their career (Morgan et al., 1988; Morgan et al., 1987c). Importantly, the rate of OT occurrence dropped to 33 % when non-elite women runners were considered (Morgan et al., 1987c), which is indicative of the close relationship between performance level and the prevalence of OT. From the latter it is suspected that being an elite athlete may not confer resistance to overtraining – rather, elite athletes enduring capacity to engage in very intensive training schedules may leave them at greater risk. In other studies of collegiate athletes the reported yearly incidence of overtraining averaged approximately 10 % in wrestlers (Morgan, Brown et al., 1987a), ranging from 7 % (Raglin and Morgan, 1994), to 21 % in collegiate swimmers (O'Connor, Morgan et al. 1989; Hooper, MacKinnon et al., 1997). Also, it has been proposed that female athletes may be more prone to becoming NFOR/ OT (Ryan, Falsetti et al., 1983; Uusitalo, 2001).

Table 2.1 – Incidence of overtraining found in adult studies.

	Incidence rates	**Performed studies**
Elite runners	60 % in females 64 % in males	Morgan, O'Connor et al., 1987 Morgan, O'Connor et al., 1988
Non-elite runners	33 % in females	Morgan, O'Connor et al., 1987
Wrestlers	10 %	Morgan, Brown et al., 1987
Collegiate swimmers	31 % 7 % 21 %	O'Connor et al., 1989 Raglin and Morgan, 1994 Hooper et al., 1995b
Soccer players	50 %	Lehmann et al., 1992
Basketball players	33 %	Verma et al., 1992

While OT is acknowledged to be an issue in adult athletes, very little research has been performed with young athletes. As such, it is important to study the overtraining phenomenon in young athletes both, from a collective (*What is the extent of the problem in young athletes? What are the contributing factors to its development?*), and individual (physiological and psychological responses to training) perspectives.

CHAPTER III

Prevalence of Non-Functional Overreaching/ Overtraining in Young Athletes

3.1. Introduction

3.1.1. Incidence of Non-Functional Overreaching/ Overtraining in Young Athletes

For young athletes, information concerning non-functional overreaching/ overtraining (NFOR/ OT) incidence and its nature are scarce and it is not known whether similar symptoms of overtraining found in adults are evident in young athletes. Furthermore, several other areas (i.e. incidence per age, incidence per gender, incidence per sport type, etc.) on the incidence of NFOR/ OT have not been studied sufficiently and are therefore lacking. It is not known at which age NFOR/ OT may emerge? Which age has the highest incidence? Are there differences between individual sports and team sports, endurance sports and power/ sprint sports, low and high-physically demanding sports, or between genders?. Furthermore, it is not known if NFOR/ OT is a problem restricted to elite-sports or if it is evident at lower competitive levels. Finally, and importantly, it is not clear what influence training load has on the development of NFOR/ OT, and what the effect of age and of years spent in sport training and competing has on the development of NFOR/ OT.

Wilson and colleagues (1999) found that 31 % of adolescent distance runners reported experiencing overtraining with the average episode lasting about 3 weeks. (Wilson, Raglin et al., 1999). In addition, Raglin et al., (2000) have investigated the prevalence of overtraining across four different countries (Japan, USA, Sweden and Greece) in a sample of adolescent swimmers (14.8 ± 1.4 yr) and found that 35 % had been overtrained at least once. Similarly, Kentta and colleagues (2001) investigated the prevalence of overtraining in Swedish age-group athletes (N = 272; mean age 17.9 yr) and found that 37 % of the athletes had been overtrained at least once in their sports careers. More recently, Gustafsson and colleagues (2007) also found that approximately 10 % of competitive adolescent athletes (N = 980; mean age 17.5 ± 0.1 yr) reported high burnout scores.

3.1.2. Signs and symptoms in young athletes

Although few investigations have collected data on overtrained athletes there is some evidence that the signs and symptoms in young athletes are similar to the ones found in the adult population (Raglin, Sawamura et al., 2000b; Kentta, Hassmen et al., 2001). The last mentioned cross-cultural study performed on swimmers found that the most frequently reported complaint from swimmers was an increased perception of effort, followed by feelings of muscle heaviness, which echoes the results from another study on young elite athletes (Kentta, Hassmen et al., 2001). Also, swimmers who were reported to be unmotivated to train/ compete had consistently higher levels of mood disturbances compared with functionally overreached swimmers who retained their incentive to train (Raglin, Sawamura et al., 2000b). The study by Raglin and colleagues (2000) reported more symptoms such as muscle soreness, sleep disturbances and loss of appetite. Athletes were also asked to report additional symptoms during the overtrained periods; they found these to be essentially of psychosocial nature, i.e. social problems (family, boyfriend / girlfriend, coach or friends), negative feelings like decreased interest in training and competition and frustration to continue training (Kentta, Hassmen et al., 2001). Finally, many other psychological problems have also been described like athletes' decreased self-confidence and ability to focus, short temper, heightened levels of irritability, depression, sadness, and elevated levels of perceived stress (Hollander and Meyers, 1995).

3.1.3. Overtraining aetiology

It has been claimed elsewhere (O'Connor, Morgan et al., 1989; Lehmann, Foster et al., 1993; Hooper, Mackinnon et al., 1995a; Budget, 1998; Halson and Jones, 2002) that training load is a strong contributor to the development of overtraining, and a number of other studies have used increments in training load as the main variable to induce a state of overtraining (Bosquet, Léger et al., 2001; Bosquet, Papelier et al., 2003; Baumert, Brechtel et al., 2006; Nederhof, Lemmink et al., 2007; Margonis, Fatouros et al., 2008). There are also indications that overtraining incidence is greater at higher competitive levels (Morgan et al., 1988b) and that female athletes tend to be more prone to its development (Ryan, Falsetti et al., 1983; Uusitalo, 2001). It has also been suggested by Gustafsson and colleagues (2007) that burnout (even though a distinct state compared to overtraining it is nevertheless interrelated) bears no relationship with training load (Gustafsson, Kentta et al., 2007).

Overall there is strong growing evidence indicating that other factors apart from training load are also playing a role for the development of overtraining, and it is likely that some of the symptoms reported in overtrained athletes and the factors that influence its development may be intertwined. As such, it is important to evaluate athletes individually to determine more confidently if what is being observed is either a cause or a symptom of the mal-adaptation. It is apparent that few studies have been conducted with young athletes in respect to overtraining incidence, its presenting symptoms and the possible factors that contribute to the development of NFOR/OT. Consequently the aim of this project was to assess the incidence, symptomology and associated factors of NFOR/ OT in young English athletes.

3.2. Methods

3.2.1. Participants

A total of 376 young English athletes (245 boys and 131 girls) from 20 different sports, spanning club to international level athletes, volunteered to participate in the study. The mean age was 15.1 yr ± 2.0 (range 11 – 18 yr). Sports clubs around Exeter and English National sports federations were contacted for volunteers. The study was approved by the Institutional Ethics Committee prior to commencement. The aims of the study were explained to the coaches, athletes and parents in an accompanying letter (*appendix 5*) and informed consent was given by the athletes and respective parents/ caregivers (*appendix 6*).

3.2.2. Measures and procedures

A questionnaire (*appendix 7*) was formulated based on work from previous studies (Raglin, Sawamura et al. 2000; Kentta, Hassmen et al. 2001; Gould, Lauer et al. 2006); items relating to training load, OT past experiences, frequency and duration of episodes, physical issues and psychosocial factors were adapted from the previous questionnaires. A pilot study (N = 60; 15.7 ± 2.3 yr) was conducted to determine the appropriateness, grammatical correctness, comprehension and clarity of the proposed survey. Personal contact was made with coaches and athletes before the questionnaire was completed, to facilitate an adequate response rate (11). The final survey included 6 sections related to the athletes' sports background, physical symptoms, psychological symptoms, psychosocial pressures, and NFOR/OT prevalence. A 5-point Likert scale was used to rate the frequency and strength of agreement or disagreement for statements. Sports were categorized as individual or team sports; high or low physically demanding sports according to the classification of Ainsworth et al. (1) (low-physically demanding = MET $\leq$ 6, and high-physically demanding = MET > 6); and competitive level categorized as club, county, regional, national or international standard.

The definition of NFOR/ OT used to classify athletes was derived from Kentta et al., (2001), but adapted to be more conservative - *Have you ever experienced a significant decrement in performance that persisted for long periods of time (i.e. weeks to months) even though you kept training and you felt extremely tired everyday*. Athletes were categorized as NFOR if the episode(s) lasted from 2 weeks to 6 months and overtrained if the episode(s) lasted for more than 6 months, and burned-out if they had completely lost their motivation to keep training and continue in the sport. The athletes were requested to indicate how many episodes they had experienced in the past, the duration of each episode, and if they were experiencing one at the time of answering the questionnaire. Finally, the athletes who reported being NFOR/ OT were asked if during the episode they kept their motivation to keep training, as this is thought to provide a better understanding of the stage of overtraining the athlete has experienced (Raglin, 1993; Raglin et al., 2000).

3.2.2.1. Statistical Analysis

Descriptive statistics are reported as mean (± SD). Differences between the NFOR/ OT and normal athletes (NORM: athletes who were not classified as NFOR/ OT) were determined using Mann-Whitney Non-Parametric tests, and differences within the

NFOR/ OT group using Kolmogorov-Smirnov Non-Parametric Test. Finally, logistic regression analysis (Backward Stepwise Method - Conditional) was used to identify the factors that were stronger significant predictors of NFOR/ OT. Six independent variables were entered into the regression model: age, gender, hours of training per day, days of training per week, years of competing in sport and competitive level. The Nagelkerke R Square Model was used to obtain the explained variance given by the significant variables of the regression equation. These variables were selected to discriminate between the discrete influences of each of these inter-related factors in contributing to the occurrence of NFOR/ OT. The level of statistical significance was set at $p < 0.05$.

3.3. Results

3.3.1. Descriptive statistics

3.3.1.1. Sample characteristics

A total of 376 athletes (131 females and 245 males) participated in the study. Twenty different sports were represented with 224 athletes (60 %) involved in individual sports, compared to 152 participants (40 %) team sports. The majority of the athletes had spent between 4 to 8 years of training and competing in their own sport (*Figure 3.1*).

Figure 3.1 – Percentage of athletes in relation to years of practice/ competition in sport.

Forty-six percent of the athletes trained between 1 and 2 hours per day, with 14 % dedicating more than 3 hours per day to the sport *(Figure 3.2)*.

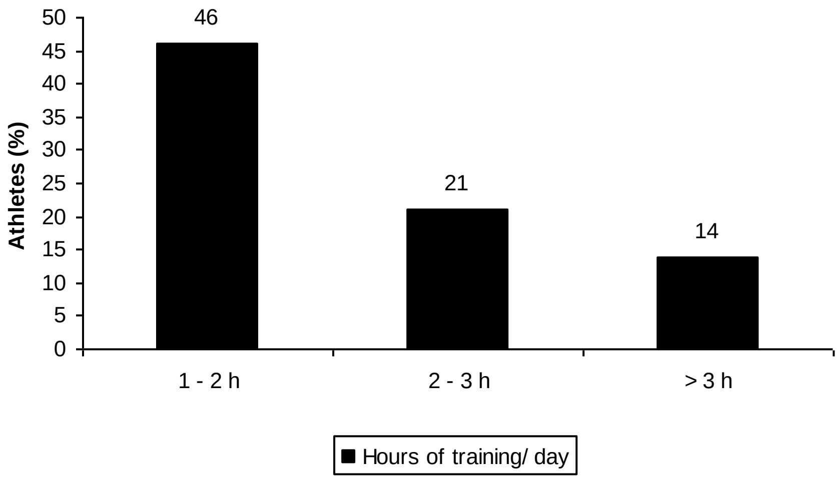

Figure 3.2 – Percentage of athletes in relation to hours of training per day.

Athletes most commonly spent 6 days per week in training, with 10 % stating they trained 7 days per week *(Figure 3.3)*.

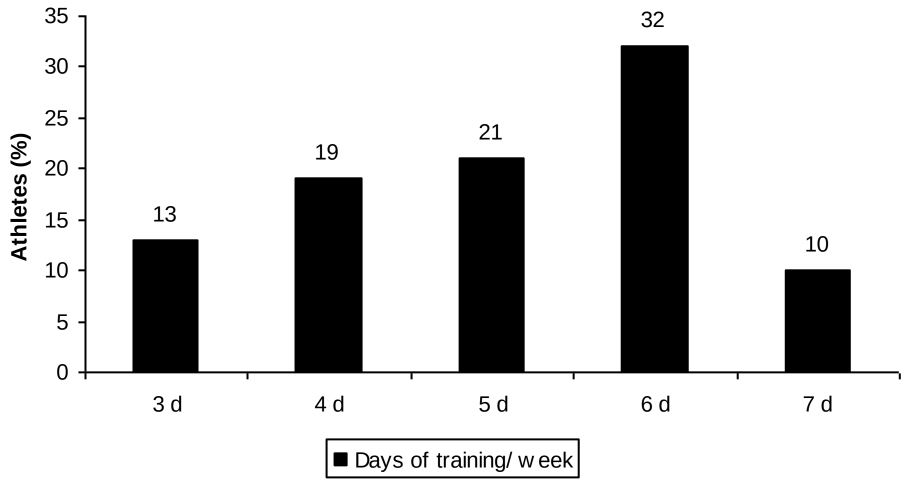

Figure 3.3 – Percentage of athletes in relation to days of training per week.

Finally, the majority of these athletes answered the questionnaire during their competitive season (72 %; *Figure 3.4)*.

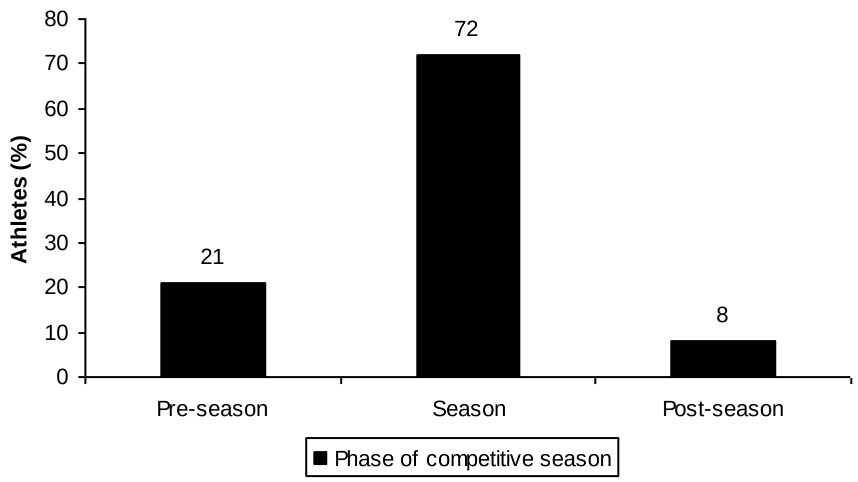

Figure 3.4 – Relative phase of the competitive season at time of answering the survey.

3.3.2. Non-functional overreaching/ overtraining incidence

A total of 110 athletes (29 %) were self reported as NFOR/ OT at least once (*Table 1*).

Table 3.1 – Incidence of NFOR/ OT across different sports, for individual and team sports, and low physically and high-physically demanding sports athletes.

Sport	Total Number	NFOR/ OT
Football (10 MET)	83	12
Athletics (13 MET)	54	13
Cycling (13 MET)	47	23
Swimming (9 MET)	32	16
Field Hockey (8 MET)	27	2
Rugby (10 MET)	26	9
Tennis (8 MET)	23	7
Squash (12 MET)	20	7
Gymnastics (4 MET)	18	9
Golf (4 MET)	13	4
Netball (4 MET)	8	3
Cricket (5 MET)	5	1
Eventing (4 MET)	5	2
Martial-arts (10 MET)	4	2
Rowing (12 MET)	3	0
Dance (5 MET)	3	0
Lacrosse (8 MET)	2	0
Fencing (6 MET)	1	0
Off-road (4 MET)	1	0
Basketball (8 MET)	1	0

The MET classification used the definitions of Ainsworth et al., (1993): *Low-physically demanding* = MET $\leq$ 6, and *high-physically demanding* = MET > 6

The incidence of NFOR/ OT is significantly greater in individual sports compared to team sports ($p < 0.01$), and also significantly higher for low-physically demanding sports compared to high-physically demanding sports ($p < 0.01$; *Table 3.2*).

Table 3.2 –Incidence of NFOR/ OT between individual and team sports, and low and high physically demanding sports.

	Total Number	**NFOR/ OT (n)**	**% NFOR/ OT**
Individual sports total	224	83	37*
Team sports total	152	27	17
Low-physically demanding	54	19	34†
High-physically demanding	322	81	25
Grand Total	**376**	**110**	**29**

* significant differences between Individual and Team sports ($p < 0.01$); † significant differences between Low and High-physically demanding sports ($p < 0.01$).

The incidence of NFOR/ OT was significantly greater in females compared to males ($p < 0.01$). In relation to age and years in sport, the rates of NFOR/ OT did not show any trend (*Table 3.3*). Furthermore, the NFOR/ OT group did not differ significantly in mean age (15.3 ± 1.9 Vs 14.9 ± 2.0 yr), or years of training/ competing in sport (3.9 ± 1.5 Vs 3.7 ± 1.4 yr), compared to the NORM (not OT) group.

Table 3.3 – Incidence rates of NFOR/ overtraining (in percentage) by sex, age at completion of the survey and years in sport in the all sample.

Variables	**Incidence rate of NFOR (%)**
Gender	
Males (N= 245)	26
Females (N= 131)	36*
Age	
11 years old (N= 18)	23
12 years old (N= 30)	17
13 years old (N= 23)	22
14 years old (N= 62)	27
15 years old (N= 84)	27
16 years old (N= 74)	30
17 years old (N= 55)	42
18 years old (N= 31)	36
Years in sport	
Less than 2 yrs (N= 17)	35
Between 2 & 4 yrs (N= 58)	33
Between 4 & 6 yrs (N= 85)	21
Between 6 & 8 yrs (N= 90)	26
Between 8 and 10 yrs (N= 73)	37
More than 10 yrs (N= 53)	32

* differences are significant between female and male athletes ($p < 0.01$).

There was a greater incidence of NFOR/ OT at the higher representative levels (p <

0.01), with national and international athletes showing higher rates of prevalence to club, county or regional athletes (*Figure 3.5*).

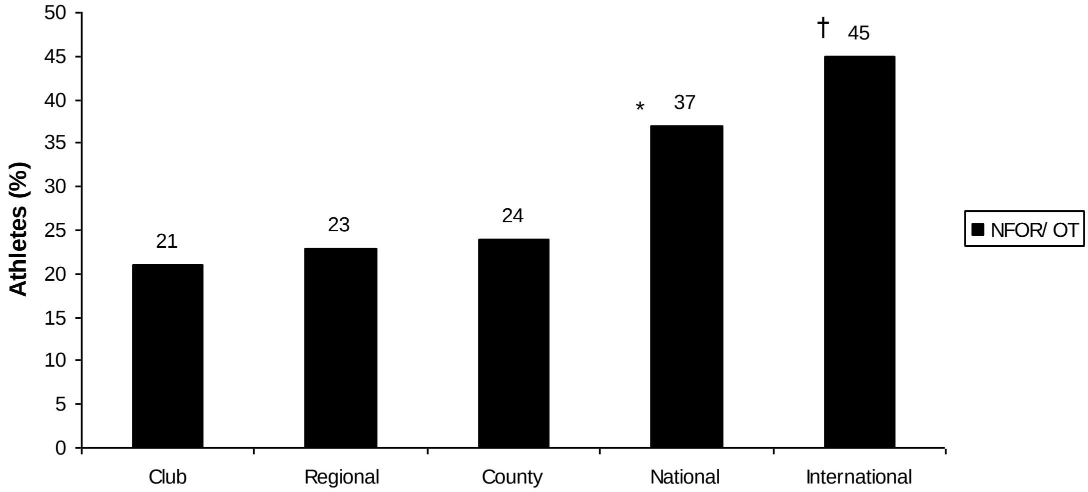

Figure 3.5 – Incidence of NFOR/ overtraining across all competitive levels (N=376). * significant differences between National level and the lower levels ($p < 0.01$); † significant differences between National and International level ($p < 0.01$).

3.3.3. Symptomology/ psychosocial issues reported by the NFOR/ overtrained athletes

The most frequently reported symptoms were loss of appetite during periods of hard training, injury occurrence, fatigue after competing, training feeling harder, high incidence of URTI's, frequently feeling that muscles heavy and stiff, and often having sleep problems (*Figure 3.6*).

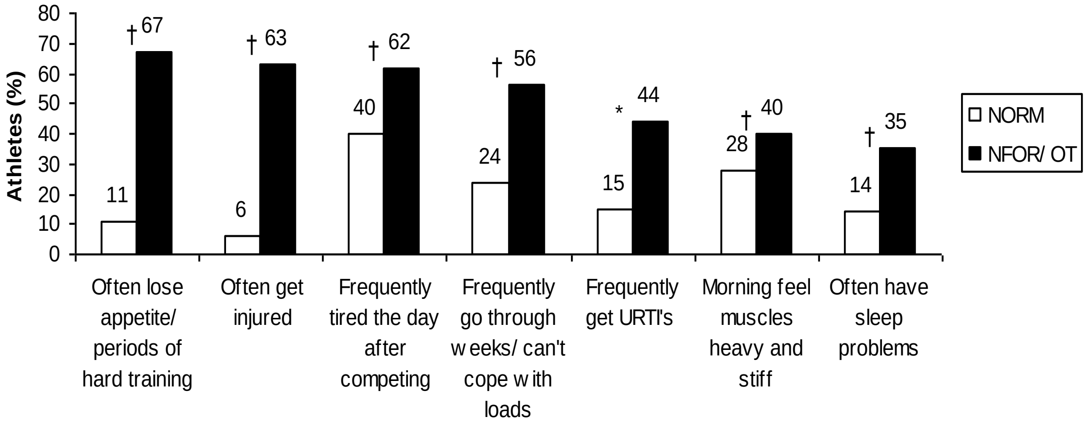

Figure 3.6 – Seven most reported physical symptoms between the NORM and NFOR/ overtrained groups

* significant difference between groups $p < 0.05$; † significant difference between groups $p < 0.01$.

The NFOR/ OT athletes complained of feeling more apathetic during periods of hard training, of feeling intimidated by the opponents, of feeling in a bad mood or sad and like crying during periods of hard training, of having a lack of confidence in their future as an athlete, lacking confidence when competing and lack of enjoyment for training (*Figure 3.7*).

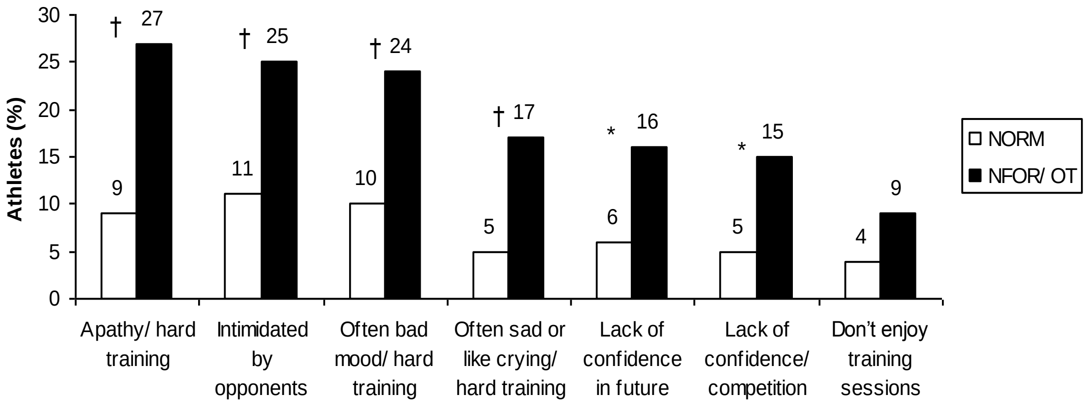

Figure 3.7 – Seven most reported psychological symptoms between the NORM and NFOR/ overtrained groups

* significant difference between groups $p < 0.05$; † significant difference between groups $p < 0.01$.

Both groups reported feeling bad when they did not perform according to their coach, parents and / or team-mates expectations; the percentage was always higher for the NFOR/ OT group, with parental expectations reaching statistical significance. Furthermore, a higher number of NFOR/ OT athletes reported their sport to be the most important thing in life, spending less than 5 hours in other activities and hobbies apart from their sport, and a lack of coping with school work and the tiredness derived from training (*Figure 3.8*).

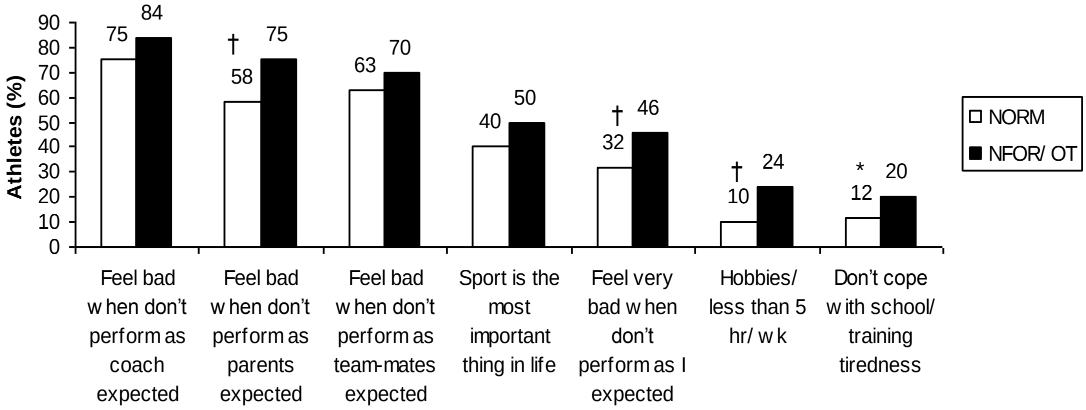

Figure 3.8 – Seven most reported psychosocial issues between the NORM and NFOR/ overtrained groups

* significant difference between groups $p < 0.05$; † significant difference between groups $p < 0.01$.

3.3.4. Symptomology of the NFOR/ OT athletes in relation to competitive level, gender and sport type

Feeling very tired after a competition and a normal training session was common in all groups (sport type, gender and competitive level) in the NFOR/ OT athletes, followed by an inability to cope with training loads during several weeks (*table 3.4*). Female athletes seemed to suffer more from sleep problems and losses of appetite compared to male athletes.

Table 3.4 – Five most reported physical symptoms by the different NFOR/ OT groups SNA - sub-national athletes; NIA- national and international athletes; * significant differences between groups $p < 0.05$.

Symptoms	Sport type		Sex		Competitive level	
	Individual Sports[1]	Team Sports	Females[2]	Males	SNA[3]	NIA
Tired after competition	√	√	√	√	√	√
Tired after session	√	√	√	√	√	√
Lack of recovery/ competition	√					
Muscles heavy and stiff/ morning				√		√*
Training harder than before				√		√
Weeks can't cope with intensity	√*		√	√	√	√
Not getting enough sleep		√			√	
Often sleep problems	√	√	√*			
Often get URTI's					√	
Tend to get URTI's/ hard training		√				
Often lose appetite/ competition			√*			

[1] – The amount of individual-sport athletes who were engaged in more than 2 hours of training per day ($p < 0.01$), and in 6 to 7 days of training per week ($p < 0.05$) was significantly higher than team-sport athletes;

[2] – No significant differences were found between females and males in relation to hours of training per day, days of training per week and years of training/ competing in sport;

[3] – The amount of NIA who were engaged in 6 to 7 days per week of training was significantly higher than SNA ($p < 0.01$).

The majority of psychological reported symptoms were common to all groups. The only significant difference reported was between gender in relation to feeling sad or like crying during periods of hard training (*table 3.5*).

Table 3.5 – Five most reported psychological symptoms by the different NFOR/ overtrained groups.

SNA – sub-national athletes; NIA – national and international athletes; * significant differences between groups $p < 0.05$.

Symptoms	Sport type		Sex		Competitive level	
	Individual Sports	Team Sports	Females	Males	SNA	NIA
Intimidated by opponents	√	√	√	√	√	√
Apathy during hard training	√	√	√	√	√	
Bad mood/ hard training	√	√	√	√	√	√
Sad or crying/ hard training	√	√		√*	√	√
Not confident in future	√	√	√	√	√	√
Don't enjoy training sessions			√			√

The one issue that was common to all groups (*table 3.6*) was that these athletes tend to feel very bad when they don't perform according to their expectations. Almost all groups (except individual sport athletes) reported that their sport was considered to be the most important thing in life. Feeling bad when not meeting parental and coach expectations was reported by all groups except individual and team sport athletes. In relation to team-mates expectations, team sport athletes reported a significantly higher incidence rate compared to individual sport athletes. Conversely, individual sport athletes reported to have significantly more problems in coping with school work and training schedule compared to team sport athletes. Female athletes had significantly higher reports that training was not exciting and fun.

Table 3.6 – Five most reported psychosocial issues by the different NFOR/ overtrained groups.

SNA – sub-national athletes; NIA – national and international athletes; * significant differences between groups $p < 0.05$.

Symptoms	Sport type		Sex		Competitive level	
	Individual Sports	Team Sports	Females	Males	SNA	NIA
Feel very bad with myself	√	√	√	√	√	√
Perception of parents' expectations	√	√	√	√		
Perception of coach's expectations	√	√	√	√		
Perception of team-mates expectations	√		√	√		√*
Pressure from father						√
Pressure from mother					√	
Sport most important thing in life	√	√	√		√	√
Training not exciting and fun				√*	√	√
Not coping with school/ schedule		√			√*	

3.3.5. Incidence of NFOR/ OT at the time of answering the survey

Of the athletes who reported being NFOR/ OT (N = 110), 32 % (N = 35) reported they were going through a NFOR/ OT episode at the time of answering the questionnaire. Comparing the current NFOR/ OT athlete with those who were NFOR/ OT in the past, no significant differences in the reported rates of symptoms were found, apart from the item "*not being motivated to train/ compete at the time*" which reached statistical significance (*Figure 3.9*; $p = 0.02$).

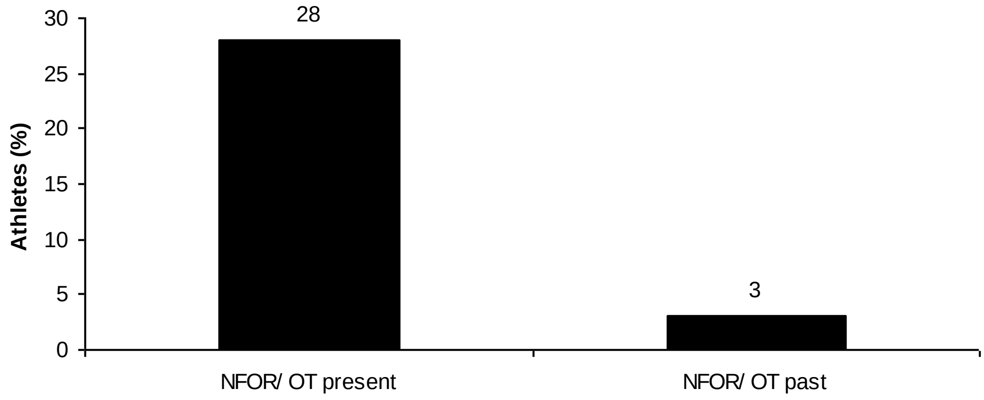

Figure 3.9 – Percentage of athletes who reported to lose their motivation to keep training/ competing during the NFOR/ overtraining episode they were experiencing at the time of answering the questionnaire.

* significant differences between both groups ($p < 0.05$).

The majority of NFOR/ OT athletes reported just one episode, with the most common duration being less than one month (*Figure 3.10*); the athletes had on average experienced NFOR/ OT on 2 occasions (SD = 1.1), with an average duration of 4 weeks (SD = 4.0).

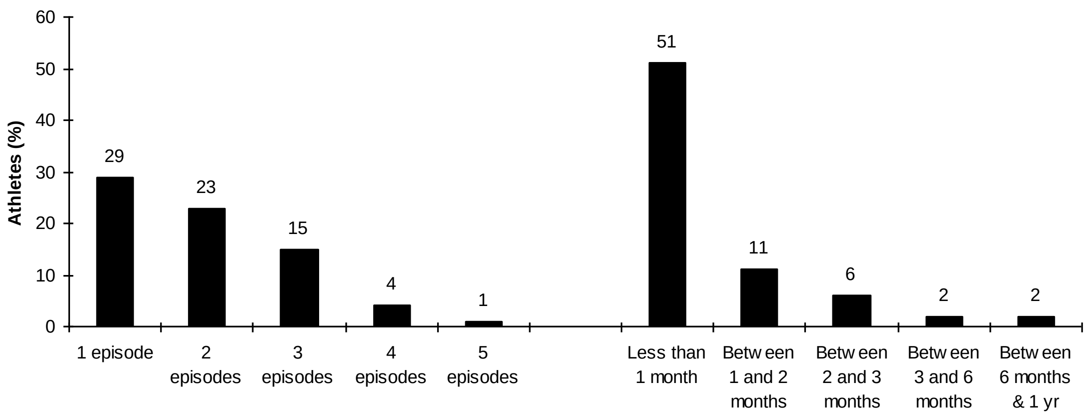

Figure 3.10 – Number of NFOR/ overtraining episodes and its duration.

In the NFOR/ OT group 62 % said they lost their motivation to continue training during the NFOR/ OT episode ($p = 0.01$); these athletes also reported a higher number of episodes as compared with the athletes who kept their motivation. The episodes of NFOR/ OT lasted longer in athletes who had decreased motivation to train, with 3 % reporting both, to have experienced NFOR/ OT between 3 and 6 months, and 6 months and 1 year; no one in the group that maintained motivation reported such long episodes (*Table 3.7*). Finally, both groups showed the same mean age (Motivation = 15.3 yr vs No motivation = 15.2 yr), and the same time of involvement in sport (1.6 years for both groups).

Table 3.7 - Characteristics of the frequency and duration of episodes of NFOR /OT related to whether motivation to keep training was present or not.

	With motivation (N=40)	**No motivation (N=70)**
Episodes		
1 episode	36 %	23 %
2 episodes	15 %	27 %
3 episodes	10 %	17 %
4 episodes	3 %	3 %
5 episodes	3 %	2 %
Duration		
Between 2 wk & 1 month	54 %	49 %
Between 1 and 2 months	10 %	12 %
Between 2 and 3 months	6 %	8 %
Between 3 and 6 months	--	3 %
Between 6 months & 1 yr	--	3 %

3.3.6. Logistic regression analysis

The two significant predictors of NFOR/ OT in these young athletes were competitive level and gender ($p < 0.05$). However, the overall explained variance was small for both gender and competitive level at 1.7 % and 4.7 %, respectively (*Table 3.8*).

Table 3.8 – Factors which predict NFOR/ OT.

	Model: NFOR/OT or NORM			
	OR 95% (CI)	*p*	Change -2 Log Likelihood	Nagelkerke R square
Age	0.45 (0.83 – 1.07)	*0.334*	0.93	---
Hours of training/ day	0.61 (0.32 – 1.51)	*0.436*	3.78	---
Years competing in sport	0.46 (0.32 - 1.48)	*0.248*	6.65	---
Days of training/ week	0.34 (0.35 – 1.78)	*0.868*	2.51	---
Gender *	0.75 (1.04 – 2.64)	*0.035*	4.43	0.017
Competitive level *	1.0 (0.63 – 3.33)	*0.000*	12.95	0.047

Odds Ratios (OR) & 95% Confidence Intervals were estimated using logistic regression. The *Log Likelihood* value refers to the amount of contribution the variable exerts on the model; the *Nagelkerke R squares* is the explained variance given by each variable to NFOR/ overtraining.

3.4. Discussion

3.4.1. Incidence rates

The purpose of this study was to determine the nature and prevalence of NFOR/ OT in young English athletes. The main finding from these data is that almost a third of young athletes (29 %) have experienced NFOR/ OT at least once during their sporting life. These data agree with 3 previously published surveys on young athletes (ages 15 to 20 years), where rates ranged from 31 % (Wilson, Raglin et al., 1999), to 35 % (Raglin, Sawamura et al., 2000b) and 37 % (Kentta, Hassmen et al., 2001). Furthermore, our data also compares closely to the adult data by Morgan et al., (1987) who found 33 % incidence of overtraining for non-elite women distance runners.

It is difficult to directly compare incidence rates from surveys because of differences in the definitions used to categorise athletes as overreached/ overtrained or not. The definition used in this survey was slightly more conservative because it was added *"and you felt extremely tired everyday even though you kept training"*. This is because an athlete who reports to be overtrained complains of feeling chronically fatigued (Fry et al., 1998; Kentta and Hassmén, 1998). On the other hand, unlike Kentta and co-workers (2001) survey, the expression *"and that without doubt was caused by too much physical training (i.e. not by illness or injury)"* was not used. Overtraining is a multidimensional phenomenon with both training and non-training stressors as potential causes (Fry, Morton et al., 1991; Kentta and Hassmen, 1998; Kentta, Hassmen et al., 2001; Meehan, Bull et al., 2004; Matos and Winsley, 2007), thus to try to reduce NFOR/ OT to a problem that is based purely on an excess of physical training is too constraining and misses the point. For example, it is known that NFOR/ OT is also present in low-physically demanding sports like golf (Kentta, Hassmen et al., 2001).

There were no significant differences between the NFOR/ OT group and the NORM group in relation to hours of training per day, days of training/ competing per week and years of competing in sport, suggesting that training load and years of involvement in sport are not necessarily the “causes” of NFOR/ OT as they are often believed to be. Supporting the latter, Raglin’s et al., (2000) survey also found no differences in relation to years in sport between the overtrained and the not overtrained group.

3.4.1.1. Incidence rates in Individual vs Team sport-athletes

It has previously been argued that OT is more common in individual sports because of the higher daily training hours, resulting in greater time and physical demands on the athlete (Coakley, 1992; Kentta et al., 2001). In our survey, the rate of overtraining differed significantly across type of sport, with individual sports (37 %) showing the higher incidence compared with team sports (17 %). Corroborating these findings, the work by Kentta and colleagues (2001) showed a higher incidence across individual sports (48 %) or team sports (30 %). Another study with Olympic athletes all practicing individual sports found an incidence rate of 46 % (Kentta and Hassmen, 1999).

It seems that individual sports tend to present a higher incidence compared with team sports. The amount of individual sport athletes who were engaged in more than 2 hours of training per day, and in 6 to 7 days of practice per week was significantly higher compared to the NFOR/ OT team-sport athletes. The latter could help explain why individual-sport athletes complained significantly more of a lack of coping with previous training loads, and of not recovering quickly enough after competition than team-sport athletes. Furthermore, individual-sport athletes also complained of not coping with the work from school and their training schedule. The survey by Kentta and colleagues (2001) also found that individual-sport athletes had more daily peak training hours than athletes in team sports. Moreover, it is not surprising that such a difference was found when the majority of athletes practicing individual sports were involved in high-endurance sports like swimming, cycling and athletics. Given that these athletes are involved in higher training loads/ schedules, it stands to reason that this could be a strong factor for the development of NFOR/ OT in individual sports.

Team mates' pressure is higher for team sport-athletes compared to individual sport-athletes. Generally, in team sports, team success will depend greatly on player cooperation and the effective meshing of the different abilities and temperaments of team members during competition. In individual sports however, team success is dependent on the summed outcome of independent individual performances (Edwards, Wetzel et al., 2006). As such, when success affects a team in an individual sport the dynamics that take place are naturally distinct compared to team sports where athletes' mood is contagious (Ryan, Falsetti et al., 1983). Due to the higher player cooperation and responsibility in dealing with effective communication happening in team sports (Edwards, Wetzel et al., 2006), it is possible that this stress could be a factor that has a stronger influence on the development of NFOR/ OT in team sports compared with individual sports. Thus overall it seems that training load may play a greater role in the development of NFOR/ OT for individual sport athletes compared to team sport athletes.

3.4.1.2. Incidence rates in Low-physically vs High-physically demanding sports

A significant and higher incidence of NFOR/ OT in low-physically demanding sports (35 %), although there were only 54 athletes (14 % of the sample) constituting the low-physically demanding sports group and 54 % were competing at national and international level. Importantly, it also seems that in sports that have a low demand in the amount of physical training load required, NFOR/ OT can be present and that other factors, such as psychosocial stressors (Coakley, 1992; Kentta and Hassmen, 1998; Kreider, Fry et al., 1998; Kentta, Hassmen et al., 2006) can play a significant influence on its development. In agreement with the results of this survey, Cohn (1990) and Kentta et al., (2001) also found overtraining present in young golfers. Sports like golf, eventing, or cricket involve many hours of training at an elite level that can result in substantial mental stress and psychological fatigue (Kentta, Hassmen et al., 2001). Since more than half of the athletes practising these sports were competing at either, national or international level it was expected that the incidence would be significantly higher in these types of sports. As such, high skill training, the amount of training hours, the number and frequency of competitions and the travel associated with elite level competition, together with psychosocial stressors could help explain why NFOR/ OT can occur in sports where training load is not a main issue. This is in agreement with Coakley (1992) who claimed that overtraining/ burnout has its causes embedded in the social organization of sport. This refers to the influence an exterior social structures, such as coaches, parents, financial rewards for example, can have on athletes causing them stress and anxiety (Wilber, 1997).

3.4.1.3. Incidence rates in Females vs Male athletes

Female incidence rates (36 %) were significantly higher compared to male athletes (26 %). Conversely, Morgan and colleagues (1987) found a higher incidence of overtraining in elite adult distance male (64 %) runners compared with females (60 %). Another study with 79 elite Swedish athletes (Kentta and Hassmen, 1999), also found the incidence of overtraining to be higher in males compared to females (57 % vs 30 %, respectively). Despite having found a similar trend in males compared to females, in the 2 young athletes surveys (Raglin, Sawamura et al., 2000b; Kentta, Hassmen et al., 2001), the rates for females were very similar to our results; Raglin's et al., (2000) survey found an incidence of 30 %, and Kentta's et al., (2001) found 35 %. The difference in the incidence rates between this survey and the other studies could be due to the different characteristics of the population that is being compared, since the athletes that participated in this survey come from all competitive levels, whereas all the other studies used elite athletes. Also, the fact that young athletes are being compared with adult data (Morgan, Brown et al., 1987a; Kentta and Hassmen, 1999) could influence the differences found in the incidence between males and females.

In terms of the amount of training load and years of competing in the sport no significant differences were found, which, once more, suggests that other factors apart from training load could be involved on the development of overtraining. However, female athletes reported significant differences from their male counterparts in relation to: sleeping problems, losses of appetite during important competitions, feeling frequently sad or like crying during periods of hard training, and to training not being exciting and fun. In general, there is the suggestion that female athletes may struggle more with sleep and appetite-related problems, be more depressed and have different expectations in relation to how the enjoyment for training is perceived (Ryan, Falsetti et al., 1983). The losses of appetite seen in female athletes may result in a reduced replenishment of glycogen, reduced calcium levels in the blood which, consequently, may affect the amount of occurrence of injuries; ballet dancers regularly complain of stress fractures developed from being in a state of chronic starvation (Ryan, Falsetti et al., 1983).

Even though the majority of the data has suggested that the incidence of overtraining is higher in males (Morgan, Brown et al., 1987a; Kentta and Hassmen, 1999; Raglin, Sawamura et al., 2000b; Kentta, Hassmen et al., 2001), it has been suggested elsewhere (Ryan, Falsetti et al., 1983; Parker, 1989; Uusitalo, 2001) that females are actually more vulnerable. Furthermore, research has shown that female athletes tend to report higher menstrual dysfunction and stress fractures (Ryan, Falsetti et al., 1983; Torstveit and Sundgot-Borgen, 2005), and worse symptoms of overtraining compared to males since they are often exacerbated by episodes of amenorrhea and/ or loss of menstruation (Birch and George, 1999; Torstveit and Sundgot-Borgen, 2005). The cultural values that view sport as a masculine realm can reinforce certain negative attributes that are often accepted as “masculine behaviour” (Lenskyj, 1986; Parker, 1989). Furthermore, feminist critiques of sport have condemned the high value placed on the Male type ethos of objectifying and alienating one’s body by excessive training, ignoring pain and injury (Messner, 1990; Duquin, 1994). This is thought to cause tension in the female athlete through the implicit pressure to conform, causing stress that may be related to OT.

3.4.1.4. Incidence rates in Sub-national vs National and International athletes

One of the advantages of our study was that it sampled young athletes at all competitive levels rather than just the elite youth athletes. The results showed that the incidence rate of NFOR/ OT was increased in national and international athletes, but that a significant minority of sub-national young athletes had also experienced NFOR/ OT. When comparing the national and international-level incidence (37 % and 45 %, respectively), these rates agree with the works by Raglin et al., (2000) (incidence of 37 %), Kentta et al., (2001) (incidence of 35 %), and Kentta and Hassmen (1999) (47 % incidence rate), who all used elite athletes in their investigations. Psychosocial pressures (Hollander and

Meyers, 1995; Kreider, Fry et al., 1998) exert a greater influence in the development of NFOR/ OT at the national and international level. Athletes will have other types of offers and prizes (that may or not be financial), eventual sponsors' contracts and media attention, and more travelling for different competitions (Ryan, Falsetti et al., 1983; Richardson, Anderson et al., 2008) that are absent from the lower competitive-levels.

Importantly NFOR and overtraining are evident at the lower competitive levels and is not just exclusively found at elite levels as is often believed. Unfortunately, the majority of research on overtraining has focused on working with elite athletes (Kuipers and Keizer, 1988; Morgan, O'Connor et al., 1988; Verma, Makindroo et al., 1992; Raglin, 1993; Hedelin, Kentta et al., 2000a; Hedelin, Wiklund et al., 2000b; Raglin, Sawamura et al., 2000; Kentta, Hassmen et al., 2001; Kentta, Hassmen et al., 2006; Gustafsson, Kentta et al., 2007; Mountjoy, Armstrong et al., 2008; Nederhoff, Zwerver et al., 2008), and have thus left unstudied athletes at the lower competitive levels.

The only available study that has compared elite athletes with non-elite is the one by Morgan and colleagues (1987) who observed that female elite distance runners are nearly twice as likely to become overtrained (60 %) compared with non-elite female athletes (33 %). Unfortunately, it is hard to determine what "elite level" in the previous study and the other surveys entails, as it could mean that only international-level athletes are being studied, or that both levels (national and international) are included. Nonetheless, modest levels of training intensity and frequency related with competing at club, county and regional level, coupled with other psychosocial stressors are very likely to act as catalysers for the development of NFOR/ OT.

There were almost no differences reported between the SNA and NIA (NFOR/ OT group) in relation to the physical and psychological symptoms. However, the NIA complained of frequently waking up in the morning with their muscles feeling heavy and stiff, and of engaging significantly more in 6 to 7 days of training per week compared to SNA; training load in the NIA could be a stronger factor compared to its influence in sub-national levels. Furthermore, NIA also reported to struggle more with coping with school demands and training schedules. It makes sense that NIA are more involved in more physical training than SNA, and therefore, these athletes have to cope with higher training loads and higher competitive pressures, which could contribute to the development of NFOR/ OT in NIA. However, young athletes playing sport at the lower representative standards are also reporting external pressure from school work, relationship stresses, pressure from parents and/ or coaches, for which in the individual young athlete, may conspire to bring about a NFOR/ OT state. This underlines that NFOR/ OT is as much an issue for the school teacher or the local club coach to consider as for those involved with high level young performers; something that is often overlooked in the education and advice that adults receive prior to their involvement.

The incidence of NFOR/ OT at the sub-national level is surprisingly high making this an important problem to be studied. Our data therefore challenges the common belief that overtraining is an issue only seen in elite athletes, as approximately 20 % of young athletes who play at local to regional level may also experience the condition at some point in their careers.

3.4.1.5. Incidence of NFOR/ overtraining at the time of answering the questionnaire

Of the NFOR/ OT athletes 12 % reported to be experiencing an NFOR/ OT episode at the time of answering the survey. Further analysis revealed that there were no differences in the physical and psychological symptomology, and the psychosocial issues present in the athletes who experienced NFOR/ OT in the past with the ones that were experiencing it at the time. This reinforces the validity of the data and strengthens the confidence in young athletes in accurately recalling negative past experiences and overtraining episodes. Some research is available that shows that athletes can be accurate when asked to recall both mood states and anxiety levels (Raglin and Hanin, 2000a), or other significant events (Yow, 1994). The only important difference was that these athletes were not motivated to train and/ or compete at the time. This makes sense since they are undergoing a difficult phase in their training, and a lack of motivation during overtraining has been widely reported as a common symptom (Hollander and Meyers, 1995; Kentta, Hassmen et al., 2001; Meehan, Bull et al., 2004).

3.4.2. Number of episodes, duration and motivational issues with the NFOR/ OT athletes

The athletes typically went through 2 episodes of NFOR/ OT, with the majority lasting 4 weeks. The results are in agreement with Wilson et al. (1999) who found an average duration of 3 weeks, or Kentta's et al. (2000) who found an average of 2 episodes, although of higher duration (7 weeks). A minority of the athletes in the survey had experienced NFOR/ OT on multiple occasions; 4 % reported to have experienced 4 episodes and 1 athlete 5 episodes, likewise around 4 % reported the episodes to have lasted 3 months and more.

Sixty-two percent of the NFOR/ OT sample lost the motivation to keep training during the NFOR/ OT episode, which is greater than the 45 % reported by Wilson et al. (1999), or the 41 % reported in 2 other adolescent surveys (Raglin, Sawamura et al., 2000b; Kentta, Hassmen et al., 2001). Because they were not asked if they were deciding to quit their sport (Raglin, Sawamura et al., 2000b; Kentta, Hassmen et al., 2001; Gustafsson, Kentta et al., 2007), we have avoided making claims about burnout incidence in these athletes. Raglin (1993) suggests that the motivation to continue training during an overtraining episode is an essential factor to differentiate between the seriousness of the overtraining episode as the athlete may be very close to dropout from the sport. Still, it is important to be aware that the loss of motivation by overtrained athletes may not be sufficient enough to lead them to drop their sport; i.e. motivation to keep training may still remain high during the overtraining episode (Kentta, Hassmen et al., 2001). Experience suggests that the number of episodes of overtraining is an important factor in predicting quitting from the sport (Kentta, Hassmen et al., 2001). The overtraining process seems involve a number of repeating and worsening episodes until the athlete eventually decides to drop-out from the sport. The survey shows that the athletes who reported a loss in motivation during the NFOR/ OT episode had a higher number of episodes that had lasted for longer, but were the same age and had a similar number of years of being involved in the sport. The loss of motivation is thought to arise because athletes start to feel mentally and physically exhausted, moody and with low confidence. Athletes feel that they are not contributing anymore to the team/ club, feeling under-valued and isolated, resulting in a lack of control over their lives (Coakley, 1992).

3.4.3. Physical symptoms

Many of the symptoms that had been previously described in other adolescent surveys (Wilson, Raglin et al., 1999; Raglin, Sawamura et al., 2000b; Kentta, Hassmen et al.,

2001) were also present in young English athletes. These were: frequent losses of appetite during periods of hard training and/ or competition, increase in perceived effort of training, feelings of muscle heaviness, and frequent sleep problems. Furthermore, the same symptoms have also been reported elsewhere (Parker, 1989; Derman, Schwellnus et al., 1997; Kentta and Hassmen, 1998; Halson and Jones, 2002; Kellman, 2002; Richardson, Anderson et al., 2008). Other symptoms which have not been reported in young athletes but have reported in adults (Kuipers and Keizer, 1988; Parker, 1989; Fry, Morton et al., 1991; Lehmann, Foster et al., 1993; Raglin, 1993; Hollander and Meyers, 1995; Derman, Schwellnus et al., 1997; Kreider, Fry et al., 1998; Uusitalo, 2001; Armstrong and VanHeest, 2002; Kentta and Hassmen, 2002) were: frequent occurrence of injuries, frequently feeling tired the day after competing, and frequently complaining of URTI's. Clearly these symptoms would be worth monitoring by coaches during the training season.

The high number of URTI's found in young athletes NFOR/ OT athletes, confirms the evidence available in the literature which points to a depressed immune function during overtrained states (Fry, Morton et al., 1991; Mackinnon and Hooper, 1994; Kentta and Hassmen, 1998; Nieman, 1998; Gleeson, McDonald et al., 1999; Gleeson and Pyne, 2000; Armstrong and VanHeest, 2002; Lac and Maso, 2004; Ring, Carroll et al., 2005; Meeusen, Duclos et al., 2006). The reason to why symptoms of URTI's have not been reported on the two other surveys (Raglin, Sawamura et al., 2000b; Kentta, Hassmen et al., 2001) is simply because they were not assessed.

The mechanisms by which overtraining depresses the immune system have been explained in chapter 2 and discussed in chapters 4 and 5.

3.4.4. Psychological symptoms

Apart from the already reported physical symptoms it was also observed that the NFOR/ OT group reported changes in psychological symptoms, regarding mood states during training and competition. The athletes reported feeling extremely apathetic during periods of hard training, often in bad moods and feeling sad or like crying during periods of hard training. These results are in agreement with the surveys on young athletes by Raglin et al. (2000) and Kentta et al. (2001) who found that overtrained athletes exhibited greater mood disturbances compared with healthy individuals. Furthermore, research into overtraining has shown that mood changes during periods of intensified training are greater in athletes who exhibit NFOR/ OT (Raglin, 1990; Morgan, 1987; Morgan, 1988b; Raglin, 1996). In addition, overtraining has been compared to clinical depression (Armstrong, 2002; Morgan, 1988b; Halson, 2002; Kentta, 2001; Derman, 1997), and it is possible that within the NFOR/ OT group there could be athletes that have developed this state.

In relation to athletes' mood states during periods of hard training, it has previously been found that a dose-response relationship exists between training and mood disturbance (Morgan, Brown et al., 1987a; Raglin, Koceja et al., 1996). From their series of studies, Morgan et al. (1987) concluded that, generally, as training loads increase, scores on the negative POMS subscales tend to increase, whereas scores on vigour tend to decrease. Also, Raglin et al. (1996) found that total mood disturbance was correlated with mean swimming power ($r = -0.34$, $p < 0.05$). However, it has also been recognized that a considerable amount of variability is present in athletes who experience similar training loads. In that sense, some individuals appear somehow resistant to the psychological modulatory effects of increased loads, whereas others are more sensitive, and therefore at a particular risk of developing NFOR/ OT (Raglin, 1993). What tends to occur when athletes become NFOR/ OT is that they show a greater magnitude of mood disturbances in comparison with healthy athletes undergoing the same training (Morgan, Brown et al., 1987a; O'Connor, Morgan et al., 1989; Raglin, Morgan et al., 1990). When a reduction in training occurs, the negative psychological effects of increased training load tend to be reversed, but in the case of athletes who are NFOR/ OT these mood disturbances are only partially abated (Raglin, 1993). The interpretation of the data make sense in light of these results, since our NFOR/ OT athletes reported to frequently experience feeling moody, sad or like crying during periods of increased training load.

Furthermore, the NFOR/ OT group complained of feeling intimidated by their opponents under competitive environments, a lack of confidence in their future as athletes, a lack of confidence during competition, and a lack of enjoyment for training sessions. It is known that excessive signs of anxiety and emotional stress are symptoms that have been associated with mood changes (Halson and Jones, 2002) and the development of overtraining (Kindermann, 1986), thus a similar aetiology appears to be showing itself in young athletes.

The NORM group reported significantly more enjoyment for the training sessions compared to the NFOR/ OT group. The reverse therefore implies that the NFOR/ OT group is not enjoying their training, which is a factor that has been identified as influencing the development of overtraining. According to social exchange theory an individual who enjoys an activity is more likely to continue doing it, whereas when there is no enjoyment an individual typically chooses to leave (Schmidt and Stein, 1991). Nevertheless, some athletes accept the nature of their sport, even though they recognize that they are missing out opportunities to socialize and to have fun (Wrisberg and Johnson, 2002), something which is tied to a strong unidimensional identity (Coakley, 1992). Also, lack of enjoyment for training could be related to training monotony. This issue has been acknowledged as a possible factor for the development of overtraining (Kuipers and Keizer, 1988; Hollander and Meyers, 1995; Armstrong and VanHeest, 2002).

The work by Morgan and colleagues has recently been challenged by Richardson et al. (2008) who essentially claimed that because mood states were not directly linked to performance they are of little value to a coach or athlete. Furthermore, the studies were based on group analysis, which “obscures what is happening at the individual level” (Richardson, Anderson et al., 2008). Corroborating the previous results are the studies by Martin et al. (2000) and Murphy et al. (1990) who observed no relationship between increments in training volume and concomitant worsening of the athletes’ mood states assessed by the POMS (Murphy, Fleck et al., 1990; Martin, Anderson et al., 2000). However, care must be taken when interpreting these two last studies because both looked at a small sample of athletes, had a small increase in load, and the studies had a maximum duration of 9 weeks, which can bias the external validity of the data.

These data suggest that in agreement with previous research (Morgan, Brown et al., 1987a; O'Connor, Morgan et al., 1989; Raglin, Morgan et al., 1990; Raglin, Koceja et al., 1996; Raglin, Sawamura et al., 2000b; Kentta, Hassmen et al., 2001) that athletes who are prone to develop NFOR/ OT, will report significantly higher mood disturbances during periods of hard training compared to healthy athletes, but interindividual differences in this response will exist (Martin, Anderson et al., 2000).

3.4.5. Psychosocial factors

Psychosocial factors were also seen as important issues that can disturb athletes' lives and cause added stress. This relates to the way these athletes perceive success seen through coach, parents, team-mates and/ or their own eyes. Interestingly, only perception of parental and self pressure reached significance, with both groups reporting high levels of coach, parents and team-mates pressure. Considering sport as the most important thing in life, a lack of interest for other things in life apart from the sport, and a struggle to cope with school work and training tiredness were also reported.

The data indicates that athletes may put a lot of pressure on themselves in case they do not perform according to their parents' or their own expectations; furthermore many young athletes add the expectations of the coach and team-mates to their burden. This issue is somehow surprising but understandable because athletes are dedicating an enormous part of their life to the sport and want to be successful in it. However, the risk of overtraining increases when athletes feel pressure from the expectations (Kuipers and Keizer, 1988; Uusitalo, 2001; Armstrong and VanHeest, 2002; Richardson, Anderson et al., 2008) and pressures (Brenner, 2007) around them; the case of athletes is that they may be highly externally motivated, i.e. people's behaviour is controlled by specific external contingencies, such as tangible rewards or to avoid punishment in whatever form (Deci and Ryan, 2000). However, note that the expectations that athletes create in themselves are highly influenced by the significant others in their lives and therefore (Deci and Ryan, 2000), the self expectations do not differ much from the expectations of their parents or coach. Furthermore, Gould et al. (1993) have stated that it is a lot easier when athletes do not have high expectations, as “people just don’t notice you” (p. 47). However, when athletes are surrounded by high expectations from others, if they do not meet them, they are very likely to be condemned, which in turn acts as a stress factor (Gould, Jackson et al., 1993). This could help explain why the negative feelings reported by the NFOR/ OR group surrounding lack of performance may help contribute to their state.

All athletes reported similar pressure from both parents - father (NFOR/ OT = 24 % vs NOR = 23 %), or mother’s pressures (NFOR/ OT = 24 % vs NORM = 15 %), but only pressures coming from the mother reached significance. A distinction is seen in the NFOR/ OT group where these athletes are more likely to have pressures coming from both parties and not just one side. It has been shown that mothers support their young athletes in sport differently from fathers and generally adopt a nurturing and organizational role, whereas fathers adopt a more hands-on, playful approach to parenting (Parke, 1995; Kimiecik and Horn, 1998). Clearly in the NFOR/ OT athletes, the mother’s additional pressure may conspire to negatively affect the young athletes.

When parents or even the coach put a lot of pressure in the athlete and try to gain control over their lives the social world of the young athletes becomes organized in such a way that will leave the athlete powerless to control events. Consequently, the decisions about the nature of their experiences in sport and the direction of their own development end up being controlled by others (Coakley, 1992). The necessity to increase the awareness of youth sport coaches about this issue has been stressed elsewhere (Hollander and Meyers, 1995). Parents can unduly pressurize their young athletes by overemphasizing winning, holding unrealistic expectations, criticizing them and pushing them to play. All of these factors reiterate the need for parents to be educated about their critical role in their sons' sporting development (Gould, Lauer et al., 2006).

Apart from coaches, parents can also encourage their sons to train more, even at excessive levels, either intentionally or indirectly. Parents can use different "strategies" to pressurize their sons, one of them being a strong work ethic that places too much importance on working hard. Within the context of reinforcement, parents can also use *the more-the-better* philosophy, by praising hard training, which in turn makes athletes believe that by dedicating and showing great amounts of effort in training and competition will bring more acceptance, recognition and, in the end, parental love (Richardson, Anderson et al., 2008). Finally, parents who see their own success through their son's success (often as a compensation for their own lack of success), may use guilt to motivate and manipulate them (Coakley, 1992), which can be extremely detrimental for the young athlete. The latter issue reduces the amount of power/ control an athlete has over her/ his sport performance, leaving them powerless and helpless over the decisions they can make. Consequently, this may lead to a lack of internal motivation and thus greater potential for overtraining or burnout (Garnezy and Rutter, 1983; Johnson, 1986; Compas, 1987; Cohen, 1988). Since social support is known to be important in personal adjustment (Sarason, Sarason et al., 1989), an athlete with poor social support may be more vulnerable to an unhealthy development through sport, and is more likely to develop overtraining or burnout (Ryan, Falsetti et al., 1983; Feigley, 1984; Kentta and Hassmen, 1998). On the contrary, athletes with both high social support and coping skills are more able to reduce stress and have reduced potential for injury (Smith, Smoll et al., 1990).

Another issue that was reported by the NFOR/ OT group was the fact that sport is considered to be the most important thing in life and that the amount of time that these individuals are dedicating to other activities outside their sport is very limited, suggesting the development of a unidimensional identity (Coakley, 1992). Comparable results were found in Swedish competitive athletes where the incidence of burnout was strongly linked to the development of a unidimensional identity (Kentta and Hassmen, 1999). Furthermore, on the survey conducted by Kentta and colleagues (2001) it was found that 20 % of their overtrained athletes devoted less than 5 hours a week to activities outside their sport, and around 40 % had nothing else to do apart from their sport. Many times, coaches appreciate the quiet hard-working and perfectionist athletes as they seem to be ideal to train. However, if their perspective becomes limited by concentrating on their sport too intensely, especially at a young age, the chances to overtrain or burnout increase drastically (Parker, 1989).

Identities are claimed and constructed through social relationships developed throughout life (Thoits, 1983; Streiker and Serpe, 1992), so if some of these athletes consider their sport as the most important thing in life, and have very few interests in life apart from their main sport, they are very likely to develop a single identity (Coakley, 1992). Athletes become involved in social experiences that may promote the development of a single identity exclusively related to their sport participation. These data lead to the suggestion that these athletes find themselves in situations where it becomes very hard to make commitments to other activities, roles or identities. When identities in athletes become so constricted all their lives are only identifiable through sport (Coakley, 1992), and if this same sport becomes “threatened” by poor performance or overtraining, so does their identities. As such, athletes live surrounded by pressures that continuously add to the stress coming from training and competition which all influence the development of overtraining. Furthermore, it is likely that some athletes stay in their sport despite their great negative experiences and low motivation, essentially because of their unidimensional identity and lack of alternative options in life, a scenario sometimes referred as entrapment (Schmidt and Stein, 1991; Raedecke, 1997).

The NFOR/ OT group reported a lack of ability to cope between the demands from school and/ or work, and the tiredness derived from training, which has previously been reported as a contributing factor to the development of overtraining (Kuipers and Keizer, 1988; Armstrong and VanHeest, 2002; Richardson, Anderson et al., 2008). It stands that because young athletes are normally under normal education (school or university) the demands from their training schedule can affect the production of course-work or the studying for exams. In some cases, teachers who are unsympathetic to the demands of athletic participation may even use punishment as a strategy to improve the athletes’ grades or performance (Wrisberg and Johnson, 2002). On the other hand, the tiredness from work may also exert the same effect on an individual and consequently affect his/ her training; i.e. being promoted and engaging in higher-responsible activities can influence the development of overtraining (Meehan, Bull et al., 2004).

It is therefore suggested that athletes should develop self-awareness (Hollander and Meyers, 1995; Kentta and Hassmen, 1998), along with coaches and parents so that their problems can be addressed and solved and they are left better psychologically and physically prepared for engaging in training and competition.

3.4.6. Training load Vs non-training stressors

From the previously discussed issues that involved individual and team sports, low and high-physically demanding sports, gender, competitive level, age and years of practice and competing in sport there is a strong indication that training load may not necessarily be the main or unique factor for the development of NFOR/ OT. These claims are further supported by the logistic regression where it was clear that within the variables selected, only competitive level and gender reached significance. These results imply that factors apart from training load are exerting an influence for NFOR/ OT development. This is also supported by recent studies that have been suggesting that non-training stressors are strong contributing factors for the development of NFOR/ OT (Kentta and Hassmen, 1998; Raglin, Sawamura et al., 2000b; Kentta, Hassmen et al., 2001; Meehan, Bull et al., 2004; Richardson, Anderson et al., 2008).

Non-functional overreaching and overtraining are complex problems that can have physical, psychological, cultural and sociological factors (Wilber, 1997) contributing to its development. These data suggest that it would be wrong to say that training load is not a factor in the development of NFOR/ OT, indeed for some athletes it may be a strong reason behind the problem, but equally it would be incorrect to think that training load is the *only* factor that causes this condition and that an appreciation of the multifactorial nature of the problem helps to guide how the condition is diagnosed and treated.

A potential limitation to this study is that it is a self-administered survey, a subjective measure that is prone to participant bias and poor memory recall. However, not only are these types of research instruments very common in medical practices but also they can yield important information, so as long as questions are clear and respondents have the resources to answer (Greenwald and Hart, 1986), which we assessed through a pilot study. We sought to reduce the effect of poor memory recall by requesting information about past as well as current prevalence of NFOR/ OT. To this end, athletes who experienced NFOR/ OT in the past showed similar issues as athletes who were undergoing a state of NFOR/ OT at the time of answering the questionnaire. Finally, the results of this survey do mirror that of previously published work (Kentta et al., 2001; Raglin et al., 2000), giving confidence to the validity of the findings.

3.5. Conclusions

In conclusion, this study assessed the current state of NFOR/ OT in young English athletes. In using a perspective that examined athletes' physical, psychological and cultural issues, a more complete and broader understanding of the problem was achieved. Approximately 29% of young English athletes had experienced NFOR/OT in their past at least once, with elite performers and those in individual sports most at risk. The symptomology of NFOR/OT in children reflects closely that seen in adults but varies widely between individuals. Importantly, both training and non-training stressors are reported as significant elements in the profile of the NFOR /OT child and that this is not just an issue of excessive training load. NFOR and OT is a serious issue for young athletes and coaches, parents, medics and athletes, who are therefore advised to view the problem as multifactorial and multidimensional. This deeper understanding is essential to develop new and effective strategies to protect athletes from experiencing the negative consequences of NFOR/OT during their sporting careers.

CHAPTER IV

Physiological and psychological responses of overtrained national-level swimmers during an 11-month competitive season

4.1. Introduction

The aim of training is to provide successive stressors that will temporarily displace the homeostasis of the athlete but ultimately facilitate beneficial adaption's resulting in enhanced physical fitness (Bompa, 1999; Smith & Norris, 2002). As the athlete progressively adapts to the training stimuli, higher training loads must be applied at the appropriate time and intensity for the athlete to improve performance. However, a nonlinear relationship exists between the amount of training and the training effect, and high training loads that will induce excessive fatigue may lead to performance incompetence (Smith & Norris, 2002) and a state of mal-adaptation known as NFOR or OT (Meeusen et al., 2006). As such, the challenge that coaches are faced with when prescribing training is that no two athletes react the same way to the same training stimuli, factors such as genetics, training history, psychosocial background, health status and tolerance to both physical and psychological stress in the sport and life in general, all influence the athlete's response to a given training load, and therefore should be taken into account.

Although the goal is to have prospective diagnosis of NFOR/ OT, attempts to obtain valid and reliable diagnostic tools have so far failed (Hooper, Mackinnon et al., 1995b; Rowbottom, Keast et al., 1998; Steinacker and Lehmann, 2002). Studies which have focused on diagnostic markers have generally been retrospective and cross-sectional.

Thus there remains the need for work that prospectively monitors, over an extended period of time, changes in physiological and psychological parameters in athletes who then become NFOR or OT. This type of longitudinal research in young swimmers' is scarce. Furthermore, there is very little information on the relationship between training load and the responses of different biochemical and psychological parameters in mal-adapted young swimmers (i.e. swimmers developing NFOR and/ or OT). The majority of the studies that have tried to investigate the effects of chronic (over) training in adult athletes have focused on immunological (Tharp and Barnes, 1990; Bury, Marechal et al., 1998; Gabriel, Urhausen et al., 1998; Gleeson, McDonald et al., 1999; Fahlman and Engels, 2005) or hormonal parameters (Kraemer, French et al., 2004). One of the few studies that attempted to gather physiological and psychological parameters in combination unfortunately only defined the athletes as OT state, simply based on a significant increment in training load (Urhausen, Gabriel, Weiler, & Kindermann, 1998b), when many of them were probably simply experiencing a state of FOR (Meeusen et al., 2006). To complicate things further, some of these adult studies (Bury, Marechal et al., 1998; Urhausen, Gabriel et al., 1998b; Fahlman and Engels, 2005) have also not appropriately monitored changes in training load, leaving the understanding between how excessive training load changes affect the immune system, hormonal system and an athlete's mood state unclear.

From the previous study it was noted that OT is happening in young athletes, with the reported symptomology being similar to that seen in adults. However, because the previous investigation comes from retrospective self-report measures, it is important to follow swimmers during a competitive season and directly assess their responses to training load in order to compare athletes who develop OT and those who remain healthy. Further, since training needs to be individualized and athletes' responses studied from this individual perspective (Kellman, 2002; Norris, 2002), it is important to provide more data that clearly highlights this perspective, and provides new and innovative information on the responses of overtrained vs healthy athletes. Because no prospective study of this kind has yet been performed in young athletes, the purpose of this study was to follow with a case-study analysis 4 young swimmers over 11 month competitive season, assess the relationship between training load and the occurrence of NFOR and/ or OT, and its association with physiological and psychological markers of NFOR/ OT.

4.2. Methods

A local swimming club was contacted and a total of 12 national-level swimmers (6 males and 6 females) volunteered to participate. The aims of the study were explained to the coaches, athletes and parents in an accompanying letter (*appendix 8*) and informed consent was obtained (*appendix 9*) by the athletes and respective parents/ caregivers. The study was approved by the Institutional Ethics Committee prior to commencement. This project took place during the 2007/ 2008 swimming season running from September 2007 to July 2008. During the study a number of athletes failed to give a complete set of measures and therefore had to be discarded from the sample. The final sample was 4 female swimmers with a mean age of 15.5 ± 1.0 yr.

4.2.1. Anthropometric measurements

Each month the swimmers had their body mass and stature measured, and the Body Mass Index (BMI = weight/ stature^2) calculated. Percentage fat (% fat) was determined monthly (*appendix 10*) according to the procedures described by Carter and Ackland

(1994).

4.2.2. Training load and performance monitoring

Training load was monitored on a weekly basis using the stress index scale (Mujika et al., 1995). At the end of each week, the coach provided details of all training sessions performed during the week together with the weekly register for all of the swimmers. Training volume and intensity were recorded individually for each of the swimmers throughout the 11 months. The intensity is extrapolated from the study by Mujica and colleagues (1995), who used a group of swimmers during a competitive season and measured their blood lactate concentration during a progressive test. The test consisted of 200 meters swims at progressively increased swimming velocity, determined from each swimmer's best competition time in the same distance. The test was stopped when the swimmer could not maintain the required pace. From the results of the test, five training intensity levels were established (Mujika et al., 1996):

- **Intensity 1**: swimming speed lower than the speed at the blood lactate accumulation threshold (~ 2 $mmol.L^{-1}$);
- **Intensity 2**: swimming speed corresponding to the blood lactate accumulation threshold of ~ 4 $mmol.L^{-1}$;
- **Intensity 3**: swimming speed slightly higher than the speed corresponding to the blood lactate accumulation threshold of ~ 6 $mmol.L^{-1}$;
- **Intensity 4**: highly lactic swimming (~ 10 $mmol.L^{-1}$);
- **Intensity 5**: maximal intensity sprint swimming.

This scale is based on the theoretical blood lactate accumulation levels encountered during the different training sets, as follows: values 2, 4, 6 and 10 $mmol.L^{-1}$ correspond to intensity levels 1, 2, 3 and 4, respectively. The corresponding value to intensity 5 is estimated as 16 $mmol.L^{-1}$, since sprint training is considered maximal intensity exercise. These values are then divided by 2 with the resulting index scale of 1, 2, 3, 5, 8. This is then multiplied by the distance swum (in kilometres) at each intensity level and summed to give a weekly stress index (*figure 4.1*).

	A		B	C	D	E	F	G	H	I
1	Name: X	Code: X1							Week 26	
2										
3	Club X		Mon	Tue	Wed	Thu	Fri	Sat	Sun	Week Total
4			25-Jan	26-Jan	27-Jan	28-Jan	29-Jan	30-Jan	31-Jan	
5										
6	Warm-up		2200	800	1210	1800	1670	0	1200	**8880**
7	A1		4400	1600	1300	2100	800	0	1200	**11400**
8	A2		4800	600	1500	1200	2500	0	3150	**13750**
9	A3		0	2000	1000	1600	0	0	0	**4600**
10	Lactate tolerance		0	400	0	0	0	0	0	**400**
11	Max Lactate production		0	0	0	0	900	0	0	**900**
12	Speed		0	0	90	60	30	0	100	**280**
13										
14										
15		Day total	11400	5400	5100	6760	5900	0	5650	**40210**
16										
17		Intensity (a.u.)	2.20	3.00	2.59	2.46	3.09	0.00	2.49	**2.58**
18										

Figure 4.1 – Example of a week of training for an individual swimmer. Distance swam is introduced in meters on each of the corresponding training intensities and at the bottom the total volume and intensity swam (both for days and week) are provided; ***Intensity 1*** *corresponds to warm-up and A1 (aerobic 1) training zones;* ***Intensity 2*** *– A2 (anaerobic threshold) training zone;* ***Intensity 3*** *– A3 (VO_2max) training zone;* ***Intensity 4*** *– Lactate tolerance and maximal lactate production training zones;* ***Intensity 5*** *– speed training zone.*

To evaluate performance during the study, the Fédération Internationale de Natacion (FINA) scale (2004) was used (*appendix 11*); this instrument enables the grading of each performance independent of the swimmer's technique or distance swam (FINA, 2004).

4.2.3. Diagnosis of NFOR and/ or OT

According to Meeusen's et al., (2006) definition, an athlete is NFOR if competitive performance stagnated or decreased over a period of weeks to months, and OT if the lack of performance has remained for several months (Meeusen et al., 2006). There is however no agreement on the number of months that have been suggested in order to distinguish both states. In order to make this definition more conservative our study classified any swimmer as OT if their swimming performance (main swimming event calculated by the 2004 FINA International Points Score) had decreased for a period of *more than 6 months*. The coach had planned 3 main periods for the season in which performance improvement was expected and focused (*figure 4.2*); these were located in the months of March, May and July/ August and occurred in both county and national competitions.

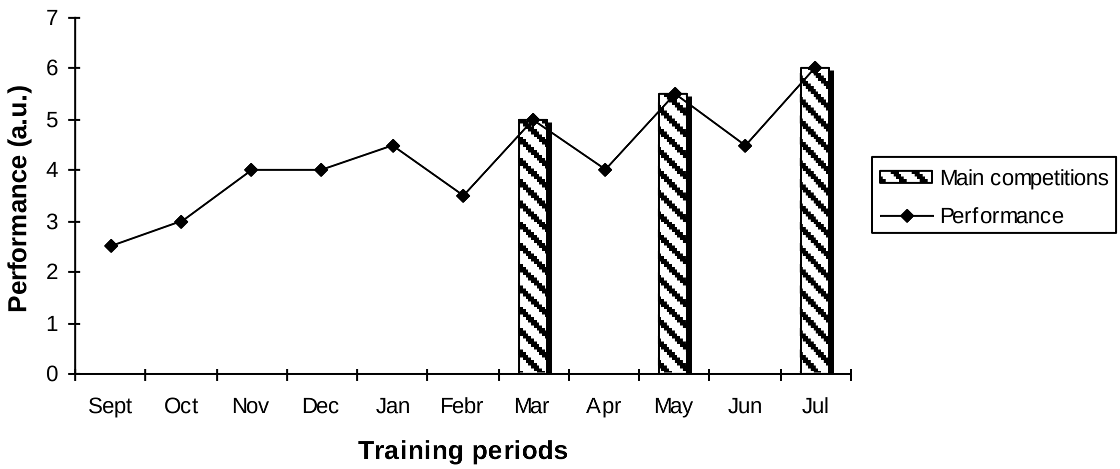

Figure 4.2 – Year-long planning for the team's performance, together with the 3 main competitions that follow after a taper; performance is expressed in arbitrary units (a.u.).

4.2.4. Salivary assays

Data collection was performed monthly and involved the collection of a saliva sample for the determination of IgA and cortisol (C), Before the beginning of the study the athletes were instructed in regards the appropriate procedures for saliva collection (Mackinnon & Jenkins, 1992):

1. Not having eaten 1 hour before collection;
2. Not having drunk alcohol 24 hours before collection;
3. Not having eaten gums or sweets 45 min before collection;
4. Not brushing teeth 2 hours before collection, although they were allowed to rinse their mouths with tap water 10 min before collection;

The swimmers were instructed to remain seated throughout the saliva collection, whilst saliva was collected passively by letting it dribble into the appropriate container for 5 minutes. After collection of 5 ml of saliva, all samples were immediately put into a thermal bag and taken to the laboratory to be kept in the freezer at - 70° C. This procedure is taken to avoid changes in temperature that may damage the molecular structure of the saliva proteins (Li & Gleeson, 2004). Before analysis all samples were defrosted for approximately 2 hours and centrifuged (HematoSpin 1400 ®) at 3000 rpm.

For the saliva analysis the Enzyme-Linked ImmunoSorbent Assay (ELISA) technique was used and the protocol was followed according to the manufactures descriptions. The salivary assays were done by a qualified laboratory technician.

4.2.4.1. Salivary IgA procedures

Microplates were precoated with goat anti-human salivary IgA conjugated to horseradish peroxidase, which was added to tubes containing specific dilutions of standards of saliva. The tubes were gently mixed and then incubated for 90 minutes at room temperature. Next, an equal solution from each of the tubes was added in duplicate to a microtitre plate coated with human salivary IgA. The free or unbound antibody conjugate binds to the salivary IgA on the plate, and the plate was then sealed and incubated for another 90 minutes at room temperature. When incubation was terminated, the unbound components were washed away manually by using a wash buffer. Then, 50 μL of Tetramethylbenzidine (TMB) solution was added to each well using a multichannel pipette. The plate was then mixed for 5 minutes (tap mix) and once more incubated in the dark for another 40 minutes. Finally, 50 μL of stop solution were added with a multichannel pipette, and mixed (tap mix) until all wells turned yellow. The plate was then put in a microplate absorbance reader (DYNEX **MRX^e ®);** the optical density is determined at 450 nm.

An inter-method comparison between the employed ELISA method and a radial immunodiffusion assay (RID), indicated a strong and significant reliability correlation ($r = 0.94$, $p < 0.0001$). Furthermore, all samples for the same subject were always kept within the same plate and that the controls (high and low) were within the expected validation limits. Finally, the intra-plate coefficient of variance (CV) was of 2.5 %, and the R^2 of the standards was 0.98.

For reference, athletes who present with lower levels of 40 $mg.L^{-1}$ of IgA in their mucosa are considered to be more vulnerable to URTI's (Gleeson et al., 1999b).

2.4.2. Salivary Cortisol procedures

Each well was added with specific antibodies anti-cortisol. The standard cortisol together with the salivary cortisol from the samples (unknowns), compete with cortisol linked to horseradish peroxidase for the antibody binding sites. After performing the recommended pipetting and dilutions, the plate was mixed (tap to mix) for 5 minutes and then incubated at room temperature for 55 minutes. The plate was then washed appropriately and 200 µL of TMB solution were added into each well with a multichannel pipette. The plate was again mixed for 5 minutes (tap to mix) and then incubated in the dark for an additional 25 minutes. Fifty µL of stop solution was added with a multichannel pipette. Finally, the plate was mixed (tap mix) for another 3 minutes and put on a plate reader at 450 nm. Using the mean optical density values in the wells, from where the cortisol concentration was determined, a sigmoid curve is plotted; cortisol was determined by interpolation of the respective optical densities.

The intra-assay precision reported by the manufacturer varied between 3.35 % and 3.65 %, whereas the inter-assay ranged between 3.75 % and 6.41 %. The correlation between salivary and serum cortisol is strong (r = 0.91), and similar for free plasma cortisol (r = 0.97). The values determined for cortisol were within the values reported by the high and low controls. Finally, our intra-plate CV was of 2.15 %, and the R^2 of the standards was 0.99. The salivary concentration of cortisol is highly correlated with free plasma cortisol (r = 0.97) (Vining, McGinley, Maksvytis, & Ho, 1983).

For reference, athletes who present with higher levels than 7.2 $nmol.L^{-1}$ of cortisol in their saliva are considered to have elevated levels of cortisol (Schwartz et al., 1998).

4.2.5. Incidence of URTIs and mood states monitoring

Incidence of upper respiratory tract infections (URTI) was recorded. The athletes were instructed to keep a training log where they could register their infections (cough, ear ache, sore throat, runny nose and throat infections; Graham, 1990). An URTI was considered when the episode lasted for at least 48 hours and discreet episode if more than a week separated the ending of previous episode (Bishop, 2006).

Training Distress Scale (TDS; Raglin and Morgan, 1994) was also completed to provide an account of the swimmers' mood states. The questionnaire was completed immediately after the collection of the saliva but prior to any swimming.

4.2.6. Swimming protocol

The swimming protocol used was the one proposed by Pyne and colleagues (2000) that consists on 7 repetitions of 200 meters using a progressively higher swimming velocity (Pyne, Boston, Martin, & Logan, 2000); the details of the protocol are described in *appendix 11*. The main objective of this protocol was to allow for the collection of blood lactate at the end of each repetition until maximum in the last and consequently, the plotting of a blood lactate curve and other parameters taken from it. As such, the metabolic adaptation resultant from training could be controlled. The test was performed 3 times during the 11-month period (dates were chosen by the coach according to the times he thought would fit his training plan (November, January and May). Swimmers perform their main stroke during the step test. To enable swimmers' performance to be compared equally, their swimming velocities achieved during the test were converted to a relevant FINA 2004 score.

Heart rates and rates of perceived exertion were also collected during the submaximal protocol. Heart rate was determined at the end of each 200 meter repetition using a Polar ® (S810) worn by the swimmer. The HR value obtained can be used as a measure of the total effort during the 200 meters repetition (Keskinen, Keskinen, & Mero, 2007).

At the end of each set of 200 meters, a finger tip capillary blood sample (10 μL) was taken from the finger of each swimmer with a final maximal lactate taken 3-minutes after the end of the test protocol. Lactate was analysed using a Lactate Pro ®, which has been validated previously against other well-referenced equipments, such as the ABL 7000 and the YSI 23L and 15000 and 23000, by Yellow Springs Instruments, Yellow Springs OH, USA (Medbo, Mamen et al., 2000; Pyne, Boston et al., 2000; Saunders, Feldman et al., 2005).

4.2.7. Descriptive statistics

With just 4-athletes included in the final study sample, it was impossible to run meaningful and valid statistical tests, consequently results are given as simple descriptive statistics (means and standard deviations) and presented as a case-study of four young female swimmers.

4.3. Results

4.3.1. Performance data

At the end of the study, 2 female swimmers were diagnosed as overtrained (OT) due to a decrement in performance for a period of 6 months or longer; one of the swimmers' performance stagnated (OT1), whereas the other experienced an obvious decrement

(OT2). Two girls who were not OT were selected for comparison (NORM1 and NORM2; *table 4.1*).

Table 4.1 – Performance improvement/ decrement from start to end season based on the FINA 2004 score.

Swimmers (N = 4)	% performance change
NORM 1	10
NORM 2	8
OT 1	0
OT 2	- 4

4.3.2. Anthropometric data

The girls were taller and lighter, and had a higher fat percentage than elite female swimmers (Carter, Aubry et al., 1982; Meleski, Shoup et al., 1982; Pires, Silva et al., 2000), who all show values ranging between 15 % to 19 %. The athletes grew between 0.5 cm and 1.5 cm, and showed negligible changes on BM and BMI, apart from swimmer OT1 who increased BM by 2.1. The OT swimmers had lower % fat in comparison to the NORM girls, but the OT1 swimmer increased her fat % by 5.3 % at the end of the season (*table 4.2*).

Table 4.2 – Descriptive statistics in relation to the anthropometric variables (input variables) measured during the 11 months for the NORM (N = 2) and OT girls (N = 2), with corresponding delta (Δ) change; BM – body mass; BMI – body mass index.

Parameters	**Sept**	**July**	**Δ change**
NORM1 stature (cm)	163.9	165.4	1.5
NORM2 stature (cm)	171.9	172.8	0.9
OT1 stature (cm)	167.7	168.8	1.2
OT2 stature (cm)	170.7	171.2	0.5
NORM1 BM (Kg)	56.6	56.5	- 0.1
NORM2 BM (Kg)	67.5	66.4	- 1.1
OT1 BM (Kg)	54.9	57.0	2.1
OT2 BM (Kg)	66.7	67.3	- 0.5
NORM1 BMI ($Kg.m^{-1}$)	21.1	20.6	- 0.4
NORM2 BMI ($Kg.m^{-1}$)	22.8	22.6	- 0.2
OT1 BMI ($Kg.m^{-1}$)	19.5	20.0	0.5
OT2 BMI ($Kg.m^{-1}$)	22.9	22.6	- 0.3
NORM1 fat (%)	28.1	26.6	- 1.4
NORM2 fat (%)	27.1	28.6	1.5
OT1 fat (%)	22.3	27.6	5.3
OT2 fat (%)	24.8	26.7	1.9

4.3.3. Training load data

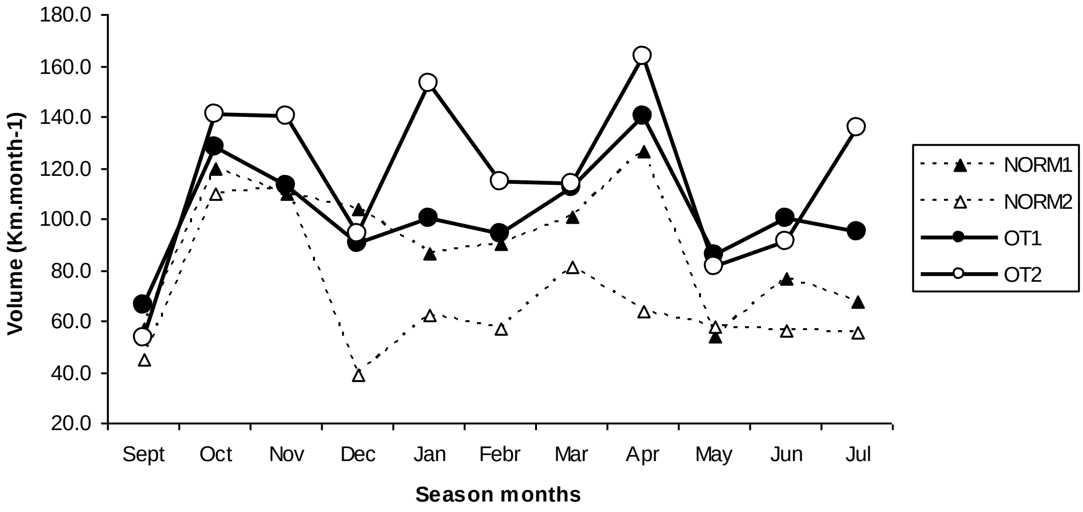

Figure 4.3 – Season volume data for the 4 swimmers. Volume (input variable) is expressed in km per month (km.month^{-1}).

The 2 overtrained females were completing higher monthly volumes throughout the season, especially when compared to NORM2 swimmer (67.2 ± 24.2 km.month^{-1}), as NORM1 (93.8 ± 29.1 km.month^{-1}) was closer to the OT girls; mean monthly volumes for OT1 and OT2 was of 102.1 ± 20.4 km.month^{-1} and 116.4 ± 33.7 km.month^{-1}, respectively (*figure 4.3*).

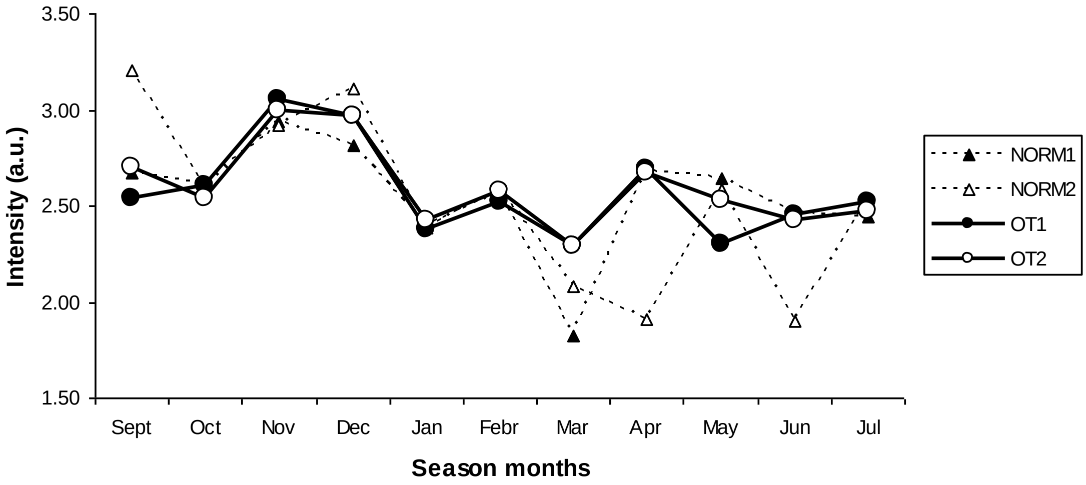

Figure 4.4 – Season intensity data for the 4 swimmers; intensity (input variable) is expressed in arbitrary units (Mujika et al., 1995) per month

The 4 swimmers showed a similar pattern in the intensity variation, with a general trend for intensity to decrease over the season with the highest intensity swimming performed in November (*figure 4.4*); all swimmers experienced similar mean training intensities throughout the season (OT1 = 2.57 ± 0.25 a.u.; OT2 = 2.60 ± 0.22 a.u.; NORM1 = 2.55 ± 0.29 a.u.; NORM2 = 2.53 ± 0.44 a.u.).

4.3.4. Biochemical parameters

Both the OT1 and the NORM1 swimmers showed higher monthly mean IgA levels (OT1 = 83.3 ± 18.3 mg.L^{-1}; NORM1 = 52.0 ± 26.2 mg.L^{-1}) compared with the OT2 and NORM2 swimmers (OT2 = 18.6 ± 14.3 mg.L^{-1}; NORM2 = 18.4 ± 13.0 mg.L^{-1}). IgA levels decreased from September until July in all 4 athletes, with the decrement being higher in all swimmers (NORM1 = 62 %; NORM2 = 85 %; OT2 = 80 %) except OT1 (18 % decrease) (*figure 4.5*); the 2 NORM swimmers and OT2 showed critical IgA levels, since they were under the limit level suggested by Gleeson and colleagues

(1999b). The only moment where a dose-response relationship between IgA and training volume is consistently observed is in October's month, whereby all 4 swimmers had a great increment in training that corresponded to a considerable decrement in their IgAs.

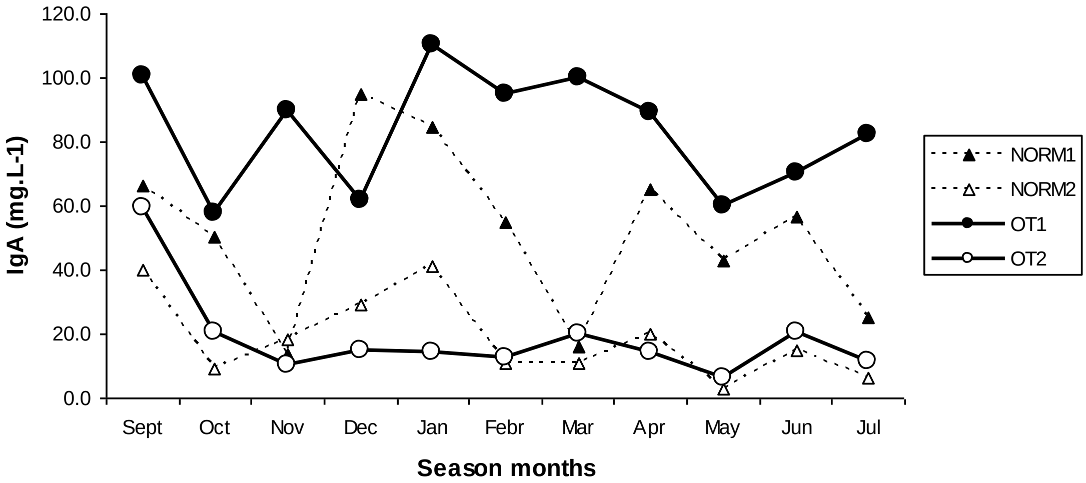

Figure 4.5 – Variation in salivary immunoglobulin A (IgA) concentration during the competitive season in the 4 swimmers; IgA (output variable) is expressed in $mg.L^{-1}$.

The NORM1 and OT2 swimmers presented with a high number of URTIs at the beginning of the study, but they progressively decreased in number through the season, with an average of 1 URTI per month from November onwards (*figure 4.6*). The same swimmers had the highest URTI incidence over the season (NORM1 = 9; OT2 = 15) compared to NORM2 and OT1 (NORM2 = 4; OT1 = 5).

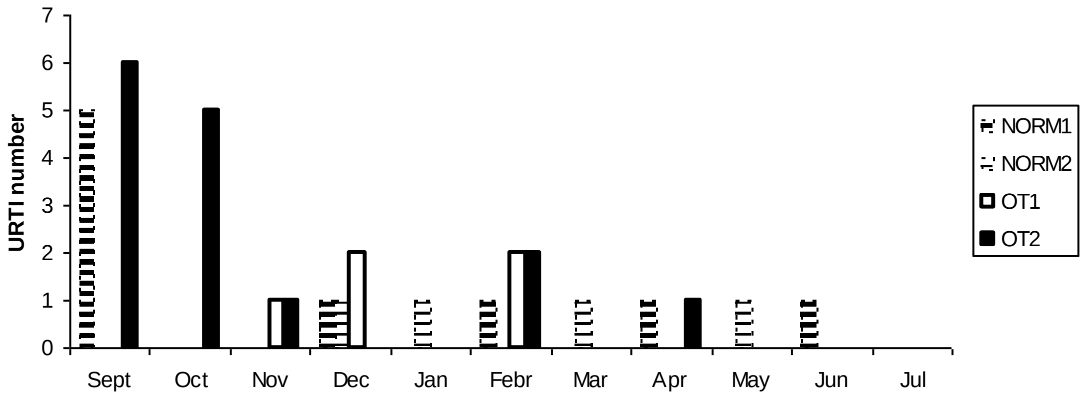

Figure 4.6 – Number of infections (URTIs; output variable) reported by the 4 swimmers throughout the season.

The OT swimmers started the season with elevated cortisol levels (OT1 = 8.0 nmol.L^{-1}; OT2 = 8.8 nmol.L^{-1}) compared to the NORM girls (NORM1 = 4.7 nmol.L^{-1}; NORM2 = 4.0 nmol.L^{-1}). Cortisol concentration was variable through the season, with all athletes showing different occasions where cortisol increased considerably (*figure 4.7*). Overall, the OT swimmers showed slightly higher mean monthly cortisol levels (OT1 = 6.8 ± 2.6 nmol.L^{-1}; OT2 = 6.0 ± 1.7 nmol.L^{-1}) compared with the NORM swimmers (NORM1 = 5.4 ± 2.3 nmol.L^{-1}; NORM2 = 4.3 ± 1.2 nmol.L^{-1}). There was no clear trend observed in regards cortisol responses with changes in training load.

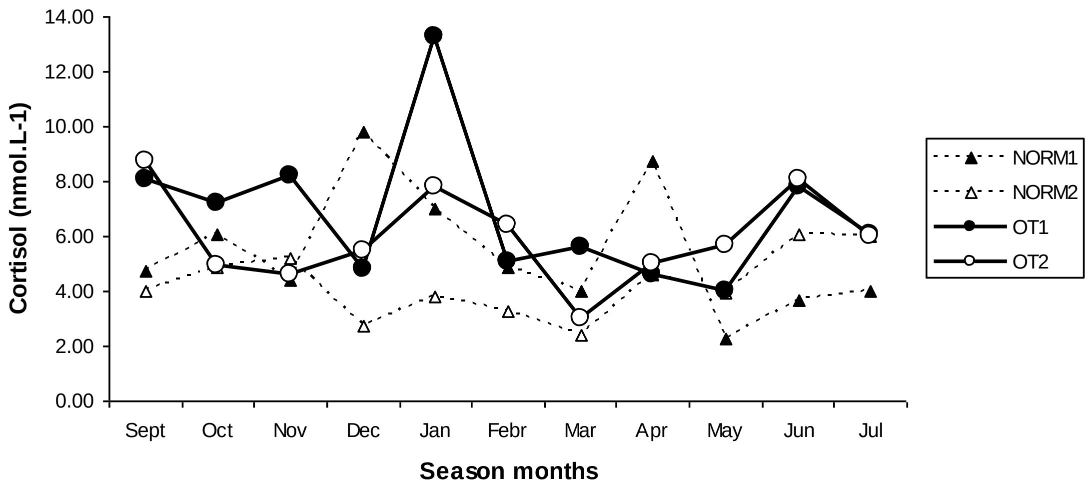

Figure 4.7 – Variation in salivary Cortisol concentration during the competitive season in the 4 swimmers; Cortisol (output variable) is expressed in $nmol.L^{-1}$.

4.3.5. Mood states (TDS)

The TDS responses (*figure 4.8*) indicate a higher level of reported distress in the OT swimmers over the season (OT1 = 2.5 ± 0.8; OT2 = 2.2 ± 0.8). In contrast, the NORM swimmers reported a lower and more stable mood state over the season (NORM1 = 1.3 ± 0.2; NORM2 = 1.1 ± 0.1). Both OT swimmers reported high levels of distress from December onwards, although OT1 swimmer showed an improvement by May. OT2 swimmer albeit showing a lower level of distress compared to OT1, had a significant increase from March up until June.

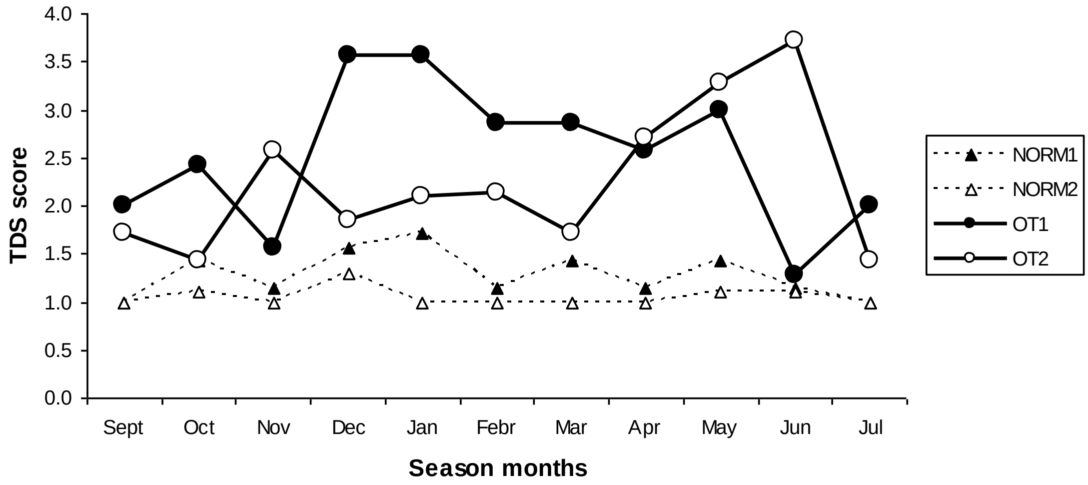

Figure 4.8 – Variation in the TDS score (output variable) during the 11 months of the season in the 4 swimmers.

4.3.6. Step Test results: 7x200m

The peak heart rates attained in all swimmers were similar, and no particular trend was observed. These swimmers also exercised at maximum and close to maximum as can be seen by their RPE scores (*table 4.3*).

Table 4.3 – Maximal test results for heart rates (output variable; HR_{max}; HR attained at the last 200 m repetition), and RPE_{max} (output variable; RPE attained at the last 200 m repetition), measured at the 3 different time points of the season in each of the 4 swimmers; T1 – Test 1; T2 – Test 2; T3 – Test 3.

Parameters		**T1**	**T2**	**T3**
HR_{max} (bpm)	**NORM1**	192	180	180
	NORM2	184	190	189
	OT1	180	186	190
	OT2	186	185	179
RPE_{max}	**NORM1**	18	18	18
	NORM2	20	20	19
	OT1	19	18	19
	OT2	20	20	19

In relation to their maximal performances, both NORM swimmers decreased performance by T2, with NORM1 improving by T3, and NORM2 showing a negligible decrement. The OT1 swimmer had a progressive decrement from T1 to T3, whereas OT2 stabilized performance by T2 and then showed an abrupt decrement in swimming performance (*figure 4.9*).

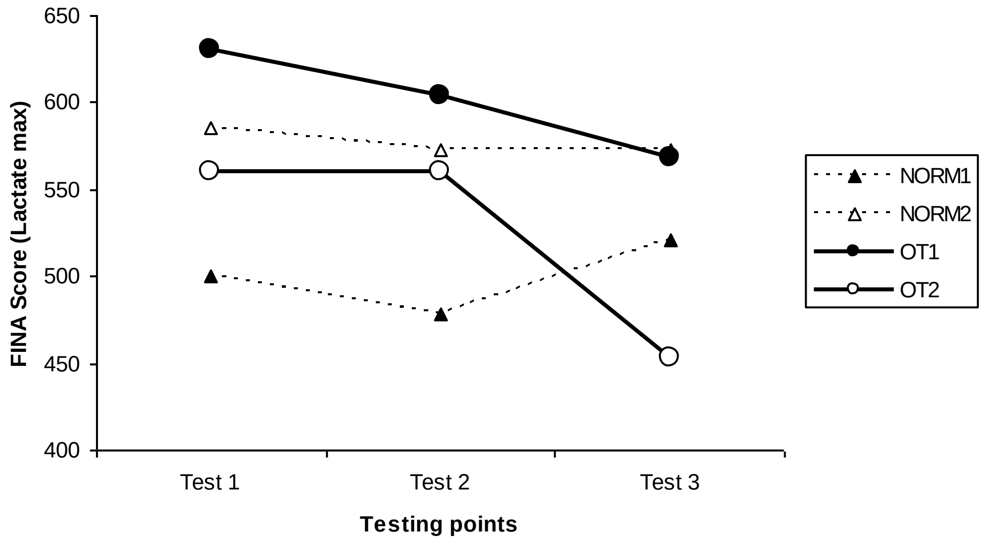

Figure 4.9 – FINA score (output variable) attained at the final 200m repetition (maximum effort) in the 4 swimmers for each of the 3 tests; T1 – Test 1; T2 – Test 2; T3 – Test 3.

All swimmers decreased maximal lactate concentration attained at the end of the test from T1 to T2. By T3, NORM2 returned to starting levels, whereas both NORM1 and OT1 swimmers decreased slightly. The OT2 swimmer had a further and considerable decrement from T2 to T3. Maximal lactate achieved by the NORM swimmers and OT1 was consistent over the testing season (between 9 and 10 $mmol.L^{-1}$), whereas OT2 showed a linear and significant decline in maximal lactate over the season (*figure 4.10*).

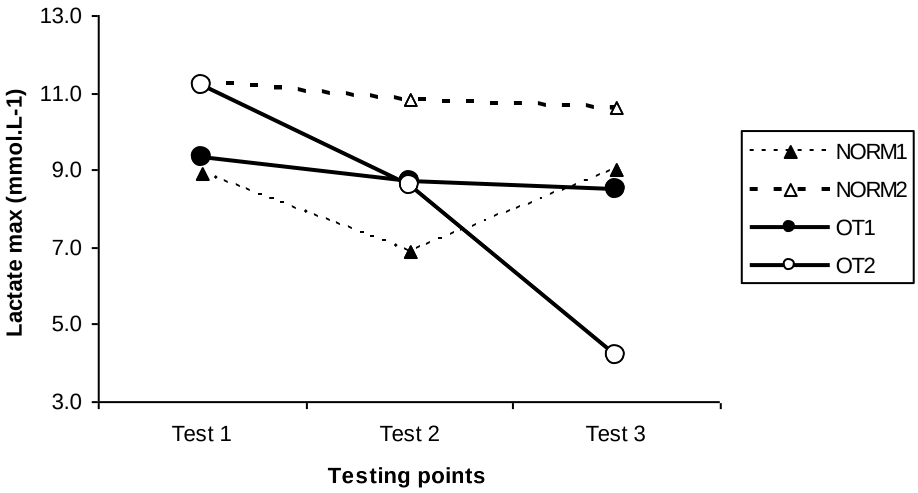

Figure 4.10 – Final maximal lactates (output variable) in the 4 swimmers for each of the 3 tests; T1 – Test 1; T2 – Test 2; T3 – Test 3.

The La/ RPE ratio decreased in the OT swimmers from T1 to T3, although the decrement observed in the OT2 was once more significant. The NORM swimmers showed a decrement in the ratio from T1 to T2, and it then increased back to starting levels by T3 (*figure 4.11*).

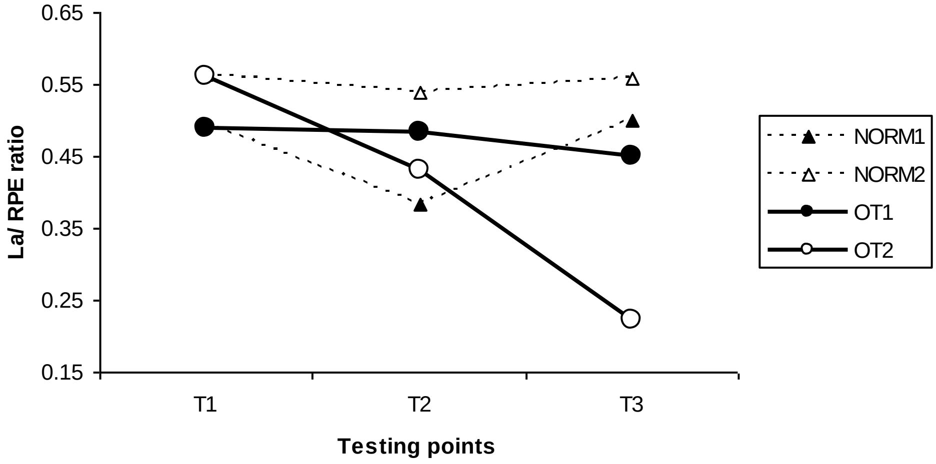

Figure 4.11 – Maximal lactate to RPE (La/ RPE) ratio (output variable) attained on the last repetition of the 7 x 200m step test by the 4 swimmers in each of the 3 tests; T1 – Test 1; T2 – Test 2; T3 – Test 3.

4.4. Discussion

This prospective study is one of the first to profile the altered physiological and psychological responses in OT young swimmers over a competitive season. The results show that the overtrained female swimmers performed higher training volumes (especially OT2), presented with paradoxical IgA concentrations, slightly elevated cortisol levels, and a higher and more variable mood distress than the non overtrained females. Their performance test results also decreased as did their maximal blood lactate concentrations. In contrast, the normal swimmers presented with a more favourable physiological (lower cortisol levels) and psychological profile (less mood disturbances), and showed more positive maximal test responses on the 7 x 200 step test, which concluded with improved performance in competitions. The OT2 swimmer presented with a classical case of an overtrained swimmer, with high training loads, low IgAs, high cortisol levels, high mood disturbances, depressed maximal lactate levels and decreased performance both at training and competition.

4.4.1. Training load

The OT swimmers showed that they were completing a higher monthly average swimming load compared with their peers. Importantly, no differences were found on the intensity levels at which all 4 swimmers exercised, suggesting that volume was a more important contributory factor for the development of OT in these girls. There is the suggestion that performance improvements resulting from very high training loads do not appear to provide superior physiological and psychological adaptations beyond those that occur at less intense training (Costill, King, Thomas, & Hargreaves, 1985b). In this regard, Costil (1985a) has stated that the same improvements in performance can be attained by a reduced training volume that is performed at a higher intensity (Costill, 1985a). In a classical short-term study it has been shown that swimmers who experienced 6 weeks of increased volume, did not improve performance above the experienced with the group of swimmers who kept their normal training volumes (Costill et al., 1991).

It is possible that that the high training loads may, in the case of the 2 OT swimmers, be one of the reasons that contributed to their OT sate, in particular for OT2 swimmer. Similarly, a 6-month study with female swimmers also found that the swimmers who overtrained had greater swim volumes and dry-land training times compared with the swimmers who performed well during the season (Hooper, Mackinnon, Howard, Gordon, & Bachman, 1995b). However, it is important to remember that this is but one possible factor contributing to OT. This reinforces how training volumes should be monitored individually (Smith & Norris, 2002) and combined with adequate regeneration periods to avoid excessive fatigue (Fry, Morton, & Keast, 1991).

Excessive training volumes can contribute to OT – not just because of the excessive physical strain this puts on the body – but as a direct result of the training mentality that surrounds endurance sports like swimming, where "the more the better" philosophy can pervade (Murphy, Fleck, G., & Callister, 1990; Richardson, Anderson, & Morris, 2008). This is not only accepted, but pervades the swimmers behaviour and influences coaches' decisions when prescribing training. Both coaches and athletes accept this mentality consequently very high training loads are accepted and therefore prescribed to young athletes, with the belief that this method will bring the best performance outcomes. However, it is important to understand that in some circumstances more training will lead to performance degradation and not improvement (O'Connor, 1997). Thus, the challenge for the coach is to balance training load so that adaptations are as optimal as possible, and the negative side effects like overtraining, injuries or burnout are prevented. Unfortunately, this can be challenging for a coach, as "the more-the-better" philosophy is very strong and well accepted, especially amongst endurance sports (Richardson et al., 2006). As such, for coaches to justify lower training volumes or reductions in training volume in certain individuals, whilst their peers can maintain high volumes is a paradoxical situation. For the athlete it is also not easy as their identities around the sport can be so strong (Coakley, 1992; Kentta and Hassmen, 1999; Kentta et al., 2001) that they will feel insecure if/ when they have their training reduced due to a lack of coping with training. In the situation where the athlete actually feels that a reduction in training load would be of benefit but if the coach and/ or parents do not agree with this wish, then the athlete is more likely to not express his/ her opinion, hence the athlete is controlled by the coach and/ or parents leaving him/ her powerless to make decisions. As a result, the decisions about the nature of experiences in sport and the direction of their own development end up being controlled by others (Coakley, 1992). This issue, once more, emphasizes how complex the overtraining phenomenon is, and that factors like training load need to be looked at, as much from a physiological perspective but also as a socio-cultural tool that it represents. A more in depth discussion of the same issues has been described in *Chapter III, section 3.4.5*.

4.4.2. Salivary Immunoglobulin A responses and URTIs

In this study IgA was not found to be an efficient tool to monitor training responses, since the observed responses were paradoxical; OT1 showed healthy levels and NORM2 unhealthy. The study did nevertheless suggest that chronic exercise training can lead to decreased mucosal IgA levels over a competitive season. The latter results corroborate the study by Gleeson and colleagues (1995) who found lower pre-training IgA levels through the season (7 months) in a cohort of adult elite Australian swimmers (Gleeson et al., 1995). Similar findings have also been reported in a short-term study with male swimmers (Tharp & Barnes, 1990), and a longitudinal one with American College Football players (Fahlman and Engels, 2005). Our data have shown that swimmers may have their mucosal immunity suppressed after a season of swimming training, and that the athletes with lower IgA levels (swimmers OT2 and NORM2) are more likely to report more URTIs. The latter gives support to the study by Gleeson and colleagues (1999) who found that swimmers who presented with lower than 40 $mg.L^{-1}$ of mucosal IgA were more prone to infections.

Interestingly, NORM2 swimmer presented with unhealthy IgA levels, which suggests that even healthy athletes with depressed IgA levels may perform well during the season. On the other hand OT1 swimmer showed healthy IgA levels, which corroborates the study by Gabriel et al. (1998) who demonstrated that their OT athletes did not show signs of immunosupression. Gleeson et al. (1995) also found that pre-training IgA levels were inversely correlated with the number of URTIs, both in swimmers and age-matched adult controls. As such, they suggested that measuring IgA levels over a season could help identify athletes who are at risk of infection (Gleeson et al., 1995). It was interesting to find that with low IgA levels present in NORM2 and OT2 swimmers, the monthly mean infection rate was higher than in the other 2 swimmers. Data for the latter 2 swimmers give support to the studies by Gleeson et al. (1995) and Teixeira et al. (2003) in swimmers who found that the higher incidence of URTIs occurred in athletes who presented with lower IgA levels (Gleeson et al., 1995; Teixeira, Rama, Martins, & Cunha, 2003). Furthermore, the yearly average infection rate in the Australian swimmers was of 2.7 episodes per month (Gleeson et al., 1995), whereas the same 2 swimmers in our study showed a lower rate, with one of them being overtrained. It should be noted that the Australian study with elite swimmers only monitored athletes for 7 months, so it is hard to determine if the incidence of URTIs would show any changes in case the study would be extended for another 4 months. A final important aspect is related with the fact that these measures are self-reported (but were confirmed by the coach and main researcher of the study) and therefore, may lack clinical significance. The latter issue was recently investigated, and it was concluded that only a reduced number of reported URTIs (30 %) actually corresponded to a true infectious episode. In the other reported URTIs, no pathogens were, i.e. they resulted from allergies or inflammations (Spence, Brown et al., 2007; Cox, Gleeson et al., 2008). These findings strongly suggest that URTIs in athletes are seldom infectious, and that non-infectious causes should be investigated to identify alternative mechanisms and mediators. In summary, one should not generalize certain findings and expect that all overtrained athletes will show a high incidence of URTIs and low IgAs. It is an individual problem, and it seems possible that some overtrained athletes may show elevated IgA levels and low infection rates (case of OT1 swimmer), and yet they will underperform.

4.4.3. Salivary Cortisol responses

The cortisol responses to changes in training load were highly variable in all swimmers and are therefore hard to interpret. The OT athletes started the season off with higher cortisol levels compared with the NORM swimmers, which are reflective of greater physiological stress (Schwartz et al., 1998). This confirms previous findings with footballers (Kraemer, French et al., 2004), who found that players who started the season with high cortisol levels were more likely to experience a lack of performance, especially if they had years of training and competing experience, which is the case with our OT and healthy swimmers. Still, this is hard to determine since the monthly mean values reported by our swimmers are in agreement with the reported cortisol levels normally found longitudinally in healthy athletes (Rama, 2010), and a study with adult rugby players failed to find any relationship between cortisol levels and overtraining (Maso, Lac, Filaire, Michaux, & Robert, 2004). Importantly, the high variability shown in all swimmers (NORM and OT) confirms other longitudinal data (Banfi, Marinelli, Roi, & Agape, 1993; Edwards, Wetzel, & Wyner, 2006; Rama, 2010).

The variability in cortisol levels has been reported previously and its relationship with training load remains questionable. No clear relationship between high cortisol levels and high monthly training loads was observed in our swimmers. In contrast, several studies have reported elevations in cortisol levels with concomitant increments in training load (Calbert, Navarro et al., 1993; Rama, 2010). Furthermore, all swimmers had low cortisol levels during the main competitions of the season, which contrasts with some studies that have shown significant elevations in cortisol before and during important competitions (Aubets and Segura, 1995; Filaire, Michaux et al., 1999; Rama, 2010). It has been suggested (Kirschbaum et al., 1995) that some individuals can react to stress with an evident physiological peak in cortisol (high responders), whereas others may show an attenuated response (low responders). A recent study using a cohort of 19 swimmers also found that 53 % of the sample showed no responsiveness to variations in the training load (low responders), whereas the other 47 % (high responders) tended to increase cortisol with moments associated with higher training volumes, and decrease during lower loads (Banfi et al., 1993; Rama, 2010). Once again, no firm conclusion can be stated in regards to cortisol profile at OT in young swimmers.

4.4.4. Mood states responses

The OT swimmers were shown to be distressed through the study, whereas the NORM swimmers showed no evidence of distress during the complete season. Our findings confirm the results obtained by Raglin and Morgan (1994) who also found the TDS scale to be effective in distinguishing well-adapted from overtrained athletes (Raglin & Morgan, 1994). Athletes who are under high stress due to their high training and other external factors will show a tendency to evidence a distressed state (Raglin, 1993). The fact that the NORM swimmers did not show a variation in mood with changes in training volume contradicts the majority of longitudinal literature that states that athletes tend to show a dose-response relationship between training volume and mood disturbance (Morgan, Brown, Raglin, O'Connor, & Ellickson, 1987a; Raglin, Morgan,

& O'Connor, 1991; Raglin, Morgan, & Luchsinger, 1990), although these results have not always been confirmed (Hartwig, Naughton, & Searl, 2009; Murphy et al., 1990). The majority of these studies have however based their arguments on the POMS, and only one study was performed that used the TDS. These authors however, did not clarify whether the athletes showed the previously mentioned dose-response trend (Raglin & Morgan, 1994). The OT swimmers started off the season distressed, which can be easily identified by coaches by using the TDS, and also showed a clear distinct psychological profile from the NORM girls. Once more, with the OT swimmers, no particular trend in relation to a dose-response relationship between training volume and mood was observable. Our findings are suggestive that the TDS is unresponsive to changes in training load in all swimmers despite a considerable difference in TDS between the OT and NORM swimmers which remained throughout the season.

Research has also demonstrated that athletes developing a mal-adaptation can be identified by using the POMS (Morgan et al., 1987a; Veale, 1991). Athletes who became OT, prior to undergoing increased training, presented with the same positive psychological characteristics commonly noted in healthy athletes (O'Connor, Morgan, Raglin, Barksdale, & Kalin, 1989; J. Raglin et al., 1990), but only following exposure to increased training did the differences emerge, whereas our OT swimmers did not require a sufficient accumulation of training to show that they were distressed. Thus, our results suggest that the scale is sensitive enough to identify the athletes who are at the beginning stages of developing a mal-adaptation. In contrast, it may not be sensitive enough to detect other subtle changes in mood in athletes relative to training variations. For the purpose of early diagnostic and mood-state monitoring in athletes, and since the POMS is a lengthy scale and takes a while to be completed, the TDS may be more easily and quickly administered.

4.4.5. Maximal performance at the 7 x 200m test

The OT swimmers progressively declined their maximal performance at training, together with a reduction of maximal lactate concentrations. In contrast, the healthy swimmers, even though not performing well on the 2nd test, NORM1 managed to improve performance on the final test, and NORM2 was just under her performance for T1 (less than 10 points on the FINA score). The latter was achieved by an improvement in swimming velocity, whilst maximal lactate levels remaining stable between 9 and 10 $mmol.L^{-1}$. Competitive performance in the NORM swimmers further confirmed their positive results in the step test. In contrast, the OT swimmers swam at lower velocities and OT2 swimmer was clearly not able to maintain her maximal lactate levels, even though she was performing at maximal, as supported by her heart rates and RPE scores. It seems clear that suppressed maximal lactate levels are occurring with the latter swimmer, which confirms what several studies have previously shown with mal-adapted athletes (Jeukendrup, Hesselink, Snyder, & Kuipers, 1992; Jeukendrup, Matthijs, & Hesselink, 1994; Lehmann, Baumgartl, Wiesenack, & Seidel, 1992a; Snyder, Jeukendrup, Hesselink, Kuipers, & Foster, 1993; Snyder, Kuipers, Cheng, Servais, & Erik, 1995; Urhausen et al., 1998b). It is not possible to know the precise reason to why OT2 swimmer maximal lactate levels decreased together with performance. A possible explanation could be that these athletes were deprived of glycogen stores in their muscles and liver and therefore could not produce lactate. This hypothesis has been confirmed in some studies (Costill et al., 1988), although OT athletes have also shown lower maximal lactate profiles and their glycogen levels were not depleted (Lehmann et al., 1992a; Snyder et al., 1995). It has also been shown in swimmers that the reason why their glycogen levels were depleted and they were underperforming was due to low carbohydrate ingestion (Costill et al., 1988).

Another possible explanation could be related with a lower sympathetic drive, and/ or reduced catecholamine sensitivity in the target organs. Catecholamines have an important regulatory role in glycogenolysis and reduced sensitivity to catecholamines or lower plasma catecholamine concentration could result in reduced lactate concentration. A study by Lehman and colleagues (1992) supports this view; they observed decreased catecholamine levels after intensified training in runners (Lehmann et al., 1992a). In contrast, two other studies by the same team of researchers found decreased catecholamine levels in overtrained athletes and therefore, suspected of an exhaustion of the sympathetic system (Lehmann et al., 1991; Lehmann, Schnee, Stockhausen, & Bachl, 1992b).

Using the lactate to RPE ratio can be another promising tool to monitor overtraining, and, in the case of swimmer OT2 confirms previous work performed in middle distance runners (Garcin, Fleury, & Billat, 2002; Snyder et al., 1993). Some authors have however suggested that relying on maximal lactate values alone is enough to monitor changes in performance (Bosquet, Léger, & Legros, 2001; Jeukendrup et al., 1992; Urhausen, Gabriel, Weiler, & Kindermann, 1998b) and in the absence of any change in maximal exercise RPE, this seems a valid point.

4.5. Conclusion

Our study is the first to provide evidence of the classical psychophysiological symptomology expected to be found in OT athletes, even though this was only achieved in OT2 swimmer. On the other hand, it found that it is possible for some athletes to overtrain and yet not evidence the expected physiological changes. Further, it also presented the case of a swimmer who performed positively during the season albeit her clinically low IgA levels. Importantly, the individualized approach and longitudinal monitoring give strength to the findings of this study. The tools we used as potential markers of OT are suggested to be applied in further research into training optimization and overtraining prevention. Still, their use needs to be clarified to allow sports scientists and especially coaches and athletes to benefit from them more. To more confidently diagnose athletes of overtraining and to monitor healthy athletes' adaptations, a combination of physiological, psychological, competitive and training performance measures should be used on an individual basis.

CHAPTER V

Physiological and psychological responses to a 6-day swimming training camp in an overtrained and a burned-out national-level swimmer

5.1. Introduction

Training camps are a commonly employed method by which swim coaches seek to improve their swimmers' performance through intentional, short-term overreaching (Kuipers & Keizer, 1988). Functional overreaching (FOR) is seen when after an initial decrement in performance, managed rest lasting days to 2 - 3 weeks results in subsequent improved performance. Conversely, if performance remains depressed longer than a few weeks, the athlete is said to be NFOR, and OT if performance remains affected for several months (Meeusen et al., 2006). The continuum between OT and burnout (BO) is not clear, but it is thought that OT athletes are at an increased risk of developing BO (Silva, 1990; Winsley & Matos, *in press*), a state potentially even more detrimental than OT.

It is therefore important for coaches to properly monitor their athletes' responses to training, using valid and effective markers so that these mal-adaptations can be prevented. Adult based data regarding the effects of short-term training have focused either on physiological or psychological variables, and conflicting results have been found. Some studies have demonstrated an increase (Kirwan et al., 1988; Meeusen et al., 2004; Stray-Gundersen, Videman, & Snell, 1986), a decrement (Rietjens et al., 2005), or no changes in cortisol (Mackinnon, Hopper, Jones, Gordon, & Bachman, 1997), an elevation of immunoglobulin A (IgA) (Gleeson, 2000a), and a decrement in immunoglobulin G2 (IgG2) and immunoglobulin G3 (IgG3) (Gleeson et al., 1996). In contrast to the mixed physiological response more consistency has been found in relation to the athletes mood states, with a typical worsening of the mood scores after the increased training load phase (Morgan, Brown, Raglin, O'Connor, & Ellickson, 1987a; Morgan, Costill, Flynn, Raglin, & O'Connor, 1988a; Nederhof, Zwerver, Brink, Meeusen, & Lemmink, 2008; Rietjens et al., 2005).

The mechanisms underlying FOR, NFOR and OT seem to be related, amongst others to the function of the autonomic nervous system (ANS) (Kreider, Fry, & O'Toole, 1998; Uusitalo, Uusitalo, & Rusko, 2000). Both, heart rate (HR) and heart rate variability (HRV) parameters have been used as indicators of ANS functioning in athletes (Malik et al., 1996; Martinmaki, Rusko, Kooistra, Kettunen, & Saalasti, 2006). A higher level of physical fitness has been strongly related to higher indexes of HRV at rest (Aubert, Seps, & Beckers, 2003; Carter, Banister, & Blaber, 2003; De Meersman, 1993; Iellamo et al., 2002). In contrast, a lack of sufficient recovery after a period of intense training can lead to an attenuated HRV response (Hedelin, Wiklund, Bjerle, & Henriksson-Larsen, 2000b; Hynynen, Uusitalo, Konttinen, & Rusko, 2006; Mourot et al., 2004; Uusitalo et al., 2000). However, the data are contradictory since a shift towards both sympathetic (Hynynen et al., 2006; Iellamo et al., 2002; Mourot et al., 2004; Pichot et al., 2000; Uusitalo et al., 2000) and parasympathetic (Hedelin et al., 2000b; Portier, Louisy, Laude, Berthelot, & Guezennec, 2001) dominance have been observed even in short-term training interventions. As a consequence, the responses to different challenges have also been observed and compared between different types of athletes. Some research has suggested that trained athletes show a stronger responses in HR and

HRV to the tilt table test than untrained controls (Furlan et al., 1993; Mourot et al., 2004). Also, Mourot and colleagues (2004) have found that the changes induced by an upright posture were greater in healthy trained than in OT athletes, i.e. a lesser decrement in HRV and parasympathetic activity in the healthy trained subjects. In contrast, the OT athletes showed higher predominance of sympathetic activity, with lower HRV (Mourot et al., 2004).

Recent interest has been shown in the use of reaction time tests to detect subtle changes in NFOR/OT athletes' cognitive capacities in reacting to stimuli. These studies found that reaction times tend to worsen after an increment in training load has taken place (Nederhof, Lemmink, Zwerver, & Mulder, 2007; Rietjens et al., 2005), and that a NFOR athlete reported higher reaction times compared to well-adapted athletes (Nederhof et al., 2008). These findings suggest that after physically and mentally demanding periods, cognitive performance, or more precisely the information processing of the brain, may be attenuated (Lieberman et al., 2006; Rietjens et al., 2005).

The majority of research on psychological constructs related to overtraining and BO has essentially focused on mood responses to periods of intensified training, using the POMS (Nederhof et al., 2007; Nederhof et al., 2008; O'Connor, Morgan, Raglin, Barksdale, & Kalin, 1989; Rietjens et al., 2005) and TDS (Raglin, Sawamura, Alexiou, Hassmén, & Kentta, 2000b; Raglin & Morgan, 1994). Although the Athlete Burnout Questionnaire (ABQ) is a recently validated tool (Raedeke & Smith, 2001), it has been successfully used to study burned-out athletes retrospectively (Cresswell & Eklund, 2007; Goodger, Wolfenden, & Lavalee, 2007; Gustafsson, Hassmen, Kentta, &

Johansson, 2008; Gustafsson, Kentta, Hassmen, & Lundqvist, 2007). Since the ABQ has been proven valid as a tool to diagnose burned-out athletes it can also be confidently used in a training camp setting.

Other tools have been suggested elsewhere (Halson & Jones, 2002b; Kentta & Hassmen, 1998; Lambert & Borrensen, 2006) as efficient for monitoring the stress associated with training and overtraining; these are: the DALDA questionnaire (Rushall, 1990), the Perceived Recovery Scale (PRS) (Kentta & Hassmen, 1998), and the Session RPE (Foster, Daines, Hector, Snyder, & Welsh, 1996). Despite having been suggested to assist coaches in training prescription, the PRS and Session RPE only have been tested once but have excellent practical value (Suzuki, Sato, Maeda, & Takahashi, 2006). The DALDA has been more widely used, although research has only focused on adults; it was suggested that it can be a useful tool to monitor training (Coutts, Slatterya, & Wallace, 2007; Nicholls, Backhouse, Polman, & McKenna, 2009). Based on the state of research, we decided to employ the DALDA to assess changes in the athletes' psychological parameters during a training camp.

Few studies have employed a multifactorial approach to assess NFOR/ OT during training camps (Bosquet, Léger, & Legros, 2001; Nederhof et al., 2008; O'Connor et al., 1989; Rietjens et al., 2005; Snyder, Jeukendrup, Hesselink, Kuipers, & Foster, 1993). Morgan and colleagues (1989) realised that combining salivary cortisol levels with psychometric measures of distress during a period of increased training load can be helpful to distinguish OT swimmers from well-adapted ones. More recently, Rietjans et al. (2005) combined reaction time values, with the POMS and RPE; they found that all parameters, when used together, can be promising tools on the diagnosis of NFOR and

OT. Finally, on a similar investigation, the effect of combining the Recovery-Stress Questionnaire for athletes (RESTQ) (Kellman & Kallus, 2001a), with a reaction time task, and Meuusen'e et al. (2004) two-bout protocol is also a potential promising tool in diagnosing NFOR and OT.

The swimmers investigated in this study were already planning to take part in a training camp as part of their season training. It is important to note that it was not known to the researchers or coach that two of the swimmers were experiencing a state of mal-adaptation at the start of the camp, as ethically it would have been problematic to have intentionally asked them to undergo increased training for the purposes of a research study. However due to this situation, an unexpected and novel opportunity to investigate healthy and mal-adapted young swimmers physiological, psychological and performance responses to an acute phase of increased training load became possible. As such, the present study monitored the responses of 2 national-level swimmers (one diagnosed as OT and another as BO) and of 2 female healthy swimmers, to a 50 % increment in training load in a 6-day training camp environment, using a combination of physiological, psychological and reaction time responses parameters.

5.2. Methods

5.2.1. Sample recruitment

The volunteers were identified from the same local swim club used in the previous study (*chapter IV*). Recruitment and the obtaining of consent were performed according to the protocol described in *chapter IV, section 4.2*. In total 4 female swimmers volunteered to participate in the study (mean age 15.0 ± 1.2 years). The study was approved by the Institutional Ethics Committee prior to commencement (information sheet and form of consent are available in *appendices 13* and *14*, respectively). There were 2 swimmers who were present in the previous study (*chapter IV*), who also participated in this one; swimmer OT1 is now referred as BO swimmer, and swimmer NORM2 maintains her previous designation.

5.2.2. Testing protocol

Athletes were tested 2 weeks before the training camp (control period; CP), the day before (PRE), the day after (POST) the training camp, and 2 weeks after (recovery period; RP), with all testing, apart from the anthropometric and the heart rate variability measurements, taking place at pool side. The study design is shown in *figure 5.1*.

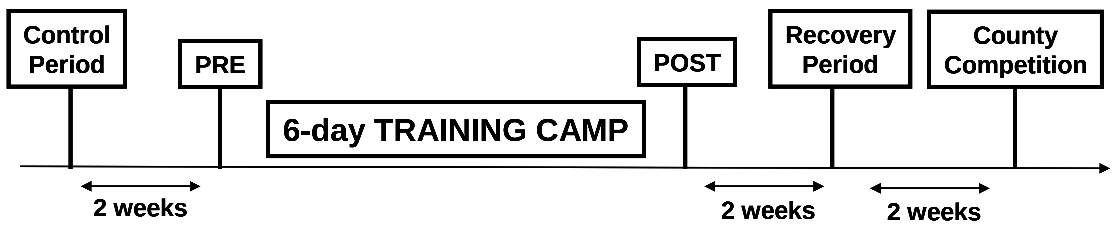

Figure 5.1 – Main testing periods of the study: control period (CP), before training camp (PRE), after training camp (POST), recovery period (RP), and a county-level competition, where all swimmers were assessed on their best events according to the FINA 2004 score.

5.2.3. Anthropometric measurements

Athletes visited the laboratories on the 4 testing periods described above for measurement of the same anthropometric variables collected for the previous study (*chapter IV, section 4.2.1.*).

5.2.4. Training load and performance monitoring

Training volume was increased by approximately 50 % (team volume: 33 $km.wk^{-1}$ between control and PRE phases, 50 $km.wk^{-1}$ during the training camp, and then 27 $km.wk^{-1}$ between POST and recovery phases) in each of the swimmers for the 6-day training camp (*figure 5.2*). The quantification of training load was done using the same procedures described in *chapter IV* (*section 4.2.2.*).

5.2.5. Salivary assays

Athletes were asked to provide a sample of saliva as described in *chapter 4*, (*section 2.4.*), for the determination of immunoglobulin A (IgA) and cortisol (C) levels; the same assay technique was also used (*chapter IV*, *section 2.4.*). The saliva sample was collected at the same time of the day (between 6:45pm and 7pm) throughout the testing periods. All athletes' samples were analysed on the same plate; the intra-class coefficient of variance for the IgA was 2.5 %, and 2.4 % for the C assay. The R^2 for both assays was of 0.99.

5.2.6. Incidence of URTIs, mood states monitoring and burnout scores

Incidence of upper respiratory tract infections (URTI) and the Training Distress Scale (TDS; Raglin and Morgan, 1994) were monitored according to the procedures outlined in *chapter IV* (*section 4.2.5.*). The Athlete Burnout Questionnaire (ABQ) (Raedeke & Smith, 2001) was also completed. Both questionnaires were completed immediately after the saliva collection but prior to the swimming training session was started.

5.2.7. Reaction time task

The Stroop test choice reaction time (Stroop, 1935) was completed at the 4 main periods of the study. The athletes were asked to sit quietly in front of a laptop and respond as fast as possible to a 30-task colour/ word stimuli that had as a correct response the matching of the colour of the word (4 possible words: “BLUE”, “GREEN”, “YELLOW”, “RED”), with one of the 4 key-board buttons. The computer then saved each swimmer’s file and calculated the number of correct answers and the average reaction time (measured in milliseconds) over all the 30 options. For purpose of familiarization and habituation all athletes from the sample, during the previous week to the starting of the study had 3 tries at the Stroop test, on the same computer and place, and with the same exact procedures as described above.

5.2.8. Swimming protocol

The swimmers’ performance was also assessed at the 4 main phases of the study at a specific training session. The protocol used was the same 7 x 200m step test, and the same parameters were calculated (*chapter IV*, *section 4.2.6.*). Once more, swimmers swam at different strokes so their swimming velocities were converted to the FINA 2004 score for purpose of comparison.

5.2.9. Competitive performance

Swimmers competitive performance was assessed 2 weeks after the study had finished, at a county level competition, with the personal best time attained in the previous season taken for comparison. Performance was quantified using the FINA 2004 scale as describe in *chapter IV* (*section 4.2.3.*).

5.2.10. Heart rate variability measurements

On the day before (PRE) and the day after (POST) the training camp the swimmers performed the HRV-orthostatic challenge. At approximately 6pm, all swimmers laid down supine quietly for 10 min (with the resting supine data collected in the last 5 minutes of this period), and on a signal from the researcher the swimmer was instructed to stand to an upright position and remain stationary for the following 5 minutes. Resting RR intervals (Polar, Kempele, Finland) were collected with Polar Vantage XL heart rate monitors, set for the R-R recording option. The influence of Respiratory Sinus Arrhythmia (RSA) was controlled for by instructing the swimmer to breath at a rate of 12 breaths per minute in time with an audio signal (Winsley, Battersby and Cockle, 2005). HRV data was cleaned using the Polar Precision Performance software set for a moderate filtering level and subsequently analysed using Kubios HRV Analysis software (version 2.0, beta 4, The MathWorks, Inc., Finland).

Data were analysed selecting the 5 minutes of supine lying just before the standing up and the 5 minutes immediately after. Average HR and the root mean square of the sum of the differences between adjacent RR intervals (RMSSD), were the chosen time domain variables analysed. Frequency domain analysis was performed by auto regressive modelling, set at a model order of 16. The spectrum densities of the different components calculated included: low frequency power (LF; set at 0.04 – 0.15 Hz) in normalised units (n.u), high frequency (HF; set at 0.15 – 0.5 Hz) power in normalised units (n.u), and the low-to-high frequency (LF/ HF) ratio.

5.2.11. Daily training camp data

During the 6 days of the training camp, swimmers were asked to respond daily to 3 different questionnaires: the DALDA questionnaire, Session-RPE (a*ppendix 14*) and the Perceived Recovery Scale (PRS; *appendix 15*). The DALDA was completed before the session, whereas both, the session RPE and the PRS were completed after the session; the PRS was completed approximately 30 minutes after the end of the swimming session.

5.2.12. Data analysis

Data were analysed using descriptive statistics (means and standard deviations), as justified on the previous *chapter IV, section 4.2.7*.

5.3. Results

5.3.1. Performance data

One female swimmer was diagnosed as BO (BO swimmer) based on her high ABQ scores (Raedeke and Smith, 2001; Gustafsson et al., 2007), and the other mal adapted swimmer was diagnosed as overtrained (OT swimmer) due to her physiological and psychological data. These swimmers state was further confirmed by their lack of performance at a county competition; competitive performance had decreased for more than 6 months (performance decreased by 7 % in BO, and by 9 % in OT), whereas the other 2 females improved performance by 4 % (NORM1) and 5 % (NORM2).

Table 5.1 – Descriptive statistics in relation to the anthropometric variables measured at the different periods in the BO and OT swimmers, and NORM girls (N = 2); CP – control period; PRE – before training camp; POST – after training camp; RP – recovery phase; body mass (BM); body mass index (BMI); percentage fat (% fat).

Parameters	CP	PRE	POST	RP
Stature (cm)				
NORM1	162.1	162.6	162.4	162.6
NORM2	172.6	172.7	172.8	172.5
BO	168.6	168.8	169.8	169.0
OT	171.8	171.3	172.4	172.3
BM (kg)				
NORM1	54.8	55.2	55.5	55.4
NORM2	66.5	66.8	68.5	67.7
BO	57.6	58.1	57.6	57.6
OT	59.8	59.1	60.5	60.2
BMI (kg.m^2)				
NORM1	20.8	20.9	21.1	20.9
NORM2	22.3	22.4	22.9	22.7
BO	20.4	20.4	20.0	20.2
OT	20.2	20.1	20.4	20.3
Fat (%)				
NORM1	28.9	28.9	28.5	28.2
NORM2	27.5	27.5	28.2	26.8
BO	24.9	25.5	24.7	24.3
OT	25.4	25.5	25.3	25.1

The sample anthropometric characteristics were within the expected range found in elite swimmers for stature and body mass in 15 year-old athletes. In relation to % fat, these swimmers showed higher values than normal elite female swimmers (20.1 ± 5.0 %) (Wells, Warburton, Haykowsky, Taylor, & Humen, 2006). During the study's 5 weeks there were no significant changes in any anthropometric parameter.

5.3.2. Training load data

All swimmers showed a similar pattern in the volume during the study with NORM1 and OT completing similar and the highest volumes per week (NORM1 = 38.7 $km.wk^{-1}$; NORM2 = 31.1 $km.wk^{-1}$; BO = 29.7 $km.wk^{-1}$; OT = 37.6 $km.wk^{-1}$). The OT swimmer showed a considerable reduction in volume during the 2 weeks that preceded competition (*figure 5.2*).

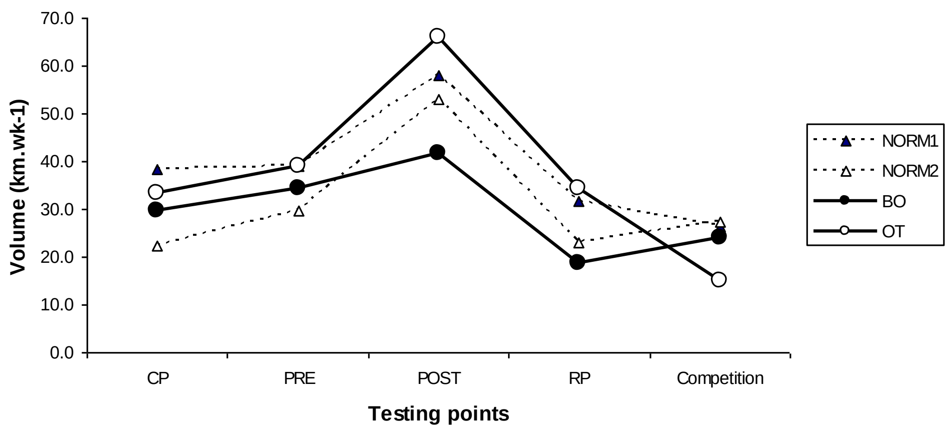

Figure 5.2 – Variation in volume for the 4 swimmers; Volume is expressed in km per week. CP – control period; PRE – before training camp; POST – after training camp; RP – recovery phase.

All 4 athletes swam with similar intensities over the study period, however before competition, intensity decreased to its lowest levels in OT because she was unable to meet the prescribed training intensities (*figure 5.3*).

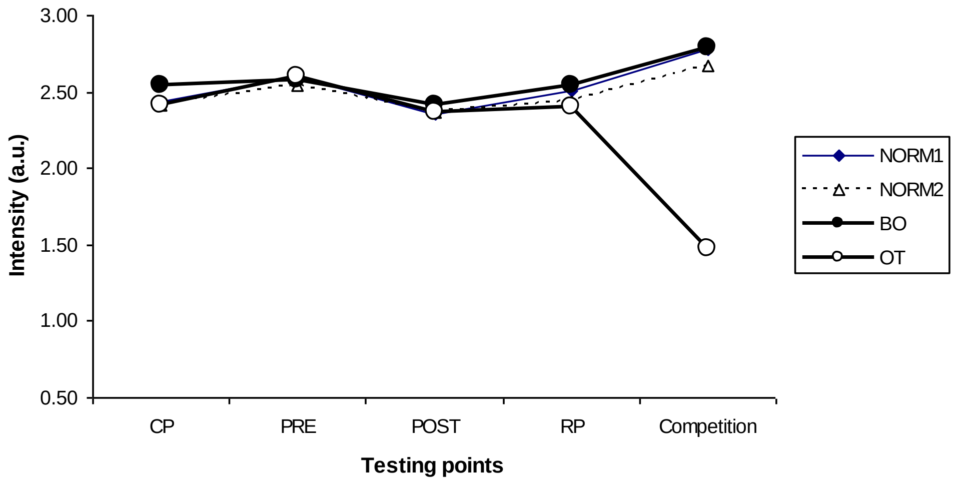

Figure 5.3 – Training intensity for the 4 swimmers; intensity is expressed in arbitrary units of measurement. CP – control period; PRE – before training camp; POST – after training camp; RP – recovery phase.

5.3.3. Biochemical data

5.3.3.1. Immunoglobulin A and URTIs

Immunoglobulin A levels were healthy in all swimmer at the outset of the study, although they became extremely low by PRE in the OT swimmer. Not all swimmers showed a consistent trend after the training camp, with only NORM1 and BO responding with a depression of their IgA, albeit above 40 $mg.ml^{-1}$, and the other swimmers showing an opposite trend (*figure 5.4*). Overall, the BO and OT swimmers IgA levels were lower compared to the NORM swimmers, but only OT presented with an IgA lower than 40 mg.ml-1 (BO = 69.2 $mg.ml^{-1}$; OT = 34.8 $mg.ml^{-1}$; NORM1 = 84.5 $mg.ml^{-1}$; NORM2 = 106.9 $mg.ml^{-1}$).

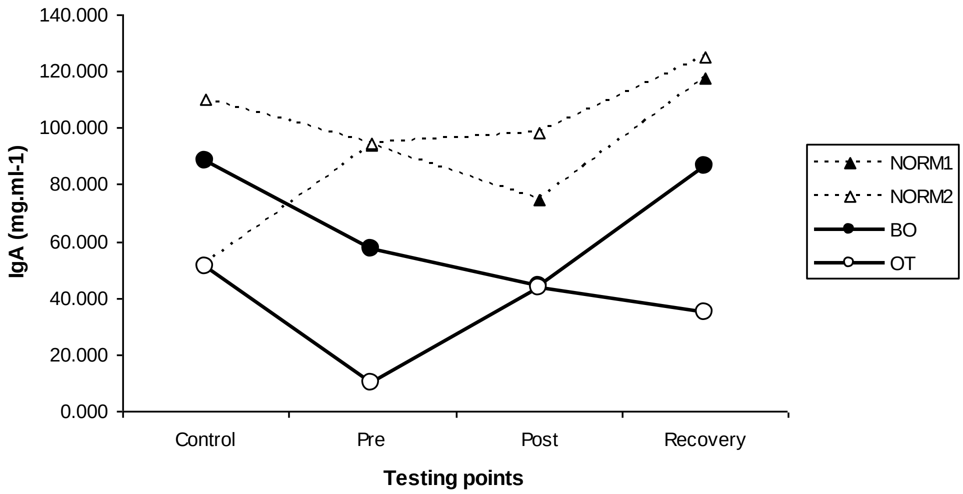

Figure 5.4 – Immunoglobulin A (IgA) variation across the study periods in the 4 swimmers; CP – control period; PRE – before training camp; POST – after training camp; RP – recovery phase.

Only the OT swimmer showed a high number of infections during the study (7 URTIs), especially during recovery (5 episodes); BO swimmer and NORM2 only reported 1 and 2 infections, respectively, during the control period.

5.3.3.2. Salivary cortisol

The NORM swimmers (and BO swimmer although not to the same extent), showed a more responsive cortisol during the study, and responded by POST with a considerable increment in the hormone, whereas in the OT swimmer the increment was negligible (*figure 5.5*). Over the all study, the OT swimmer showed an unresponsive cortisol profile.

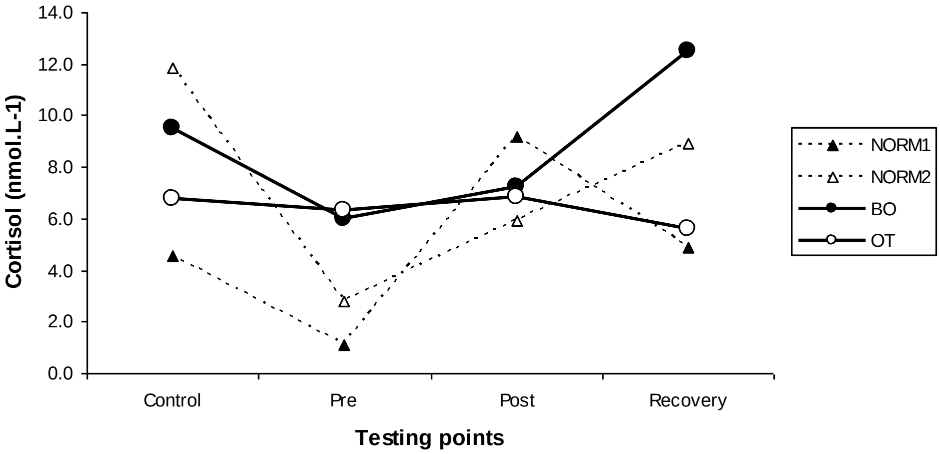

Figure 5.5 – Cortisol variation during the study periods in the 4 swimmers; CP – control period; PRE – before training camp; POST – after training camp; RP – recovery phase.

5.3.4. HRV

These data (both at rest and during the orthostatic challenge) were inconclusive.

5.3.5. Performance test results

There was little variation in swimming performance during the 4 different periods. Paradoxically, an improvement was observed in all swimmers (except for NORM1) after the training camp, followed by a stabilization in the NORM swimmers and BO, and a decrement in the OT swimmer (*figure 5.6)*.

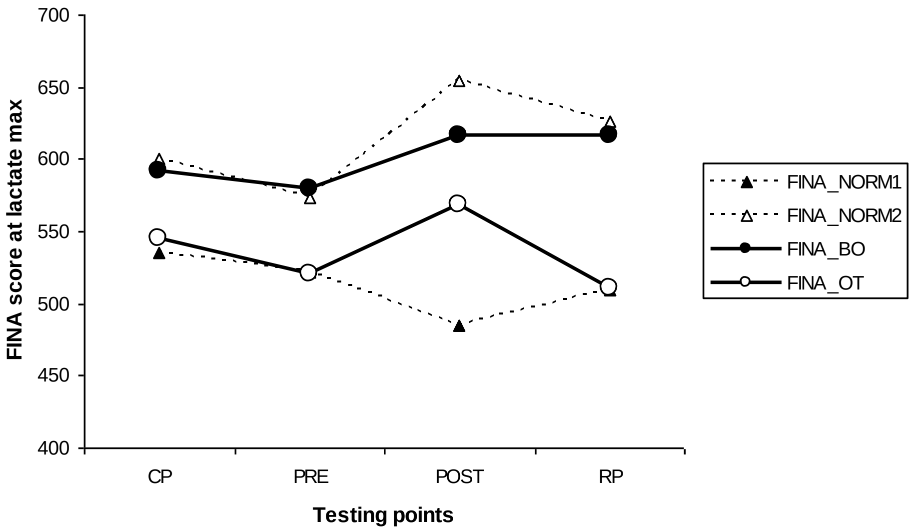

Figure 5.6 – Variation in swimming performance (FINA 2004 score) attained at the last 200m repetition during the 4 study periods in the 4 swimmers; CP – control period; PRE – before training camp; POST – after training camp; RP – recovery phase.

The BO and OT swimmers showed an altered response in comparison with the NORM girls who could consistently produce the same maximal lactate levels. In contrast, the 2 mal-adapted athletes either consistently (OT) or temporarily (BO) could not produce it, with OT swimmer evidencing a progressive depression of her maximal lactate levels throughout the study (*figure 5.7*).

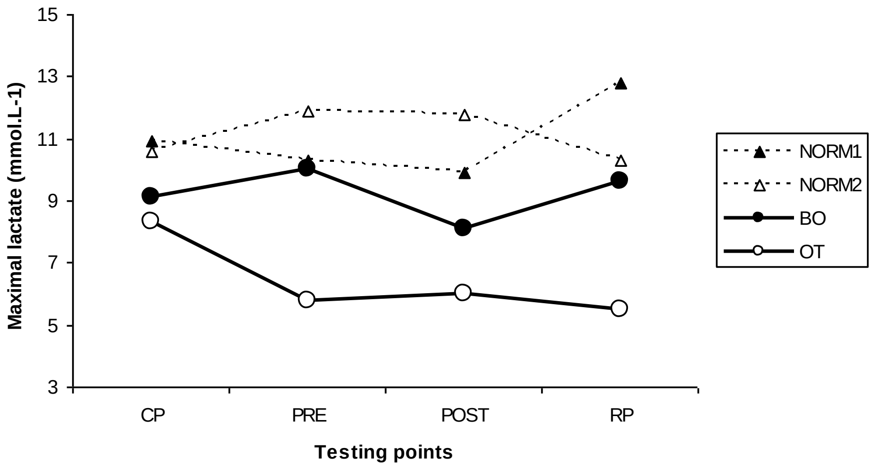

Figure 5.7 – Variation in maximal lactate levels attained at the last 200m repetition during the 4 study periods in the 4 swimmers; CP – control period; PRE – before training camp; POST – after training camp; RP – recovery phase.

There was no definitive pattern in the swimmers' maximal RPE ratings, with all swimmers reporting close to maximum effort (*figure 5.8*).

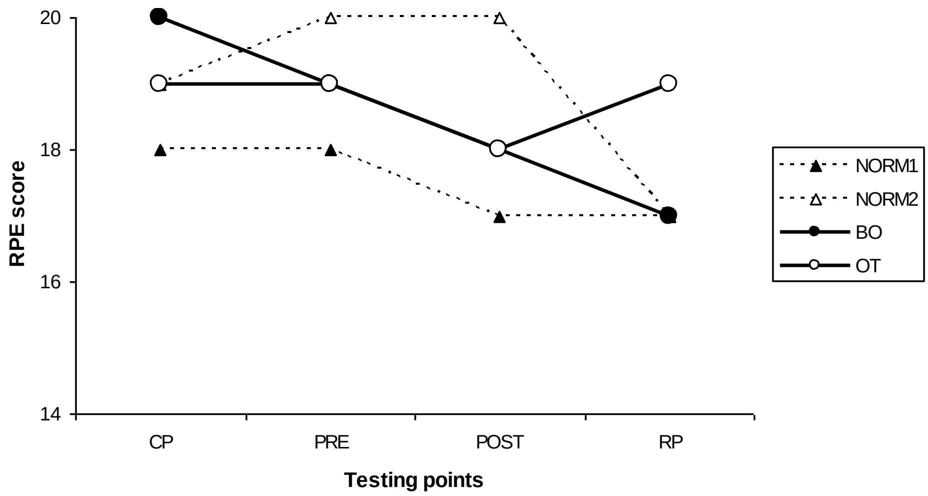

Figure 5.8 – Variation in the RPE score attained at the last 200m repetition during the 4 study periods in the 4 swimmers; CP – control period; PRE – before training camp; POST – after training camp; RP – recovery phase.

The La/ RPE ratio was stable in the NORM swimmers until POST and then increased in NORM1 by the recovery phase. The BO and OT swimmers showed lower La/ RPE values, particularly OT (*figure 5.9*).

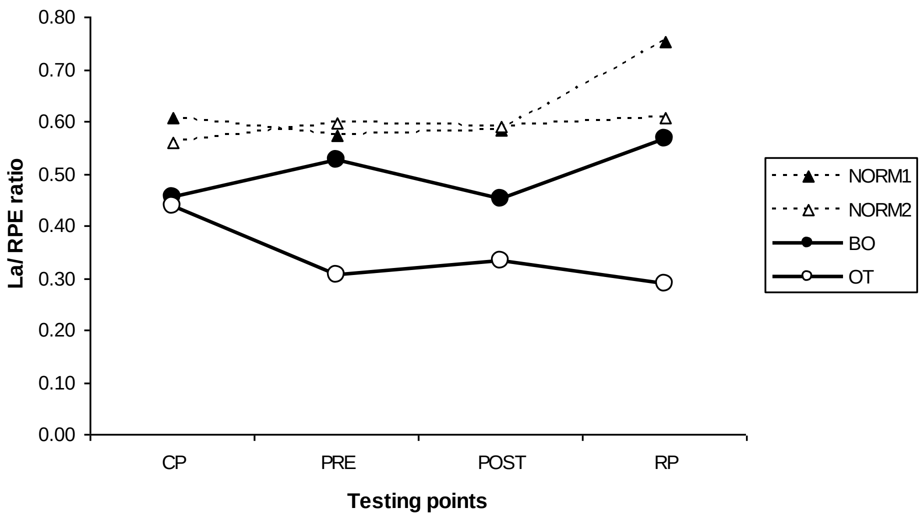

Figure 5.9 – Variation in the La/ RPE ratio attained at the last 200m repetition during the 4 study periods in the 4 swimmers; CP – control period; PRE – before training camp; POST – after training camp; RP – recovery phase.

5.3.6. Psychological data

5.3.6.1. TDS responses

The OT swimmer was considerably distressed at the outset of the study, reduced by PRE and increased until the end of the study. The TDS profile of the NORM and BO swimmers was consistently lower by comparison (*figure 5.10*).

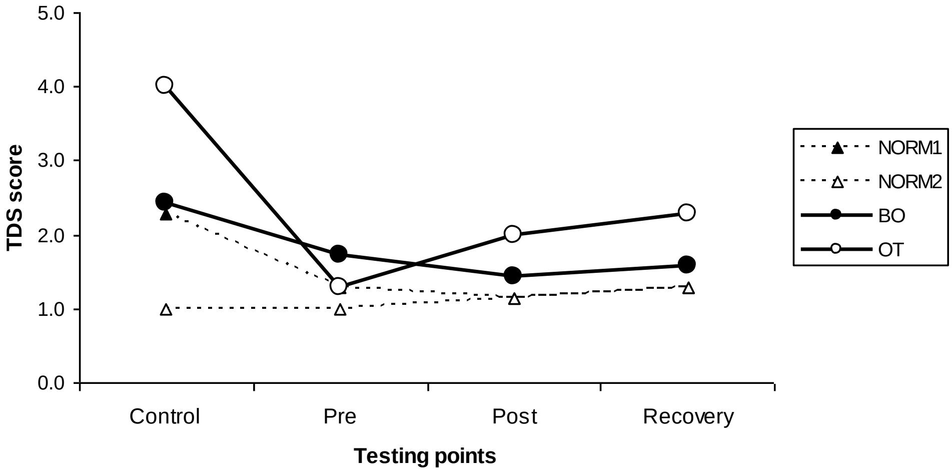

Figure 5.10 – Training distress scale (TDS) variation across the study periods in the 4 swimmers; CP – control period; PRE – before training camp; POST – after training camp; RP – recovery phase.

5.3.6.2. ABQ scores

The BO swimmer reported high levels of reduced accomplishment throughout the study in comparison with the rest of the swimmers, and both BO and OT swimmers finished the study with an increment in the ABQ score that fell within unhealthy levels. By comparison NORM1 maintained a low score throughout, whereas NORM2 reported unhealthy values up until POST that decreased thereafter (*figure 5.11*).

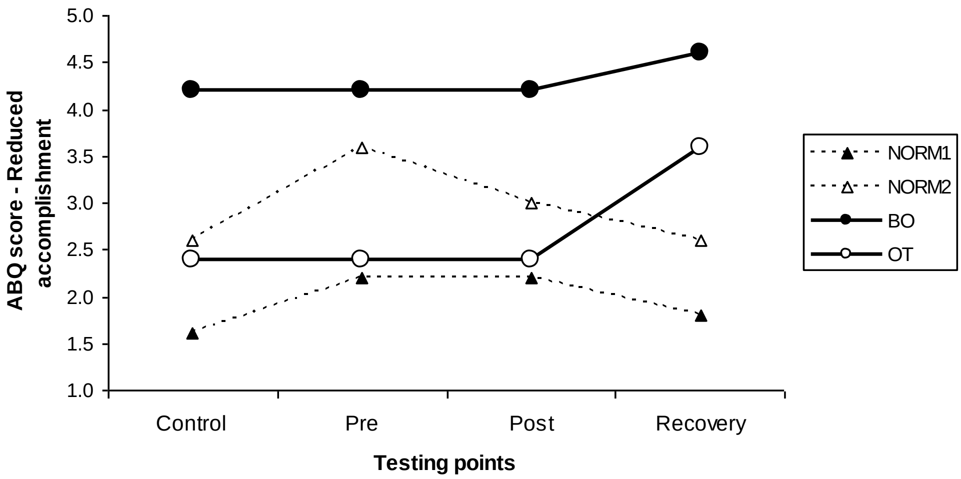

Figure 5.11 – Athlete Burnout Questionnaire (reduced sense of accomplishment) scores across the study periods in the 4 swimmers; CP – control period; PRE – before training camp; POST – after training camp; RP – recovery phase.

During the all study, emotional/ physical exhaustion (ABQe) was generally stable but considerably elevated in the NORM and BO swimmers, with the OT swimmer showing the lowest scores (*figure 5.12*).

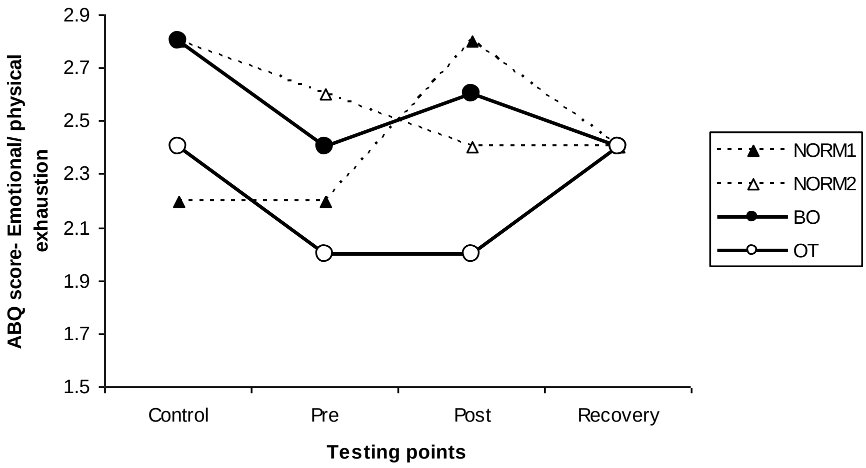

Figure 5.12 – Athlete Burnout Questionnaire (emotional/ physical exhaustion) scores across the study periods in the 4 swimmers; CP – control period; PRE – before training camp; POST – after training camp; RP – recovery phase.

Ratings of devaluation (ABQd) were greater in the BO swimmer through the study, with the rest of the swimmers not showing unhealthy scores (*figure 5.13*).

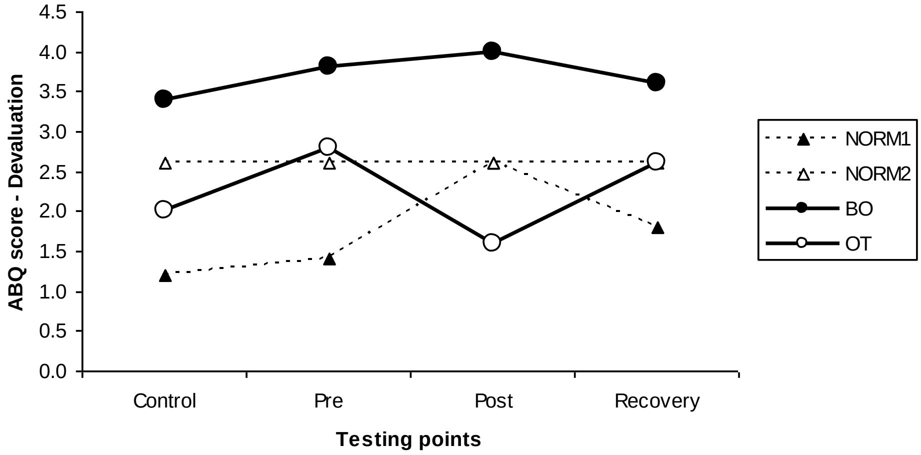

Figure 5.13 – Athlete Burnout Questionnaire (devaluation) scores across the study periods in the 4 swimmers; CP – control period; PRE – before training camp; POST – after training camp; RP – recovery phase.

5.3.7. Reaction time task

The BO and OT swimmers choice reaction times on the Stroop test were slower than the NORM swimmers, in particular the scores from BO (*figure 5.14)*. The OT swimmer was the only athlete who showed a worsening of the scores after the training camp, with NORM2 and BO improving, and NORM1 maintaining a low score.

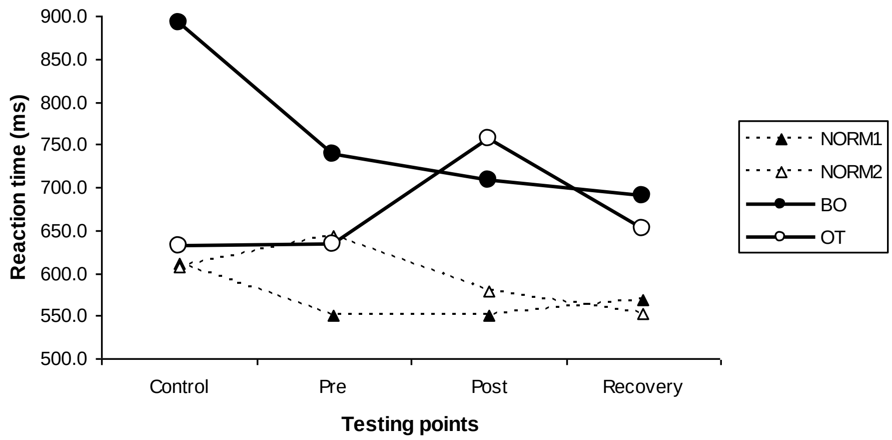

Figure 5.14 – Stroop test reaction times across the study periods in the 4 swimmers; CP – control period; PRE – before training camp; POST – after training camp; RP – recovery phase.

5.3.8. Six-day training camp daily responses

No identifiable trends were found in the responses obtained by the swimmers in the questionnaires (DALDA, PRQ, and Session-RPE) used during the training camp.

It is important to note that the BO swimmer completely withdrew from swimming 2 weeks after the study was terminated.

5.4. Discussion

The OT swimmer evidenced a more depressed immune system, an unresponsive hormonal system, and a high state of distress during the training camp. Further, she also showed a negative performance profile at training with depressed maximal lactate levels. With the BO swimmer her state was more evident when seen through her high ABQ scores and her slow responses on the Stroop test. Importantly, the profile the 2 mal-adapted swimmers presented was quite distinct, although at a main competition, and regardless of their state (overtrained or burned-out), both had their performances considerably decreased (between 7 % and 9 % decrement). The latter contrasts with the NORM swimmers who were able to improve performance (approximately 5 %). Our data parallels other studies who found performance decrements between 5 % and 8 % in mal-adapted cyclists (Halson et al., 2002a) and runners (Lehmann et al., 1991), respectively. Similar performance improvements (between 3 and 4 %) to the NORM swimmers after taper periods have been observed in runners (Bishop & Edge, 2005), and competitive swimmers (Costill, King, Thomas, & Hargreaves, 1985b; Costill et al., 1991; Johns, Houmard, & Kobe, 1992). Training volume did not seem to be, for this particular study, a potential cause of the mal-adaptation, since all 4 swimmers were accumulating similar volumes before the start of the training camp. However, it could be that the chronic accumulation of fatigue due to very high training loads in the past, and through the years, may in fact have contributed to the development of the mal-adaptation. In this regard, it has previously been suggested that the chronic accumulation of high volumes may play a major role for the development of OT in swimmers (Hooper, Mackinnon, Howard, Gordon, & Bachman, 1995b), and that to recover from OT athletes need to have long periods of rest or greatly reduced training loads (Barron et al. 1985; Kuipers and Keizer, 1988).

5.4.1. Immunoglobulin A and URTI's

This study is one of the first to investigate IgA responses in young swimmers to a training camp environment. Only the OT swimmer presented with a depressed IgA profile (particularly before the training camp), and a higher number of infections compared to the other swimmers. Immune system deficits after training camps have also been shown, but in different immune parameters like decreased natural killer (NK) cells ($CD56^+$ cells), and increased of lymphocyte activation antigens ($CD25^+$) (Fry et al., 1994; Fry et al., 1992). Similarly, a depressed immune function has also been observed but after acute exercise for IgA (Blannin et al., 1998; Nieman et al., 2002; Reid, Drummond, & Mackinnon, 2001; Ring et al., 2005; Walsh, Bishop, Blackwell, Wierzbicki, & Montague, 2002), and NK cells (Cunniffe et al., 2010; Malm, Ekblom, & Eckblom, 2004). A study with endurance runners suggested that volume can have a much higher detrimental effect on the athletes' changes in metabolism and catecholamine concentrations than intensity per se (Lehmann, Baumgartl, Wiesenack, & Seidel, 1992a). However, it was not clear from this study if both significant increments in training load and acute bouts of intensive exercise may lead to a depressed immune function in athletes, since only 2 swimmers (NORM1 and BO) showed this response, emphasizing the importance to individualize data.

The mechanisms behind a decrement in the IgA are still not well understood, and there are essentially 3 theories that have attempted to explain it. The most frequently cited theory relates to a lack of glutamine (an amino acid that is essential for the optimal functioning of lymphocytes). Several studies have demonstrated low glutamine levels in athletes (Keast et al., 1995; Kingsbury et al., 1998; Rowbottom et al., 1995), it has consequently been hypothesized that low levels of glutamine in the body depress lymphocyte proliferation, thus rendering the athlete more prone to infections. The open window theory has previously been explained in *chapter II, section 2.4.2*. The most recent theory proposed by Smith (2003) (tissue injury theory) involves T helper lymphocytes (Th), that comprise 2 subsets: Th-1 and Th-2. Th1 are associated with cell-mediated immunity, whereas Th-2 are associated with humoral immunity. When Th-precursors are activated, one subset, Th-1 or Th-2, is upregulated in favour of the other depending on the nature of the stimulus; the upregulation of one subset or the other is determined by the predominant circulating cytokines at the time. When the tissues in the body (i.e. muscle fibres) become injured due to excessive or unbalanced exercise, the circulating pattern of cytokines leads to an up regulation of Th-2 lymphocytes. The increase in Th-2 lymphocytes is further augmented by the elevation of circulating glucocurticoids, catecholamines and prostaglandins E2. The upregulation of Th-2 lymphocytes down-regulates Th-1 lymphocytes and consequently, cell-mediated immunity becomes suppressed. As such, immune cell functions become depressed (Northoff et al., 1998) and athletes are left more vulnerable to viral infections (Smith, 2003). This theory suggests that the increased incidence of illness is not due to a depressed immune function but instead to an altered aspect of immune function that results from a down-regulation of cell-mediated immunity.

Interestingly, all swimmers except the OT one showed a recovery in IgA levels 2 weeks after the training camp had taken place, with the same swimmer keeping her IgA at unhealthy levels. The only training camp-type study that has also monitored recovery showed that the number of natural killer cells ($CD54^+$) was depressed after the recovery period, indicating a depressed immune function (Fry, Morton, Garcia-Webb, Crawford, & Keast, 1992). However, the latter study only had 5 days of recovery, whereas our swimmers had 2 weeks, which could account for the differences seen. Another study purposefully attempted to induce a mal-adaptation in rugby players during 6 weeks of intensified training and a 7-day taper period; they demonstrated that plasma IgA was depressed from baseline after the 6 weeks, and recovered after taper, although to lower levels than baseline (Coutts, Reaburn, Piva, & Rowsell, 2007a). These data parallel the results from our OT swimmer who also showed lower IgA levels compared to baseline. Once more, the recovery period that the rugby players from the previous study were exposed to was shorter than our swimmers, and it could be that if they had a longer recovery their IgA levels would overcome baseline.

There are few studies comparing the immune function of well-adapted athletes with OT or BO athletes. However, there is evidence that has shown that exercise temporarily impairs several immune cell functions (Mackinnon, 1999; Nieman, 1994; Pederson & Bruunsgaard, 1995), and athletes who are engaged in intensive and prolonged periods of exercise appear to be more susceptible to minor infections. This seemed to be the case with the OT swimmer, since by recovery her IgA levels were below 40 $mmol.L^{-1}$, and she reported the highest incidence of URTIs. It makes sense then that an athlete experiencing a mal-adaptation to training, who has to engage in very hard physical training will show a depressed immune function compared with their peers, although the same pattern was not observed in the BO swimmer. It has been suggested that chronic exposure periods of heavy training in adults, may cause both innate and adaptive immunity to become depressed, leaving athletes more vulnerable to URTI's (Gleeson, 2007). The OT swimmer showed depressed levels of IgA throughout the study, which corroborates the results from Mackinnon (1996a) who also found lower IgA levels in overtrained swimmers when compared with healthy swimmers (Mackinnon, 1996a). The increase in IgA from PRE to RP in the OT girl was in parallel with an increased number of URTI's, indicating a normal response to fighting infection - the organism responds by raising their IgA concentration (Gleeson, 2007) - albeit from a lower baseline. It has been argued that periods of high intensity and volume exercise with inadequate rest cause injuries (microtraumas) to joints, muscles and connective tissue.

Consequently, the body reacts by increasing monocyte derived production of cytokines, which then causes a suppression of immune function (Mackinnon, 2000), thus lowering IgA levels, and ultimately leaving the athlete more susceptible to new infections.

Since very few studies have looked at the effects of a training camp increment in training load, it is hard to state whether these athletes are left vulnerable to a higher incidence of URTIs, or if it is simply a normal organic response to the higher stress load. The present study only showed a higher incidence of infectious episodes in the OT swimmer, which could correlate with her lower levels of IgA. Some studies have linked the low acute post-exercise defence levels to a higher incidence of URTIs (Nieman, Johansson, Lee, & Arabatzis, 1990; Novas, Rowbottom, & Jenkins, 2003; Peters, Goetzsche, Grobbelaar, & Noakes, 1996), whereas others have found no direct effect (Nieman et al., 2002; Ring et al., 2005; Walsh et al., 2002). The problem with the approach normally used to determine if the athlete has contracted an infection is that it is done by self-report questionnaires based on Bishop's (2006) definition of URTI. This is open to criticism since the reporting symptoms (e.g., sore throat, runny nose, flu, fever, etc) are subjective and factors other than the infection could actually be the cause of the symptom. Recently, a 5-month study investigated the pathogenic aetiology and symptomatology of URTIs in elite (N = 32) and recreational (N = 31) athletes, and sedentary controls (N = 20). It was found that out of all the episodes reported, only 30 % were due to infectious causes, whereas the remainder were due to non-infectious agents (Spence et al., 2005). Further adding to the problem is that relatively large samples are required, and the majority of studies have investigated only a small group of athletes. Nevertheless, when monitoring URTIs it is important to consider both infectious and non-infectious causes when athletes present with symptoms.

5.4.2. Cortisol responses

All swimmers showed distinct cortisol concentrations at the beginning of the study (control period), with no clear pattern identifiable. The BO swimmer cortisol concentration was elevated throughout the study, suggesting a greater physiological stress response and a shift of her metabolism to a higher catabolic state (Urhausen & Kindermann, 2002). Similar results have also been found in overtrained athletes who reported elevated resting levels of cortisol (Adlercreutz et al., 1986; Barron, Noakes, Levy, Smith, & Millar, 1985), although some studies show unchanged values (Hooper et al., 1993; Meeusen et al., 2004; Urhausen, Gabriel, & Bruckner, 1998) like the OT athlete, and even decrements (Snyder, Kuipers, Cheng, Servais, & Erik, 1995).

After an increase in training load, athletes naturally display an increase in cortisol levels as a response to the physical and mental stresses they are experiencing (Stansbury & Gunnar, 1994), and therefore this may explain the increment seen in the NORM swimmers in contrast with the BO and OT girls. After 10 days of intensified training an increment in cortisol was also observed in a group of swimmers (Kirwan et al., 1988; Stray-Gundersen et al., 1986). Conversely, a similar response was not observed in a cohort of elite canoeists who had their cortisol levels decreased after a 6-day training camp that involved a 50 % increment in training load (Hedelin, Kentta, Wiklund, Bjerle, & Henriksson-Larsen, 2000a). It could be that these athletes were showing a dysfunction of their HPA axis, with a lowering of the production of ACTH due to a negative feedback mechanism attained in the past, that left the cortisol levels of these athletes unresponsive to changes in training load (Gesing et al., 2001), in a similar fashion to the BO and OT swimmers. The fact that the NORM swimmers were the only ones to show a considerable increment in cortisol after the training camp, suggests that their HPA axis was reactive to the training increment. In the BO and OT swimmers their potential chronic cortisol levels may lead to a reduced pituitary sensitivity to cortisol feedback (Gesing et al., 2001), alterations in hormone actions, and changes in muscle metabolism that can ultimately lead to autonomic dysfunction (Mackinnon, 2000). Meeusen and colleagues (2004) have recently suggested a two exercise bout to be taken with mal-adapted athletes where ACTH and cortisol levels are monitored; they showed that their OT athlete could not respond to the second bout like the other healthy athletes, by raising ACTH levels and consequently cortisol levels (Meeusen et al., 2004). An analogous response could be occurring with our mal-adapted athletes since they also show to be unresponsive to the increment in training load, indicating a potential dysfunctional HPA axis response.

It is hard to determine why the BO and NORM2 swimmers had a further increment in cortisol levels during recovery. There is only one available study that has monitored changes in cortisol after an increase in training load and a subsequent taper. Interestingly, they found that cortisol remained elevated after recovery (Stray-Gundersen et al., 1986), just like in these 2 athletes. If an athlete under a mal-adaptation carries chronic elevated levels of cortisol it can have adverse long-term physiological and health effects (Kemeny, 2003), although this is only true for the BO swimmer. The physiological implications of the hormonal profile described in our OT and BO athletes are still not well understood. It is possible that the lack of responsiveness observed after the training camp in the BO and OT girls impairs the resynthesis of protein and glycogen, which could induce a shift in the energy mechanism in favour of an increased fat usage and decreased glycolysis. As such, at maximal intensities the swimmers would have to rely more on fat metabolism for ATP production and consequently having their performance impaired.

It has been proposed that during the acute phases of a mal-adaptation athletes will tend to show high cortisol levels due to a lost of sensitivity of the pituitary gland, which will consequently lead to a higher production of ACTH (Lehmann, Foster, Dickhuth, & Gastmann, 1998), whereas during the more chronic state, athletes would show depressed levels of cortisol (Gabriel, Urhausen, Valet, Heidelbach, & Kindermann, 1998; Kirwan et al., 1988; Urhausen, Kullmer, & Kindermann, 1987). Our data however, shows an opposite trend; the 2 mal-adapted swimmers had not performed for almost 1 year and half, and were used to swimming very high volumes. As such, one would expect that their cortisol levels would be chronically depressed and this was not the case. The only suggestion that can be made out of these data is that their HPA axis was affected and showed a lack of response to a 50 % increment in training load, analogous to the results by Meeusen and colleagues (2004). Still, these could only have been confirmed if the 2 bout exercise protocol had been followed, so we only speculate this to be the case.

5.4.3. Heart Rate Variability data

Although this method of monitoring has been suggested to be used as a promising tool to monitor changes in the ANS related to training, and/ or to identify athletes who are overtrained, data from these swimmers did not show it could be useful. As such, and based on our results we don’t think that this tool can be of help to coaches and sports scientists if it is to be used in the field and for athlete consultancy purposes.

5.4.5. Maximal performance data

The data from the performance test was unclear. Only the OT swimmer showed evidence of a negative response to training. The rest of the swimmers, including the BO one, showed improved swimming velocity at maximal or near maximal intensities, with maintenance of maximal lactate levels. In contrast, and despite a slight reduction in maximal swimming velocity, the OT athlete had a clear decrement of her maximal lactate levels, whilst maintaining a maximal effort. This is echoed by the distinct response she showed in her La:RPE ratio.

The potential reasons behind the decrement in maximal lactate levels in the OT swimmer have been described in the previous *chapter IV* (*section 4.4.6.*). In resume, the performance test data shows the unpredictability of dealing with athletes who are undergoing a mal-adaptation to training, be it NFOR, OT or BO. The latter underlines the caution that needs to be given to relying on one diagnostic variable and hence why coaches and sport scientists need to use a range of measures.

5.4.6. Mood state responses

The TDS scores indicated that the NORM swimmers and the BO one reported a better mood state and less distress than the OT girl. The NORM and BO swimmers distress scores were lower throughout the study, with the training camp not inducing a worsening in their moods. The latter results contrast with many studies that have suggested a worsening of mood states after training camps in healthy athletes (Kentta, Hassmen, & Raglin, 2006; Morgan et al., 1988a). However, these studies have employed the POMS to measure mood states, and as was previously stated in *chapter IV* (*section 4.4.4.*), the TDS scale may be more efficient to determine athletes at distress compared with the POMS. On the other hand, it is likely that the TDS will not detect more subtle mood changes that the POMS is able to detect. These findings echo the results from *chapter IV* (*section 4.4.4.*), whereby the POMS may be more efficient to detect other subtle changes in mood in athletes relative to training variations.

Only the OT swimmer showed that she was under distress even at the outset of the study which suggests the potential use of the TDS to screen for OT before embarking on a training camp. The fact that she had an abrupt reduction in the scores at PRE is hard to explain. It could be that because she was participating in a training camp where only the best swimmers in the club were able to enter, she felt as important and engaged in the group. This could have acted as a higher sense of social support, and because social support is an essential factor influencing success in sport (Gould et al. 1999), she may have benefited emotionally with it. Family and significant others (in this case the coach, the swimmers in the club, and parents) can act as a tremendous source of social support for the athlete (Gould et al. 1999), and if athletes feel supported it is natural that their moods will improve and lower distress will result. On a similar fashion, it could be that with the BO swimmer the sense of support was the same and she was able to show relatively low scores during the study, although a clear reason for this is hard to find.

5.4.7. Burnout scores

Using the ABQ to investigate the deconstruction of the components of burnout during a training camp in young athletes has never been performed previously. Our data demonstrated consistently higher BO scores in the BO swimmer during the study on all constructs in comparison with the other 3 swimmers. The latter gives support to the use of the ABQ as a screening tool for athletes who are close to BO, particularly reinforced by the fact that the BO girl withdrew her practice from swimming 2 weeks after the investigation was completed. These data are also congruent with the multidimensional nature of BO, confirming the 3 constructs in which BO expresses itself (Gustafsson, Kentta, Hassmen, & Lundqvist, 2007b).

The paradoxical response observed in the OT swimmer with the devaluation construct may be related to the fact that this athlete was coming from long periods of time without performing well, which affected her sense of identity in sport (Coakley, 1992). Following from that, this swimmer may have seen in the training camp, one good opportunity to regain her sense of identity by completing a training camp that involved a strong commitment and very high training loads. This could have acted to enhance how she valued her sport, hence the reduction in scores at POST; even though this swimmer was exhausted, that accomplishment in itself could have worked as a boosting in her sense of self. As such, the collective experience of the training camp and the peer/ coach attention could possibly have made her feel less isolated and more supported, thus explaining such changes (Gould et al., 1999).

In the emotional and physical exhaustion construct (ABQe), the only athletes who showed an increment in scores after the training camp were the BO and NORM1 swimmer. Unexpectedly, it was observed that the OT swimmer maintained her scores whilst the NORM2 girl decreased them. The explanation that we find for this outcome is the same presented previously in regards the TDS scores in the OT girl. In this case, both swimmers may have benefited from the training camp which acted as a psychological "boost" due to their participation on it. Our BO girl presented with higher means in all constructs than the ones presented by Maslach and Smith (2001) and by the case-study approach done in 3 BO athletes by Gustaffson's et al. (2007c) study. Our data confirms other studies that showed high scores in all 3 constructs of the ABQ in BO athletes (Golembiewsky, Boudreau, Munzenrider, & Luo, 1996; Gustafsson et al., 2007b; Gustafsson et al., 2007c; Maslach, Schaufeli, & Leiter, 2001), and that the BO girl was defined as an active burnout because, despite the high scores in the ABQ she was still training (Gould, Tuffey, & Udry, 1996a; Gustafsson et al., 2008). The results confirm the state of mal-adaptation that the BO swimmer was experiencing, although more research is necessary to confirm its use as a BO monitoring tool for coaches and sport scientists.

5.4.8. Reaction time responses

Our data regarding choice reaction times in the mal-adapted swimmers - they had on average 18% slower reaction times - compares favourably with the recent work by Nederhof and colleagues (2007, 2008) who found a trend towards psychomotor slowness after a period of high training load and a consequent improvement on the recovery phase (Nederhof et al., 2007; Nederhof et al., 2008). Similar results are normally seen in patients with major depression; 20 - 26% slower reaction times than healthy controls (Nederhof et al., 2006). Athletes who are overtrained typically show concentration problems, attentional dysfunction, cognitive and memory complaints, which results in a poorer performance on a psychometric task (Nederhof et al., 2006). Unfortunately, it was not clear that the NORM swimmers could easily be distinguished from the mal-adapted athletes, since at the beginning of the study the OT and the NORM athletes all had similar performances. As such, more research with the Stroop test is required in order to determine if it can also be useful to distinguish athletes who are developing OT from healthy ones.

5.4.9. Daily questionnaires data

The daily results from the training camp were inconclusive, with no observable difference detected between the OT and BO swimmers and the well-adapted ones. Although these questionnaires have been suggested as valid tools to monitor training responses, stress levels and recovery from training sessions (Coutts, Slatterya, & Wallace, 2007b; Halson & Jones, 2002b; Nicholls et al., 2009; Rushall, 1990), this investigation showed that this was not the case with these athletes. The fact that only 4 athletes were sampled is clearly a limitation on drawing conclusion, however if the purpose of training and monitoring performance is to support an individual athlete (Fry et al., 1992; Fry, Morton, & Keast, 1991), clearly these tools were unable to differentiate between the mal-adapted and NORM swimmers in this study questioning their general usefulness.

5.5. Conclusions

A 6-day training camp induced changes in the physiological and psychological profile of these young swimmers suggesting increased physiological and psychological stress. The OT swimmer showed a distinct physiological and psychological profile to the BO girl, who had her state of BO confirmed only from the ABQ questionnaire. Unfortunately, the mal-adapted state in the OT swimmer cannot be identified at the beginning of the training camp, whilst in the BO swimmer that could have been the case judging from her ABQ scores. In the NORM swimmers, a short period of recovery after the training camp allowed their profile to return towards the recovered state and may have positively contributed to the improved performance. The training camp appeared to worsen the state of the OT girl, although the same was not true for the BO swimmer.

Still, and since performance did not ultimately improve in both swimmers, the time may have been more constructively spent resting or individualizing training with more precision.

CHAPTER VI

Literature Review – Qualitative research

6.1. Scientific methods – Introducing Qualitative Research

For many years, and still strongly present, academic sport physiology together with sport psychology are characterized by their concern with applying rules of science in a way considered acceptable among behavioural/ positivist researchers. However, this paradigm does not allow for individuals to be studied in-depth as human beings (Martens, 1987). The result is that what is deemed external and observable is able to be an object of study, but what is not observable and belongs to an interior realm does not fit the assumptions of empirical and positivistic methods, and therefore is not considered “true”. As Falhberg et al. (1992) stated: “this mistaking of the material part of the human whole has resulted in the use of the same epistemology (empiricism) for humans as one might study and predict outcomes for rats and rockets for example.” (p. 177) (Fahlberg, Fahlberg, & Gates, 1992). In other words, the traditional scientific/ positivistic method requires 3 essential criteria: (a) the phenomenon must be observable, (b) the phenomenon must be measurable, and (c) the phenomenon must lend itself to verification by other observers (Valle, King, & Halling, 1989). The same criteria suggests that studying human behaviour that is quantifiable, observable and, open to verification by independent observers is thus the only valid approach to scientific research (Knaack, 1984). These 3 criteria are also known as the 3 main strands of science: (a) injunction, (b) experiment and (c) confirmation (Wilber, 2001). Importantly, Wilber (2001) argues that these same 3 strands are also used even when looking at phenomenological aspects of human existence, so that they apply not only to an exterior observable reality but also to an interior subjective realm (Wilber, 2001). Polanyi (1958) has recognized the mistake of adopting orthodox science as it has developed in the physical sciences (sports science included) to investigate human behaviour (Polanyi, 1958). He writes, "In the exact sciences, this false ideal is perhaps harmless, for it is in fact disregarded there by scientists. But… it exercises a destructive influence in biology, psychology and sociology and falsifies our whole outlook far beyond the domain of science" (p. vii) (Polanyi, 1958). Scientists cannot be detached from their own values, objectivity, and/ or an unbiased stance about the phenomena they study. Instead, they are very likely to become just as biased, and less objective as other scientists, and therefore not as independent as one considers them to be (Martens, 1987). Importantly, this debate does not imply that the social sciences are the only way to find truth, or that they provide a "better" method to access truth compared to the natural sciences. What is being stressed is that both epistemologies are extremely useful and, if put together, they will provide a more realistic and complete account of reality, and not leave findings partially constructed. The aim is to work with a science that progressively becomes more integral, i.e. less partial. Fortunately, the sports science community has recently been recognizing that to gain more in-depth knowledge and understanding about sport phenomena, quantitative and qualitative approaches are required; in regards the latter, qualitative methods have fortunately been gaining more credibility (Dale, 1996; Jackson, 1998; Munroe-Chandler, 2005). Importantly, my stance is to do science that, as much as possible, will consider both the exterior and interior realities of phenomenon and will work researching these "two" sides of reality.

The adoption of a sociological perspective in research has been strengthened by the work within the philosophy of science of neorealist philosophers elsewhere (Bhasker, 1978; Outwhaite, 1987). In this regard, Mennel (1989) stated: “by removing hypothetico-deductive nomological theories from the central place in their conception of the natural sciences, the neo-realist philosophers have been able to argue that the social sciences are sciences in exactly the same sense, but not exactly the same ways as the natural sciences… the neo-realists are able to accept that all the sciences consist in establishing patterns of connections between observed events, but they do so by many different methods and use different methods” (p. 198-199) (Mennel, 1989). In summary, a more complete picture of human beings, in the case of this thesis, athletes, can be made if they are studied “in the round”, viewing individuals as a whole, and not as isolated physiological and psychological entities (Maguire, 1991).

6.2. Qualitative research methods

When trying to understand athletes’ lives, their thoughts, perspectives and emotions become very important, and consequently taking a perspective of an objective interpretation of reality becomes both difficult and incomplete. As a consequence, qualitative research has gained more interest and is starting to be used on a more frequent basis in sport science research (Cutliffe & McKenna, 1999; Dale, 1996; Jackson, 1998; Munroe-Chandler, 2005), since it provides an insight into the interior realities of both, the individual and the collective (Wilber, 1997). As Flybjerg (2004) recently stated, social science is problem-driven and not methodology-driven. On the contrary, quantitative methodologies are applied when one wants to investigate cause and effect, or for hypothesis testing (Bryman, 1988; Cresswell & Eklund, 2003).

Introducing qualitative inquiry in this work is justified by the complexity of overtraining as a social problem (Coakley, 1992), and as such a multidisciplinary approach of the problem may provide a better understanding (Kentta & Hassmen, 2002; Meehan, Bull, Wood, & James, 2004). The growth of qualitative methodologies in science has raised important ontological and epistemological questions, or has questioned the researcher's role during data collection and analysis, and essentially, how a relativistic perspective can still produce important findings (Altheide & Johnson, 1994). According to Maxwell (1996), qualitative research methods have got several strengths, one of them being a better understanding of the meaning participants give to the events and actions they are involved with, and an account of how they experience their lives. Further, it allows a more in-depth study of the context within which individuals act and how the latter influences their decisions. Finally, it enables an understanding of the process by which events and actions occur (Maxwell, 1996). As such, qualitative research can help improve practice rather than simply assessing the exterior and objective value of the phenomenon under evaluation (Scriven, 1991). For this study the use of qualitative methods may bring new insights into the understanding and experiences of training and overtraining in young swimmers as it will provide information regarding the personal experiences of the athletes through their training. Additionally, understanding an athlete's perspective of how he/ she sees themselves in the sport may allow for other sources of stress to be acknowledged rather than the ones coming from training.

6.3. Validity issues in qualitative research

Validity is the scientific concept of the everyday notion of truth, and has got different meanings depending on the methodologies being used. In qualitative research, validity relates to the extent to which findings accurately reflect the purpose of the study and how much they give an account of reality (Holloway, 1997). Wolcott (1994) suggests that, quite often, validity acts as tool for scientific accuracy for those who identify closely with a positivistic stance and for credibility among those who don't (Wolcott, 1994). In this regard, Sparkes (1998) has argued that this concept should be abandoned so that alternative criteria to judge someone's' work can be found. Both inside and outside the academic world, the creation of boundaries and their maintenance is a socially constructed process. Consequently, specific criteria are often required to judge what is acceptable and unacceptable within any tradition (Sparkes, 2000). Whenever issues of truth or validity are being considered it becomes evident that there is a need to use appropriate but different criteria to evaluate the different forms of qualitative inquiry (Denzin & Lincoln, 1994).

The issue of authenticity in criteria have grown from post-modern philosophy in that it states that there is no single or objective truth, and as such, authenticity is held to be both a relativist ontology and subjectivist epistemology (Sparkes, 1998). As researchers continue debating authenticity they find more open-ended and flexible criteria, and consequently become freer from the positivist and post-positivist paradigm and its notions of criteria (Sparkes, 1998). Since qualitative inquiry is held by different epistemological and ontological assumptions it makes little sense to impose criteria used to pass judgment on one upon the other (Sparkes, 2000). Therefore, the differences between diverse forms of qualitative research need to be recognized in terms of the paths and steps taken during the investigative process, in order to be consistent with researcher's own internal meaning structures. Consequently, one's judgement is continually shifting and is therefore characterized by being flexible and open rather than stable and closed.

Postmodernism is based on the premise that reality is dependent on the cultural and social context that every human being is involved in, and therefore is a relativistic and pluralistic one (Wilber, 1997). However, the latter does not mean that simply because all truths are context-dependent they should be accepted. As an example, to say that a swimmer's experience of overtraining is the same as the experience of a businessman at work is surely not correct. Therefore, criteria should be judged within the trained community who have a deeper understanding of the phenomenon, and to leave it to anyone's interpretation simply because reality is relative would be a serious mistake and a strong impediment for good qualitative inquiry.

There are fundamental differences between positivism and naturalistic inquiry in qualitative research.

6.3.1. Reality

Positivism rests on the assumption that there is one single reality that can be discovered and studied by the scientist; there is a straight relationship between the word (objects, events, phenomena) and our perception and understanding of it. According to Kirk and Miller (1986), "the external world itself determines absolutely the one and only correct view that can be taken of it, independent of the process or circumstances of viewing it" (p. 32) (Kirk & Miller, 1986). In contrast, in qualitative inquiry reality is seen as socially constructed, therefore reality can be seen as multiple, relativistic and pluralistic (Wilber, 1997).

6.3.2. Relationship of the researcher to the participant

Because of a socially constructed world, for a researcher to study anyone's reality, he must get close to the person being studied, which strongly contrasts with the more distant and objective position of the positivist researcher (Lincoln & Guba, 1985). In qualitative research, the researcher is in fact the instrument of analysis, so his or her qualifications are important for the credibility of the investigation. As such, a description of the researcher is important for the reader to judge on the validity of the work (Patton, 2002).

6.3.3. Generalisability

The fact that reality is socially constructed limits the extent to which generalisations can be made. As such, qualitative research tends to work with a relatively small number of participants (Lincoln & Guba, 1985). Despite being impossible to know who or how many people share a particular experience, once the same experience is identified, one concludes that it is available within a particular culture and society. Consequently, each individual's experience becomes potentially generalisable (Kippax, Crawford, Benton, Gault, & Noesjirwar, 1988).

6.3.4. Causality

For positivists, proving causality in events is considered to be an advanced stage of the research process. However, in qualitative research, separating "causes" from "effects" is questionable, since events mutually influence each other; as such, the separation of both concepts is not recommended (Lincoln & Guba, 1985). The human being is inevitably linked to the world in which he/ she lives, independent of what he/ she does; the individual and the world are not separate from each other, so one cannot study an individual without incorporating he's/ her's own world, and vice-versa (Dale, 1996).

6.3.5. Reflexivity

Reflexivity is an important aspect that affects the validity of the findings. Unlike the positivist paradigm, in qualitative research the investigator has an interdependent influence in the research process (Henwood & Pidgeon, 1992). Reflexivity in qualitative inquiry implies that the researcher's previous experience is acknowledge to the reader and that his/ her knowledge influences the research process as well as the outcome of the study, i.e. its findings (Mays & Pope, 2000). A critical friend during the interpretative process is also important so that reflexivity is encouraged and potential sources of bias found (Marshall & Rossman, 2006).

6.3.6. Member checking

Member checking adds credibility to the findings of the study, because it provides an opportunity for the participants to give an opinion about the findings of the study; some researchers consider this to be a good technique to assess the credibility of findings (Lincoln & Guba, 1985). In contrast, since data are abstracted, synthesized and interpreted, participants may not recognize themselves and their personal experiences (Sandelowsky, 1993), which could bias the findings. Still, Stake (1995) argues that participants can actually provide critical observations and interpretations, sometimes making suggestions to sources of data, increasing trustworthiness to the researcher's observations and interpretations (Stake, 1995).

6.3.7. Data triangulation

The idea behind triangulation is to gather evidence in more than one way in order to provide support to the findings, which has been described in the previous sub-sections. It may however, also involve collecting data from different methodologies (qualitative and quantitative) (Patton, 2002), like questionnaires, and other psychological and even physiological variables, which was the case with the case-study in the following chapter (*chapter VII*).

There are several methodologies that can be used in qualitative research designs: from case-studies (Stake, 1995; Yin, 1994), to interpretive phenomenological analysis (IPA) (Smith, 1996, 1997; Willig, 2001b), to ethnographic designs (Faulkner & Sparkes, 1999; Sparkes, 2002), to grounded theory (Strauss & Corbin, 1997) and more. For the purpose of this thesis, the focus will be on case-study and IPA methodologies.

For the following case-study (*chapter VII*) we felt it was important that 2 different analysts independently studied the data, checking findings with the informants and using the critical friend procedure. The other measure we used to provide trustworthiness was thick description. Since our experience as individuals is affected by the environment we are surrounded by, and consequently our interpretations and intentions, letting the reader know the relevant aspects of the research process is important so that the he/ she can value our work (Yardley, 2000). As such, information about the main researcher and detailed descriptions of the procedures and analysis are provided. Finally, a detailed description about the athletes using quotations to illustrate the findings help the reader to judge the people and situations, thereby enhancing the transferability of the findings (Elliot et al., 1999).

6.4. Case-study design

Case studies have become one of the major methodologies used in qualitative inquiry. Several times, researchers in education and social service want to investigate people and programmes, with each case-study being similar in many ways, but also unique in many other ways. As such, what the researcher is interested in is the uniqueness and commonality that case-studies share (Stake, 1995). The case study is not itself a research method. Instead, it constitutes an approach to the study of singular entities, which may involve the use of a wide range of diverse methods of data collection and analysis (Willig, 2001a). As Stake (2000) puts it, "case study is not a methodological choice but a choice of what is to be studied" (p. 435) (Stake, 2000). The case could be a child, an adolescent, a cancer patient or an OT athlete. The important is that the case is one amongst others, and for any given case, the focus will be on the single case itself (Stake, 1995).

6.4.1. Case study characteristics

Case studies can make use of both qualitative and quantitative data. Still, and despite such diversity, it is possible to identify a number of defining features of case study research. These include:

1 – An *idiographic approach*. This is taken when the researcher is interested in the particularities and details rather than the general. How one learns from a singular case is related to the case's characteristics and how distinct from others it is (Yin, 1994). The aim is therefore, to understand an individual from its particularity. This approach contrasts with a nomothetic one, because the latter aims to identify general laws of

human behaviour by investigating individual responses (Willig, 2001a). After the researcher's narrative is produced, the reader is given an opportunity to identify with the experience being described; this process is called naturalistic generalisation (Stake & Trumbull, 1982). The reader comes to know some things told, as if he or she has experienced it. Further, because the reader is involved in a social process its understanding of the issue is enriched. The case study emerged therefore, from a social experience and observation, and the narrative describes what has happened partly in terms of what others reveal as their experience (Stake, 2000).

2 – Attention to *contextual data*, by taking a more complete approach, simply because it considers the case within its context. With its own unique history, the case is influenced by a number of contexts that can be physical, psychological, economic, ethical, aesthetic, and so on. As such, a holistic case study calls for the examination of these complexities. Since social phenomena are situational and influenced by events of many kinds, much of the qualitative research is based on a holistic view of reality (Lincoln & Guba, 1985). In other words, the researcher places the main focus on the ways in which the various dimensions of the case relate and interact with the environment (Willig, 2001a).

3 – *Triangulation*, a process that enables the integration of information coming from different sources, in order to gain a more complete understanding of the phenomenon. This may involve the use of a range of data collection and analysis techniques within the framework of one case study. Triangulation has been generally considered a process of using multiple data sources (quantitative and qualitative) that help clarifying certain aspects of the interpretation. Further, and despite understanding that no observations or

interpretations are repeatable, triangulation may also help finding new perspectives to study the same phenomenon (Flick, 1998; Silverman, 1993). This, in turn, facilitates an appreciation of the various dimensions of the case, as well as its connections with the social, physical, symbolic and psychological realms (Willig, 2001a).

4 – A *temporal element* is present because case studies are concerned with processes that take place over time. This means that a focus on change and development is an important feature of case studies (Willig, 2001a). According to Yin (1994), it is important to establish how and why a complex human situation is a classic example of the use of case studies (Yin, 1994).

5 – Finally, case studies are also characterized by its *concern for theory*, i.e. they facilitate theory generation. Case studies can provide insights into social and psychological processes, which consequently allow for theoretical formulations and hypothesis. Furthermore, case studies can also be used to test existing theories or to clarify certain theories, by looking at cases that deviate from what is considered to be the norm (Willig, 2001a).

6.4.2. Types of design for case study research

Case studies can be conducted for different reasons. One may want to focus on a particular case simply because it is interesting in its own right or because it is seen as representative of a certain situation. The researcher may also want to focus the research on a single case, or may seek to compare a number of cases in order to arrive at a more general understanding of the phenomenon. Finally, the researcher may want to purely explore the case or he/ she may want to use it to test an existing theory. In addition, it may be predominantly descriptive or it may aim to generate explanations for specific events. As such, in case study research there are several different designs that can be combined, but they are essentially: *intrinsic* versus *instrumental*, *single* versus *multiple*, and *descriptive* versus *explanatory*.

1 - *Intrinsic case studies* happen when a researcher decides to study some phenomenon because he/ she finds it interesting. The researcher wants to study the case in particular, rather than studying a more general phenomenon. This type of case-study is undertaken not because it illustrates a particular trait or problem, but because the case's particularity itself is of interest to the researcher (Stake, 1995, 2000; Willig, 2001a). On the other hand, *instrumental case studies* are used when the researcher wants to provide insight into an issue and/ or to generalize from the findings (Willig, 2001a). Importantly, the phenomenon under study is of secondary interest to the researcher, but it plays a supportive role, and facilitates our understanding of something else (Stake, 2000).

2 - *Single case studies* relate to the study of a single case, and are chosen because they may challenge a previously formulated theory, or because they may represent a unique or extreme case that, once more, is of particular interest for the researcher. It is also possible that the case being studied may give insight into something that was previously inaccessible (Yin, 1994); rare case studies can be of extreme value for the researcher to understand. *Multiple case studies*, in contrast, provide the researcher with an opportunity to generate new theories. Theoretical formulations can be developed and by comparing different cases. The researcher analyses the first case and formulates potential hypothesis that can then be tested in light of the evidence given by other similar cases; multiple case studies are considered to be instrumental (Willig, 2001a).

Whenever a new case is analysed, the theory emerging from it is modified and adapted according to the findings, a process also know as analytic induction (Smith, 1997).

3 - A common feature in case studies is that they are all descriptive. However, some will be purely descriptive and therefore called *descriptive case studies*, whereas others give the reader explanations for the phenomenon and, as such, are called *explanatory case studies*. The former are concerned with making a detailed description of the phenomenon within its context, and they are not interpreted in relation to any existing theory; the aim is to provide enough detail to generate new insights into the phenomenon. Explanatory case studies aim to generate explanations of phenomenon, so the interpretation of the findings is paralleled by attempts to deploy explanatory concepts within the account. As Brombley (1986) put it, the explanatory case study "goes beyond mere narrative or description" (p. 32) (Bromley, 1986).

The study presented in *chapter VII* is an instrumental, single and explanatory case-study.

6.5. Interpretive Phenomenological Analysis

Interpretive Phenomenological Analysis (IPA) derives from phenomenology, which is a school of philosophical thought that underpins all of qualitative research. Qualitative research draws from the philosophy of phenomenology in its emphasis on experience and interpretation. Phenomenological psychology developed from Husserl's philosophy, which can be described as "an individual's personal perception or account of an object or event itself" (p. 263) (Smith, 1996). Phenomenology is interested in the world as it is experienced by human beings within particular contexts and at particular times, rather than in more general statements about the nature of the world. It is concerned with the phenomenon as it appears in our consciousness as we engage with the world around us. In the conduct of a phenomenological study, the focus is on the essence or structure of an experience (phenomenon). According to Patton (1996) this type of research is based on "the assumption that there is an essence or essences to shared experience. These essences are the core meanings mutually understood through a phenomenon commonly experienced. The experiences of different people are bracketed, analysed and compared to identify the essences of the phenomenon, for example, the essences of loneliness, the essence of being a mother, or the essence of being a participant in a particular programme. The assumption of essence, like the ethnographer's assumption that culture exists and is important, becomes the defining characteristic of a purely phenomenological study" (p. 70) (Patton, 1990). Phenomenologists are expected to represent the essence of experience. As such, prior beliefs of the phenomenon of interest are temporarily put aside, in order to avoid interfering with the interpretation of the phenomenon. According to Spiegelberg (1965) a researcher must have an intuitive grasp of the phenomenon and then investigate similar examples to gain a deeper understanding of its essence. Then, the researcher should attempt to systematically explore the phenomenon as it appears, either focusing on particular or general issues, and on the process by which the phenomenon develops (Spiegelberg, 1965). Even though it is hard to summarize what phenomenology is, Moustakas (1994) gives a statement that captures its principal tenets: "The challenge facing the human science researcher is to describe things in themselves, to permit what is before one to enter consciousness and be understood in its meanings and essences in the light of intuition and self-reflection. The process involves a blending of what is really present with what is imagined as present from the vantage point of possible meanings; thus, a unity of the real and the ideal” (p. 27) (Moustakas, 1994).

By using IPA one can capture an individual’s personal experience and social behaviour, and add another element that other modes of qualitative inquiry do not allow, i.e. describe the subjective experience and meaning making that is inherent to individuals (De Visser and Smith, 2006). The aim of IPA is to explore the participant’s view of the world and to adopt, as far as possible, an “insider’s perspective” (Conrad, 1987) of the phenomenon under investigation. At the same time, the researcher also acknowledges that the investigative process is a dynamic one. Despite attempting to become close to the participant’s personal experience, one cannot do this directly or completely. It is a paradoxical relation since access is both dependent on, and complicated by the researcher’s own conceptions of the world, which, on the other hand, are required to interpret the other personal world through a process of interpretative activity. As such, IPA can deepen the understanding of a phenomenon previously only studied quantitatively, and allow for a useful dialogue between quantitative and qualitative practices (Smith, 1996).

CHAPTER VII

A case-study of a young burned out female swimmer

With this PhD having ended the previous study with an athlete who was an active BO and who, 2 weeks after the same investigation had terminated, decided to withdraw from practice, it felt logical that the story of this swimmer would be studied through qualitative lens, and as a case-study approach. As such, this case-study explores the story of a national-level swimmer who, through the years of practice, experienced OT that culminated into her state of BO, and complete withdrawal from the sport.

7.1. Introduction

Early work into BO focused on people working in the human services, with one of the first works being presented by Freudenberger (1974), with his study into BO among volunteers at a New York drug rehabilitation clinic. Some years later, Christina Maslach, the well known social-psychologist, started describing BO as a gradual process of emotional exhaustion, depersonalization, and reduced personal accomplishment amongst poverty lawyers (Maslach & Jackson, 1984). However it was not until the 1990's that work into BO in sport was published (Kelley & Gill, 1993; Vealey, Udry, Zimmerman, & Soliday, 1992).

It has been suggested that BO develops from OT along a continuum, with some authors describing it as the most difficult and serious outcome of the same continuum (Kentta, 2001a; Silva, 1990), and believe that there is a sequential link between overtraining and burnout (Gould, Tuffey, & Udry, 1996a; Kentta, et al., 2001b). However, there is still debate as to the relative positioning of overtraining and BO – are they sequential or parallel entities (Winsley & Matos, in press) - with only one study available to support this model (Gustafsson, Kentta, Hassmen, Lundqvist, & Durand-Bush, 2007c). Essentially, the different stages of the training continuum have been studied as separate and individual entities, and no connections within stages attempted. It is not clear for example when does functional overreaching (FOR) develop into non-functional overreaching (NFOR), or when does NFOR develop into OT, and when/ if OT can develop into BO? Also, there is now evidence that some athletes can present high BO scores and yet remain training; when this is the case, the athletes are considered to be *active burnouts* (Gould, et al., 1996b; Gustafsson, Kentta, Hassmen, & Lundqvist, 2007b) because they are still involved in the sport, albeit at a decreased level; in contrast the non-active BO will have completely dropped out from their sport.

One of the potential factors underlying this confusion is that OT and BO both share similar characteristics. However, although OT and BO share similar characteristics this does not imply that they are identical phenomena (Gustafsson, et al., 2007c). This is based on the premise that athletes under an OT state or even an NFOR state, will maintain their motivation to keep training and competing, whereas BO athletes will typically show very low motivation levels to continue in their sport (Cresswell & Ecklund, 2005; Gould & Dieffenbach, 2002; Gould, et al., 1996a). Overtraining research has focused more on the symptomology of the mal-adaptive response (Fry, Morton, & Keast, 1991; Kuipers & Keizer, 1988), whereas BO research has investigated the social and psychological factors, related to high external pressures, lack of control and entrapment (Gould, et al., 1996a; Gould, et al., 1996b; Raedecke, 1997) and so this has led some authors to argue that OT and BO are different entities (Raglin, 1993). In contrast recent research into OT is focusing equally on non-training factors and suggesting the problem to be holistic in nature (Matos & Winsley, 2007; Meehan, Bull, Wood, & James, 2004), which makes the boundaries between these two phenomena unclear.

It is known that sporting related BO is a phenomenon that involves psychological, emotional and physical realms of the athlete, and that most possibly, it will lead to withdrawal from sport, as a result of excessive stress in the athlete (Raglin, 1993). Furthermore, it manifests itself through physiologic, psychologic, situational and behavioural components of excessive stress (Gould, Udry, Tuffey, & Loehr, 1996b), hence, BO is a phenomenon that must be studied taking into account all these factors. In an attempt to try and explain BO, several models have been developed by sport scientists, the most well know being the ones developed by Smith (1986b), Silva (1990) and Coakley (1992). Smith's (1986b) cognitive-affective stress model was created from general psychology research on BO. It proposes a 4-stage process in the development of BO: the first stage relates to the athlete's overload through practice and training time, and to the early pressures to win coming from significant others; in stage 2, the demand is not perceived equally by participants, with some athletes viewing situations as more threatening and overwhelming than others; the third stage relates to the physiological response (e.g., insomnia, fatigue) to the threatening situation such as competition; finally, stage 4 is described as the moment where by the athlete creates his own coping mechanisms to deal with stress, that can then be observed by his/ her decrement in performance, interpersonal difficulties and withdrawal from the activity. In this model, all the four stages of the BO process are influenced by personality and situational factors (Smith, 1986b). For example, some young athletes are so perfectionist or have limited ways to deal with their perfectionism that they perceive high levels of stress in situations other elite athletes don't consider to be physical or psychologically demanding. Conversely, athletes who may not have a perfectionist personality but are placed in situations where psychological stress is generated from others, particularly parents, may also burnout (Gould, Tuffey et al. 1996a). In Silva's model (Silva, 1990), BO is understood as a negative adaptation to training, moving from a continuum of NFOR, to OT and eventually terminating in BO - "an exhaustive psychophysiological response exhibited as a result of frequent, sometimes extreme, but generally ineffective efforts to meet excessive training and sometimes competitive demands" (Silva, 1990, p. 11). Coakley's (1992) model, the first one to focus specifically on adolescents, instead of investigating the psychophysiological stress the individual experiences through training, views the problem through a collective perspective, where the social infrastructures in which elite sports (e.g., time demands, training/ competitive schedule) are embedded do not allow the young athlete to develop a healthy multifaceted identity. Coakley (1992) argues that the social environment/ structures that surround the young athlete are organized in such ways that leave them powerless to make decisions and to voice their problems about the experiences they have during their development through sport (Coakley, 1992). Further to the BO models, certain aspects of athletes' personality have also been emphasized by Feigley (1984) as traits that can be potentially dangerous for the development of BO (perfectionism, lack of assertiveness skills and the need to please others) (Feigley, 1984; Gould, Jackson, & Finch, 1993).

Even though the knowledge on BO has grown considerably over the last 20 years (Goodger, Wolfenden, & Lavalee, 2007), its empirical base still remains relatively small, leaving the factors behind the development of OT and/ or BO still unclear. Since both Smith's and Silva's models of BO are adult-based and Coakley´s one is the only available in regards young athletes, the reality of BO needs to be more researched in order to ascertain the suitability of all the accepted models of BO for use with young athletes. In addition, there are very few reports available on the phenomenological experience athletes have when undergoing a process of mal-adaptation. As such, the purpose of this project was to use IPA (Smith, 1996) to explore the experiences and views of a young female swimmer who was in an active BO state, using a combination of quantitative (ABQ scores) and qualitative data.

7.2. Methods

7.2.1. Participant

A female swimmer was purposefully sampled to participate in the study. This type of sampling has been used extensively in qualitative methods as it allows the capture and study of specific phenomena that otherwise would not be available or easily accessible (Merriam, 1998; Patton, 1990). The participant was made aware that her involvement was voluntary and confidentiality would be assured. With the agreement of the coach and after both, swimmer and parents read the information sheet (*appendix 16*) and provided informed consent (*appendix 17*) the swimmer was invited to participate in a retrospective interview about her swimming and personal life experiences. For purpose of anonymity and confidentiality (Willig, 2001a) the pseudonym *Kate* will be used to refer to the athlete whereas the pseudonyms *Phil* and *Steve*, will refer to her first and second respectively, most influential coaches. Kate's club (Club X) was known to produce high-level national athletes, including Olympic swimmers, giving it a respected status around England. Phil coached Kate during 3 years (11 to 14) and Steve coached her during 1 year up until the time the interview took place, when she was 16. The reason why Steve started coaching Kate was because Phil was sacked from the club and Steve was employed; the club directors and parents were unhappy with Phil because a lot of the swimmers had been underperforming for a long time.

7.2.2. Quantitative data – Athlete Burnout Questionnaire

The quantitative data chosen for this study was used to enrich the analysis (Moran-Ellis, et al., 2006) and to increase the credibility of the findings using triangulation (Moran-Ellis, et al., 2006; Patton, 2002; Yin, 2003). Kate's ABQ (Raedeke & Smith, 2001) individual data obtained at the end of the training camp study will be presented to give evidence of her BO state.

7.2.3. Qualitative data

7.2.3.1. Main researcher background

The main researcher of the study had a long history as a swimmer, competing at both national and international level. Further, he also trained with Club X (having Steve as his coach) during the year that preceded the interview and had therefore a close interaction with the main swimmers in the club and Kate. The researcher retrospectively acknowledges that he experienced OT in his late teenage years and then after went on to develop BO. The fact that the main researcher had such a strong involvement in swimming in his past, allows for credibility of the findings to be judged (Patton, 2002). This background allowed the researcher to understand in greater depth the demands of the sport, subculture and terminology used, which helped foster an open, trusting and mutual bond between the main researcher and the participant. This was essential so that the qualitative data provided by the participant would be more truthful and rich, thus ensuring validity and an ability to judge the findings from the viewpoint of the participant (Eklund, 1993). The main researcher has also received qualitative methods and case methodology training during his post-graduate studies as outlined by Patton (2002).

7.2.3.2. Interview

The interview was semi-structured and was conducted in a comfortable environment (chosen by the interviewee) with only the main researcher and the swimmer present; this was to ensure that sensitive and complex issues could be spoken about with no major obstacles (Shuy, 2002). The interview guide (*appendix 18*) relied on open-ended questions allowing the interviewee to speak frankly and without constraints to fully discuss her experiences (Rapley, 2004). The concepts of overtraining/ burnout were not addressed until the end of the interview and were discussed between interviewer and interviewee. This was to avoid any negative bias towards both concepts, which can be found in sport settings (Gould, et al., 1996a).

We only took one interview because, at the time it was done, it was part of a different project in this PhD that involved interviewing more swimmers. As such, it was only possible to collect data at one time point, although having done 2 interviews, especially after the athlete had dropped-out from swimming would have been helpful to add even more trustworthiness to the findings.

7.2.3.3. Data analysis

The transcript from the interview was analyzed using Interpretive Phenomenological Analyses (IPA) (Smith, 1996). The interview was individually analyzed by the main and second researchers; after having read through the transcripts 3 times to become familiar with the data the emergent raw-data themes were discussed. The researchers then met and discussed the analysis until consensus was reached, with only minor differences pertaining to how the analysts' interpreted important events found. Next, both looked for connections and similarities between the raw-data themes, which were later organized into categories and subcategories; this part of the analysis was mainly conducted by the main researcher with support from the second investigator. Finally, Kate's individual case profile (narrative) was written based on the themes and categories. Kate's case profile was then discussed in the research group until consensus was reached. After additional extensive reading of the transcript, a case narrative was constructed from the case profile. Kate then read the narrative to check for accuracy and adequacy (Lincoln & Guba, 1985; Yin, 2003), with subsequent personal discussion of the themes as part of the member-checking procedure (Lincoln & Guba, 1985); the narrative was discussed extensively with Kate until consensus was reached and the final case-study developed.

7.3. Results

7.3.1. Athlete Burnout Questionnaire

After the year-long study (*chapter IV*) Kate was diagnosed as OT due to a lack of performance (Meeusen, et al., 2006). Three months after the interview Kate participated in the training camp study (*chapter V*); Kate's ABQ scores were high, for both *reduced accomplishment* and *sport devaluation* constructs (*table 7.1*), confirming her as an *active burnout* (Gould, et al., 1996b; Gustafsson, et al., 2007b).

Table 7.1 - Kate's ABQ average scores (Mean ± SD) for each of the 3 constructs observed in study 3; Reduced sense of accomplishment (RA); Emotional/ physical exhaustion (EPE); and Sport Devaluation (SD).

	RA	**EPE**	**SD**
Study 3	4.3 ± 0.2	2.6 ± 0.2	3.7 ± 0.2

7.3.2. Qualitative data

Figure 7.1 illustrates the main theme (factors associated with OT and BO), and corresponding higher-order themes that emerged from the IPA analysis done on the interview. These were analyzed in form of a narrative with IPA as the method for interpretation.

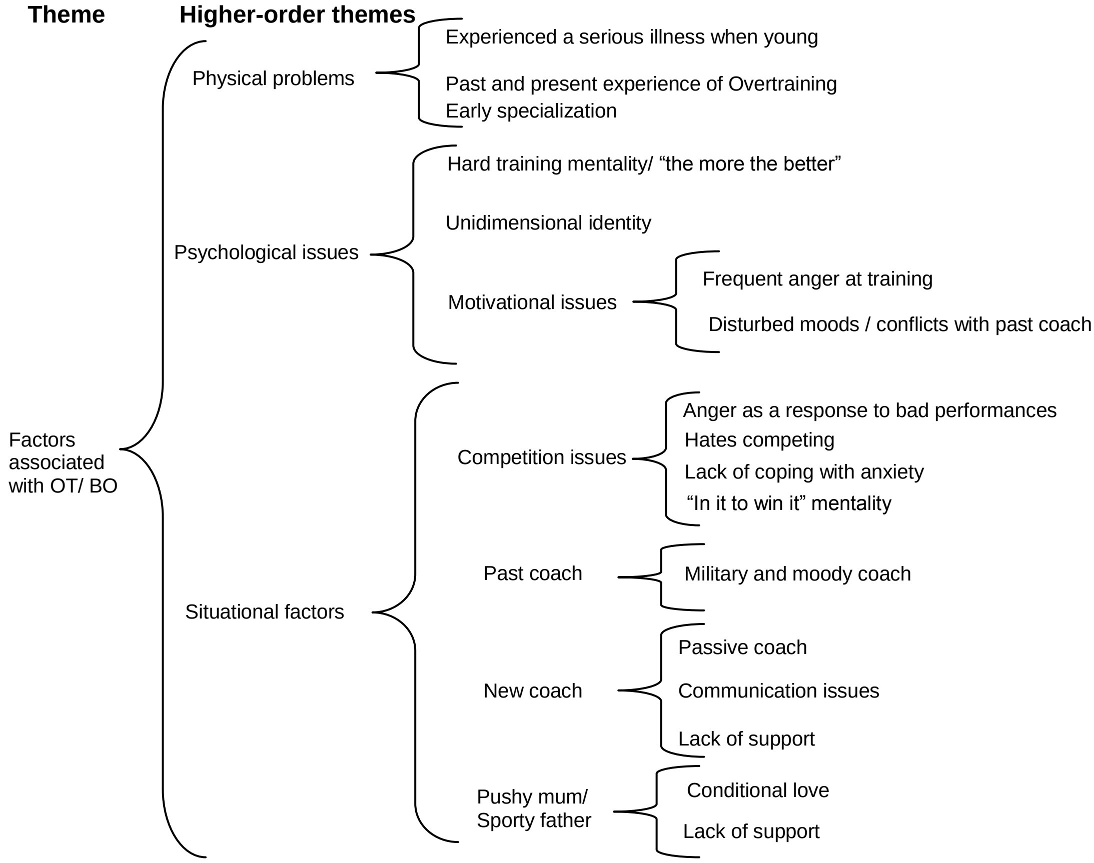

Figure 7.1 – Hierarchical structure of the theme "Factors associated with Overtraining/ Burnout" that emerged from Kate's interview.

7.3.3. Analysis

This case study will be presented as a narrative rather than thematically based on the work of Smith (1996, 1997) and Gustafsson et al. (2007c), who have used IPA and developed their case-study analysis as narratives justified by the idiographic nature of the interpretation.

Too much training at an early age, first experience of overtraining at the age of 13, a military coach, and a pushy mum, all collapsing in the end of a career of a talented swimmer

Kate had an uncommon childhood; she was born in England and at the age of 3, together with her parents she moved to America and lived there for 4 years. Then, the family moved back from America (Kate was 8 years old) and she started swimming in a local club. She was very talented and progressed quite fast: "*I was the best in my class at primary school, so I got into swimming and then I was alright and then I was like in top lane with all the older boys*". Early in her swimming years (age of 10), Kate left home to train and live at Ruletta College, known for the high training loads young swimmers have to abide to, and for producing top swimmers in the country; she stayed there 3 years. During her third year (13 years old) she developed a serious state of overtraining: "*…then I got really ill cause I was doing too much training*", which seemed to be related to the high training loads she had been exposed to, together with the stress of living away from home at such an early age. Her experience of OT was so debilitating that she stopped swimming completely for a long period of time: "*…I was off school for 9 months and then came home*", and had to drop out from the school and come back home to live again with her parents.

Having experienced training at Ruletta College, Kate developed "the more the better" philosophy, which remained as such during the following years training at X swimming club with Phil (her new coach after Rulleta College): "*Its like if you decide that you want to go all the way and you're prepared to put it in. Then you're gonna have to suffer, like you'll burn*". Kate's understanding of high intensity training is explained with some excitement and raise in her voice tone: "*Hard! Hard work! And a lot of it! Yeah!*". After the hard times she experienced at Rulleta College and having stayed 9 months off training, the new experience with Phil in terms of performances was a positive one for the 1st year and half, and Kate does well at county and national level. From here, another mal-adaptation starts developing and Kate experiences another episode of overtraining, this time with Phil when she does not want to be present at training, providing evidence that what happened during the year paralleled with her elevated sport devaluation (SD = 3.7) and emotional and physical exhaustion (EPE = 2.6) dimensions of the ABQ:

> *"…when I didn't want to go back to swimming, I didn't want to do it, I didn't enjoy it anymore because I was so tired all the time. I found it really hard (…) and it was hardly any people coming because everyone was just like that, nobody was getting their times (…) and he was making the training harder so that we would benefit more, but everyone just got ill, kept getting ill all the time."*; "*I was so tired all the time. I found it really hard*"

Kate's performance, deteriorated further with the coming of Steve to the club, and not aware that she was experiencing OT, she describes her past in swimming as "*I haven't swam that badly, apart from this year*", making a clear reference of how things did not go well with the coming of Steve to the club. The latter may also relates to why her reduced accomplishment (RA = 4.3) dimension on the ABQ was high: "*This year (…) I dropped 13 seconds*". For Kate, her past was filled with ups and downs and, after several negative experiences, she was facing one of her final chances of becoming a world-class swimmer.

Phil's methods were different to Steve's which brought more stress to Kate because she did not believe Steve's training worked for her: "*I don't think his training works for me personally (…) its just that I don't think there's enough of it, or at the intensity it should be at, cause he does do hard sets, but its just once every month probably*". Kate refers to her previous training with Phil: *"…a week at school, with pool mornings and 5 evenings, about 9 sessions which are all quite medium to high intensity training. Not easy… 9 sessions!*". Furthermore, she justified her lack of performance during the year due to the lack of training, even though, together with the other OT girl (*chapter IV*), she was completing the highest monthly volumes: *"…this year you didn't know whether the pool would be working (…) I think they [significant others in the club] knew that I wouldn't get them [good performances], so in way there was no way around it*".

During the time the main researcher spent with Kate (*chapter IV*) it was already clear that Kate had a *pushy* mum, who would come to the anthropometric measurements and frequently call her child of "*fatty*", making Kate feel very insecure and accentuating the insecurities in regards her physical appearance. As an example, when Kate goes on vacations or when she misses training she feels "*fat and lazy*", and uses her swimming status to make her feel superior to other people: "*It gives you something over other people to say you are like a national level swimmer and they don't have anything to say; they just go home and watch TV*"; "*Like you have learnt a language and you're an obese… I think that doesn't make you feel really good*". Kate's physical appearance is very important and so as long as she is not fat then she can remain confident when asked about what are the main benefits swimming brings: "*Appearance that's probably the biggest one and you're like physique. Like you're not fat or obese*".

Kate also developed a strong identity related to swimming, with the majority of her life focused around swimming: "*Like you always have to train, never get a social life (...) sometimes you want to do something and then you can't because you've got like a competition and your training*". When she was asked about how much of her life revolves around swimming, she said: "*A lot! Quite a lot, yeah. Not like the main basics like going to school, but before and after school. The good majority of the day*", with her swimming friends being "*an extended family (...) they're like the first people you see in the morning and then the last people you see at night*". Kate goes on to say that "*I wouldn't change things*", demonstrating how attached her identity is to swimming. Then she shows some confusion or lack of clarity related to why she swims: "*I only train and compete 'cause that's what I do (insecure laughter). I don't know I just want to swim for a long time and carry on*".

Although Kate continuously shows a great passion for swimming, her motivation, moods and emotional state at training are constantly affected (leaving her moody and/ or angry) either by other swimmers: "*because if someone turns and I run into him or someone's scrapping you, or… that makes me angry and I just feel better when I'm angry*"; "*If someone annoys me, which they do quite regularly (insecure laughter) then I get really angry*" or simply by the previous events of the day: "*if I've had a good day then I'll be alright… I'll just swim up and down. If I'm really tired I just get annoyed and count down how long I've got left and want to get out*". Kate also complains of regularly being in a bad mood: "*I think sometimes, quite a lot of times I'm just feeling medium (insecure laughter), but it depends what happens while I'm there, like if I get bad splits from swimming, I'll just be like... (sad face)*".

Her relationship with her old coach Phil was not good, and she frequently gave evidence of past conflicts with him: "*I used to get on well with Phil (...) I used to get on well with him half the time and I didn't the other half cause I used to talk back to him all the time when I didn't agree with what he was saying or doing*". On the other hand, Phil seemed to also manipulate Kate by "teasing" her and taking advantage of her personality trait to become angry easily: "*he knew what he was doing and he knew he was like annoying me (insecure laughter) (...) he knew that would make me angry*".

Phil gave the impression of a being a military-type coach, with a style that would often be patronizing and use hard measures to bring strict discipline in the group of swimmers: "*So like if someone does something wrong and then he starts everyone doing the set again…*", or if any swimmer would miss a session "*because of school or something else*" Phil "*would just ignore you for a week (...) he likes to be in charge*". In contrast, Steve had a passive presence in the club which would contrast with Phil's style, which was hard to cope with for Kate, since the support she felt from Steve and communication with him were not good: "*I like Steve… he's a bit quiet, he's very quiet actually, and you can see he's annoyed*"; "*…he stands on the pool side like (…) shaking his head, but he wont ever tell us what's wrong*". In regards competition, Kate does not feel supported by Steve due to his passive attitude: "*he does support you when you're racing but I think he's just a bit… soft, not that it's a bad thing but it's not good either*".

In competition Kate's coping mechanisms were poor, and many of the similar issues present during the training sessions were also present, especially the amount of anger Kate would show in regards bad performances: "*Normally I get angry and decide not to* *go swim (...) I don't like doing badly. I don't cope with losing very well either (insecure laughter)*". If Kate would swim really badly then she would decide not to go training and would miss several sessions, which would obviously annoy Phil: "*If I lose for just a little bit it just makes me angry and so I just train more and want to beat whoever (...) but if I lose and I don't get my time by miles then I just don't go training (insecure laughter*)". Her inability to cope during competition was evident along with her perception that competition was a hard experience for Kate to tolerate due to the amount of pressure she felt: "*I actually like swimming. I like training. I don't like racing at all. I hate racing! (...) I don't like the pressure, I get really nervous. I don't know, I've always hated racing, but I like training*".

Kate also shows how her mentality when competing is a destructive one, since she only counts on one outcome (i.e. to win), not allowing space for learning to occur when she loses. This is also most possibly an influence of her parental guidance who taught her to be "*in it to win it*", as the following example shows: "*If you haven't been brought up to become competitive or… unlazy (laughs), I don't think you have as much motivation and it's harder to motivate yourself to do something*". She even admits that her parents taught her that mentality: "*…it's your parents, they're either like, they're in it to win it, or they're just taking part*" After being asked what her position in competition was Kate immediately stated that she is "*in it to win it, definitely!!*".

It is not surprising that Kate developed this mentality, especially when considering that she had a military coach, a "in it to win it" mentality, a "*pushy mum*" as she described her, and a very competitive father who is in the Royal Marines: "*he's in the marines and he's quite competitive*". Although Kate's father seemed to be very competitive and used to the hard discipline from being in the Marines, he yet seems to be more understandable and flexible in regards her performances than the mother or Phil: "*…my dad knows what it's like to do a sport and training (…) my dad he still cycles* and he *runs. He used to be really into rugby when he was younger; he used to be in the triathlon team and stuff*". In contrast, the mother had a different view of Kate's swimming performances, and shows evidence of a conditional love based on good performances: "*my dad's quite good, he just accepts everything (…) whereas my mum just gets annoyed when I do badly and then she gets really happy when I do well (insecure laughter)*". And when she did not perform well at competitions her mother was described as "*…extra pushy if you don't do well… like she was really patronizing, she used to be really annoying about it*".

7.4. Discussion

The narrative has shown that both concepts, overtraining and burnout, are multifactorial in nature. That is, they are influenced by external (objective and interobjective) and internal factors (subjective and intersubjective) (Wilber, 1997). The external relate to bio-physiological issues and social structures, whereas the internal relate to the athlete's psychology and personality issues, and to cultural and relationship factors. This reinforces past findings that have suggested this phenomenon to be multifactorial and therefore, to be studied accordingly (Dale and Weinberg, 1990; Meehan et al., 2004). Raglin (1993) stated that "research paradigms that attempt to integrate psychological and physiological sources of information can potentially provide a more complete understanding of overtraining and staleness" (p. 848). Furthermore, this case study supports the possibility that overtraining and burnout are part of a continuum with BO as the final result of the mal-adaptation that eventually leads the athlete to withdraw from sport (Gustafsson et al., 2007; Gould, Tuffey et al., 1996a; Kentta, 2001; Winsley and Matos, *in press*). Not only, Kate gave evidence of her past overtraining experiences (*"…I got really ill cause I was doing too much training*"), but also she was diagnosed as OT based on her lack of performance after the year-long study (*chapter IV*). Her scores from the ABQ from *chapter V* have further helped confirm her state of BO, and have given trustworthiness to the findings from this narrative (Patton, 2002). Further, adding qualitative data to the study from *chapter IV* has deepen the understanding of her experience as an active BO by providing an "insider perspective" (Patton, 2002), and has shown how so many factors are acting together to produce the mal-adaptation (Meehan et al., 2004; Gustafsson et al., 2008). Considering that Kate withdrew from sport after the training camp study (*chapter V*), it is clear how the spectrum of the mal-adaptation has been completed (Kentta 2001; Winsley and Matos, *in press*).

In Kate's case her state of active BO seems to be related to physical factors (past and present high training loads, together with past experiences of OT) and to other situational factors (non-training stressors) that also have contributed to the mal-adaptation. Her ABQ scores that were collected 3 months after the interview however support that BO can take different forms, since her emotional and physical exhaustion construct (EPE) were lower than the other two constructs (reduced accomplishment; RA, and sport devaluation; SD). Still, Kate's attachment to "the more the better" philosophy and high training loads, may have contributed to her state of BO. However, it is clear that she also had to contend with the high psychological stress as a result of the lack of control and entrapment over her sporting life(Gould, Udry et al., 1996b; Raedecke, 1997; Coakley, 1992). The latter data agrees with Gustafsson and colleagues (2007) who also found a similar situation in a former cross-country skier, whereas in 2 other athletes BO was more related to physical factors. Her constant moody and angry state, communication issues with past and present coaches, “pushy” mum, and lack of performances, contrast with the fact that she still maintained the motivation to continue in sport, and once more provide confirmation of Kate as being an active BO (Gould, Udry et al., 1996b). Our data is also supported by Cresswell and Eklund’s (2007) investigation with professional New Zealand rugby players who showed high BO scores but still maintained their motivation to keep training and competing over a 12-month season. In the case of Kate, staying in sport with all the negative experiences she was having is most possibly because of her years growing as a swimmer, whereby she developed a strong swimming identity that left her incapable of dealing with the problems she was facing; mixed with low performances, Kate had long-term communication issues with her coach, had been and was under pressure by her mother, and still, she decides to remain swimming. Her state of active BO may have developed because she could not construct or develop a desired social identity apart from her swimming identity (Coakley, 1992), and was therefore entrapped and even unaware of her present state, since she refers in the past to her experience of OT: “*This was with Phil towards the end of last year* ”. Nevertheless, the narrative indicates that Kate experienced exhaustion, devaluation for her swimming and performances, and reduced accomplishment, the three core dimensions of BO.

Kate describes a history of being talented and successful at a very young age and how that led to her being picked up by her coach \and quickly starting to train with the older and more developed swimmers. She was very motivated to train since she would do, by the age of 13 that involved per week “*9 sessions which are all quite medium to high intensity training*”. However, the serious nature of early involvement in deliberate practice leads to less enjoyment, which in turn may lead more young athletes to drop out or BO from sport (Côté and Fraser-Thomas, 2008). Even though motivation is known to be a key feature of success in sport (Durand-Bush et al., 2001), her early success together with her strong motivation, and "the more the better" mentality were all factors that helped the development of her OT and later state of active BO. Furthermore, being very successful at a young age, also contributed to the development of a strong unidimensional identity (Coakley, 1992; Kentta and Hassmen, 1999; Webb et al., 1998). The addition of a strong identity to an early specialization also was clearly a problem for Kate. Children who specialize in their sport without trying other sports and developing general motor skills applicable to other sports are more likely to have an unhealthy development through sport (Baker and Cobley, 2008). Baker and Cobley (2008) have suggested that a diversified approach to early development leads to better sport specific performance and can still lead to elite performance in sport. This varied approach leads to more chances to meet other friends away from a single sport, thus helping the development of a multi dimensional identity (Coakley, 1992).

From Kate's case it is clear how identities are formed through an accumulation of experiences through social relationships (Stryker and Serpe, 1982; Thoits, 1983), and how this process is a complex one; Kate was a young talented successful swimmer who only focused on one sport (swimming), with a father who took sport very competitively and a mother who always followed her to training and competitions. Further, the parents' mentality of being "in it to win it" was passed to Kate and became a very strong feature in her personality. The critical role that parents play in their children's growth in sport is essential. Gould and colleagues (2006) found that 36 % of the parents had unknowingly emotionally hurt and interfered with their child's development.

Parents are not only the gatekeepers of sport opportunities for their children but also serve an important role in how they influence the child's interpretation of the sporting experience (Frederick and Eccles, 2001). Kate developed a performance based self-esteem that continuously left her vulnerable and angry within her swimming environment. When a strong and fixed identity is combined with a performance based self-esteem, athletes easily become stressed because they are continuously at the mercy of a good performance (Crocker, 2002). Further, Kate was likely to grow with an ego-involved orientation since the demands placed on her reinforced the development of an ego-oriented goal instead of an arguably healthier task-oriented goal (Nicholls, 1989; Roberts and Treasure, 1995). The latter characteristic also contributed to her active BO, as has been previously shown that intrinsic motivation is negatively associated with BO (Goodger et al., 2007). Coping with adversity, i.e. coping with levels of anxiety and perceived stress is extremely important in sport, particularly at an elite level where pressures tend to be higher; athletes who are better at handling the demands placed on them are at lower risk of BO (Goodger et al., 2007). With Kate this was hardly the case since she showed to become very nervous under competitive environments, to react with anger at her competitive friends or club friends, therefore leaving herself open to stress. For Kate to be happy within swimming she had to perform well and this was her "fuel" in swimming for her self-esteem, which she constantly had to pursue. However, her strong drive to succeed and improve self-esteem was just another factor influencing her state of active BO (Gustafsson et al., 2007).

Kate was still showing hopes for her future as a swimmer and would see herself swimming *"at hopefully high level",* even though she had not experienced any success for the past 2 years. This questions the assumption that athletes under a state of overtraining will still maintain their motivation to train, whereas athletes who have lost their motivation to train are considered BO (Gould, Tuffey et al., 1996a). However, it has been previously shown that even athletes that are experiencing extreme overreaching or overtraining can either be high or low in motivation (Kentta, 2001). It is possible that Kate's strong identity did not allow her to reflect and admit that things were not going well. For someone who had past experiences in OT and BO, and who had been under an OT state for the previous 2 years, Kate seemed to be deluded because she would still like to see herself swimming by the age of 25. The motivation she shows in regards the future, at the time of the interview, can be clouded by her self unawareness. This is evident since 3 months after the interview she takes the decision to quit swimming and try water-polo as a new sport. As such, it is possible that during the interview Kate had no more motivation to train, but she could not admit it because she was so tied to her unidimensional identity (Coakley, 1992). The only times where references to low motivation were made was on how Kate would react to very bad performances (she reported that she would give up half way through the event and have a "don't care" attitude); similar characteristics have also been reported in swimmers (Raedecke et al., 2002) and rugby players (Cresswell and Ecklund, 2005a). Further, when she reflected on the possibility of being overtrained whilst training with Phil she showed the signs of having low motivation: "*I didn't want to go back to swimming, I didn't want to do it, I didn't enjoy it anymore because I was so tired all the time*". The distinction between OT and BO may, not only, reflect temporal issues in regards the timing of motivation assessment (Gustafsson et al., 2007), but also they may be related to psychological issues which connect to the athlete's identity. It needs to be emphasized that Kate's decision to drop-out from swimming occurred at the very end of the training camp (*chapter V*), whilst during the start of the study and the actual training camp her motivation to train was still high; being an active BO she still made the decision of going through a week with a 50 % increment in training load. It is therefore possible that some athletes may be scared to admit that they have lost their motivation to train and yet they can be very close to drop-out from sport. In summary, these data give support to a sequential link between OT and BO, as proposed by other authors (Gould, Tuffey et al., 1996a; Kentta, 2001), with the end product of the spectrum of the mal-adaptation being BO (Winsley and Matos, *in press*).

The symptoms described by Kate are consistent with previous qualitative research studies (Cresswell and Eklund, 2005a; Raedecke et al., 2002; Gustafsson et al., 2007). Kate gave evidence of having issues within all the 3 constructs of the ABQ. In regards to physical complaints Kate recalled periods where she was "tired all the time", or in her past where she went through periods of being very ill and had to refrain from any sport activity in order to recover. Such physical complaints have been reported previously in BO (Cresswell and Eklund, 2004; Gould, Udry et al., 1996b; Gustafsson et al., 2007; Gustafsson et al., 2008). Emotional disturbances were frequent, with episodes of anger, disturbed moods, frustration due to bad performances, no effective coping strategies to deal with anger and anxiety at training and competition, lack of recovery time and no social life apart from sport; similar results have also been found elsewhere (Gustafsson et al., 2007; Gustafsson et al., 2008; Gould, Tuffey et al., 1996a). Kate also showed strong signs of sport devaluation, by taking a "don't care" attitude when she swam badly, a negative attitude towards her swimming partners, loathing of competition, and a lack of enjoyment and desire to train. When athletes become physically and emotionally drained, levels of motivation tend to decline and they can adopt a "don't care" attitude consequently devaluing their sport participation; therefore, a link between the continuous loss of motivation and sport devaluation seems to occur (Goodger et al., 2007). Our data also compares to Gustafsson and coworkers' (2008) and Goodger and colleagues (2007) studies where similar symptoms of devaluation were found in 10 Swedish elite athletes and six former national level tennis players, respectively. The motivational change associated with the devaluation construct is not only related to a decrease in motivation but also can signal a change of interest or a will to do something else (Creswell and Eklund, 2003, 2005; Gould, Tuffey et al., 1997). In Kate's case she ended up choosing water-polo in preference to swimming. Finally, reduced accomplishment dimension was also highly scored on the ABQ. During the past 2 years, Kate's performances started to decline although she kept training hard. Similar results were also found by Gustafsson and colleagues (2008) where the same history was noted. The fact that Kate still wanted to train more and with high loads can be seen as a response to her frustration due to the lack of achievement (Cresswell and Eklund, 2005; Goodger et al., 2007), although the latter was also tied to a "more the better" mentality of training. Kate clearly demonstrated evidence of all 3 dimensions of BO according to the ABQ profile offering further validation to Raedecke's (1997) conceptualization of athletic BO (burnout dimensions: *physical/ emotional exhaustion, reduced sense of accomplishment,* and *sports devaluation*).

In Kate's BO profile, training load may have played a key role. She reported that she had trained a lot during her swimming career and data from the year-long study (*chapter IV*) gives support to this idea. In her case it could be that, at some points in her career, too much training was an essential factor influencing her state of mal-adaptation. Despite some studies having failed to find any significant contribution between training volume and burnout levels (Tebenhaum et al., 2003; Gustafsson et al., 2007), or even

NFOR and OT (survey from *chapter III*) some authors argue that it is central to the condition (Budget, 1998; Hooper et al. 1995a).

Alternatively, it could be that Kate was having a lack of recovery in her training, since all her life revolved around swimming she did not have time to recover and was always busy, either swimming or studying and preparing for school; social life was limited. Kate had no time for physical recovery, a main contributing factor for developing OT (Kellman, 2002). The fact that Kate showed conflicts with Phil, and communication issues with both coaches, left them unaware of her frequent fatigue, and therefore, no measures were taken to improve her state. Some coaches may underestimate the importance of systematically monitoring training load and recovery. This underestimation may however be reinforced by some sport cultures, subcultures and athletes themselves, wherein quantity (high intensity and high volume) is emphasized over quality (Hanin, 2002). With Kate and especially, with her previous coach Phil, "the more the better" philosophy seemed to be very important - Kate was used to train a lot and believed that by training more she would improve more. It is clear how such a type of mentality/ philosophy can be destructive for an athlete. Having such a mentality is more likely to create cultures of risk instead of promoting positive self-care and self-awareness (Brustad and Ritter-Taylor, 2002). Further, she also did not seem to have time to recover emotionally and mentally, since she would continuously be in bad moods at training/ competition, and she had to cope with a poor coaching relationships and a pushy mother. It has been previously suggested that emotional and mental recovery are also of extreme importance (Gustafsson et al., 2007), and that not spending time with friends limits emotional recovery and correlates with BO (Kjormo and Halvari, 2002). Our interpretation is that training load may indeed contribute to the maladaptation but it will not be the sole factor (Gould, Tuffey et al., 1996a; Gustafsson et al., 2007), and potentially lack of recovery and other factors (psychologic, cultural and social) will also contribute.

Kate had a “busy” childhood with leaving the country at the age of 4 to go and live in America, and then returning to England when she was 8. Further, Kate left home by the age of 11 to go and train at a boarding school (Rulleta College), away from parents, family and friends. Situations like travelling to another country to go and live, or moving away from home to go and train in another place, all potentially act as stressors in an athlete’s life and are known to be strong contributors to the development of OT (Beil, 1988; Uusitalo, 2001). Findings from our survey (chapter 3) and other investigations elsewhere (Kentta and Hassmen et al., 2001) have shown that an accumulation of OT episodes is related to lower motivation levels in athletes, which can leave them more vulnerable to develop a serious state of OT. Kate had reported that she previously OT at Rulletta College. As such, it is likely that by experiencing different episodes of OT through her career, Kate’s condition kept worsening and as such, influenced the development of a mal-adaptation. Kate had been training with Steve for one year, but she still speaks of Phil as her preferred coach, since he had, in her view, better training methods. Even though, her relationship with Phil was not good, it was with him that she attained her top performances. Therefore, it is possible that the fact that a new coach came to the club, who had a different approach to training (not as high volumes, with a lower intensity), also added more stress to Kate because this did not suit her view of training. This can be seen as a change in environment and relates more to issues that involve the directors in the club and the coach directly, so they are out of Kate’s control; these types of situations can have a profound effect on an athlete’s adaptation to training (Kellman, 2002), since athletes have developed low coping skills to deal with stressful events within their sport (Gould, Tuffey et al., 1996a; Smith, 1986b).

Once again, the important contribution of the adults (parents, coaches etc) in Kate's life may have influenced the BO seen in Kate. Kate had communication issues with her coaches, conflicts with her past coach, a pushy mother and a father who, although seeming the one who was most involved in sport and therefore someone who could understand better Kate, he was not involved in her practice and did not accompany Kate to her swimming sessions and competitions like her mother did. It is known that parents and coaches can act as potential buffers who are able to moderate demands placed on athletes by acting as much-needed sources of social support (Udry et al., 1997). Equally, pressure to perform and unrealistic expectations vocalized by coaches and parents are potential stressors and contributors to BO (Goodger et al., 2007). It is arguable therefore that Kate had inappropriate social support possibly contributing to the development of OT and BO (Coakley, 1992).

Kate's experience as an active BO gave evidence of the presence of several important domains that, together, all influence the development of BO. The presence of physical factors together with psychological ones was acknowledged. Further, the contribution of swimming culture and of how social structures contribute to the development of BO were also present, and in Kate's case the psycho-cultural and –sociological reasons seemed to play a stronger role than the physical factors.

As such, the models that have been put forward in research on BO, namely, Smith's (1986b) cognitive affective stress model, Silva's (1990) negative-training stress response, and Coakley's (1992) unidimensional identity development and external control view, were all interacting with each other. The fact that Smith's (1986b) and Coakley's (1992) models seemed to explain more Kate's case at the time of the interview, whereas the physical factors (Silva, 1990) were mentioned more as playing a strong role in the past, does not stop them from having had an significant influence. All these models give a different perspective of the same problem and therefore, they investigate with "different eyes" the same phenomenon, i.e. burnout. Smith's (1986b) model focus more on the psychological aspects of the individual, so it studies how an individual responds psychologically to the stresses within and outside sport, taking a subjective perspective (interior aspect of an individual, i.e. psychology). Silva's (1990) model tends to put its focus on the physical factors and the physiological responses to training, and therefore studies the exterior of an individual and assumes an objective stance. Finally, Coakley's (1992) model concentrates more on the power relationships between human beings and how that influences the formation of an athlete's identity (inside perspective of the collective, i.e. culture), and on how the social organization of sport also plays a role and leaves athletes powerless to make decisions (outside perspective of the collective, i.e. social structures). It is important to integrate aspects of all three models, that is all 4 main perspectives (inside and outside of the individual and the collective), and study the problem taking these into consideration. In so doing a more inclusive and comprehensive approach to this phenomenon may emerge.

7.5. Conclusions

This study, although retrospective in nature, gives an account of the final stages of the spectrum of mal-adaptation in a young female national-level swimmer, a novelty in OT and BO research. Unfortunately it is not possible in one interview to grasp an account of everything that happens and influences the development of OT and BO in an athlete. This case study has provided a real perspective of the multidimensional factors that accumulate in an individual to tip them into a state of OT / BO. In this example the data confirmed several tenets already reported in the literature; Early specialization, rapid success at an early age, "the more the better" mentality, pressures from mother and coach, communication issues with coaches and significant others, disturbed moods, and a strong unidimensional identity attached with a performance-based self-esteem were all potential contributing factors to the development of BO. Kate's case gives evidence of a sequential link between training, overtraining and BO, and finally how it is a complex interaction of contributing factors that lead to the development of overtraining and burnout in an individual.

CHAPTER VIII

Final discussion

8.1. Key findings

This thesis investigated overtraining and burnout in young athletes using a holistic perspective whereby different areas of knowledge were combined; physiology, psychology and qualitative inquiry. The result was a broader understanding of the phenomenon, providing evidence that both training and non-training issues need to be considered. This work has shown that physical, psychological and psychosocial issues are all equally important to consider when trying to understand OT in an individual athlete. The TDS along with the Stroop test have shown to be promising tools to discriminate athletes undergoing a mal-adaptation, with the ABQ showing to be good to diagnose athletes under a state of BO. The trends in biological parameters (i.e. IgA, cortisol, HRV) were not very clear, making their use in the sport setting questionable due to the high inter-individual variability shown in the responses. Conversely, the use of maximal lactates together with session RPE may have use in helping sport scientists and coaches monitor athletes' appropriately for signs of OT. The recommended tools can provide valuable information about the state of distress and degree of the mal-adaptation, with the advantage of being easy to administer and with low financial costs.

Additionally, individual domestic and cultural factors like a strong unidimensional identity, early and rapid success, "the more, the better" philosophy, communication issues with coaches and parents, pressure from coaches and parents, high training loads, separation from family, a change of coach, were all noted as potential stress factors in the profile of an OT/ BO athlete. Motivation is shown to be a key factor in the BO process (Gustafsson et al., 2007), as once this goes then drop-out typically follows, as evidenced by Kate's decision of withdrawing from swimming just 3 months after the interview.

The results of this work lead us to suggest that NFOR, OT and BO are, arguably, part of the same spectrum that increases in severity (*figure 9.1*), with the difference being that an NFOR athlete will not present with as complex or serious state as the OT athlete. Just like atoms become more complex to produce cells and cells become more complex to produce tissues, the same happens with a process of mal-adaptation; the levels above include and encompass the ones below, i.e., an athlete cannot be NFOR and at the same time be BO. Still, more work is needed to confirm this hypothesis.

Figure 8.1 - The mal-adaptive process. FOR = Functional overreaching; NFOR = Non-functional overreaching; OT = Overtrained; BO= Burnout.

The very fact that this is a continuous process does not enable the different conditions to be easily diagnosed with objective measures. Because they are part of a spectrum, the way the condition develops in athletes may differ and fluctuate, making the attempt to derive a specific temporal definition that the scientific community will agree upon, a pointless task. Paradoxically, it does not mean that boundaries within each of the states are not acknowledged, and certainly an athlete who has not performed for more than 6 months is not NFOR, but likely OT or potentially an active BO. Importantly, all these states develop gradually and can long remain unnoticed by the athlete, coaches and parents alike.

If it is agreed that NFOR, OT and BO are multifactorial problems, which can only be understood by taking a holistic view, the challenge then comes with how does the coach, team doctor, parents, athlete assimilate the information they need and then interpret the resulting profile?

8.2. The problem with previous overtraining and burnout models

Several models have been put forward in an attempt to explain such a complex phenomenon. The most well known are the Meyers and Whelan (1998) and Kentta and Hassmen (1998) models, but more recently, Richardson and coworkers (2008) have also created a model. These models have all described the importance of understanding multiple sources of stress in athletes' lives but in different ways. All 3 models have important factors in common: all acknowledge physical, psychological and socio-cultural forces as acting together to produce the mal-adaptation, and further, they all involve issues that relate to the individual and to a collective (*table 8.1*). However the Richardson et al. (2008) model of OT is the most complete one. Unfortunately, due to their necessary complexity, these models are difficult to interpret, let alone to apply.

Table 8.1 – The 3 models main commonalities and gaps.

Common issues
1. Training and non training stress factors: acknowledgement of physical, psychological and sociological risk factors;
2. Athlete as the main focus of study;
3. Kentta and Hassmen (1998) and Richardson *et al.'s* (2008) view OT as a continuum/ process with outcomes/ responses;
Gaps
1. Kentta and Hassmen (1998) does not reinforce relationships between athlete and significant others (coach, team players, family);
2. Meyers and Whelan (1998) sees the main influencing factors being related to relationships with significant others;
3. Richardson *et al.* (2008) model is the only to emphasize the importance of social systems for the development of OT;
4. All 3 models do not show/ represent the interconnections between the main contributing factors, i.e. how physiology, psychology, culture and social systems all interact with each other to influence the development of the mal-adaptation.

8.2.1. A new model – Integral Operational Systems (Wilber, 1997)

Ken Wilber (1997), philosopher and psychologist, devised a model that he proposes can be used to study reality or a phenomenon. The model (Integral Operational System; IOS) proposes to acknowledge and investigate patterns that connect with each other leading towards a more comprehensive, inclusive, and effective approach. The main 5 components of this model are referred together as A-Q-A-L (shorthand for all quadrants, all levels, all lines, all states and all types). Essentially, it is important to understand that AQAL or IOS is a map and not a territory.

Most major languages have 1^{st}-person, 2^{nd}-person and 3^{rd}-person pronouns. The 1^{st}-person perspective refers to "the person who is speaking", which includes pronouns like *I*, *me*, *mine* (in the singular), and *we*, *us*, *ours* (in the plural). The 2^{nd}-person perspective refers to "the person who is spoken to", which includes pronouns like *you* and *yours*.

Finally, the 3rd-person perspective refers to "the person or thing being spoken about", such as *he, him, she, her, they, them, it* and *its*. If I am speaking about my new house, "I" am 1st-person, "you" are 2nd-person, and the new house (or "it") is 3rd-person. "We" is technically 1st-person plural, but if you and I are communicating, then your 2nd-person and my 1st-person are part of the "we". Thus, sometimes 2nd person is indicated as "you/ we" or simply "we". In resume, a simplification of this can come by using 1st-, 2nd-, and 3rd-person as "I", "we", and "it", respectively (Wilber, 1997).

The "I", "we", and "it" dimensions of experience refer to *art, morals* and *science*, or *self, culture* and *nature*, respectively. It is suggested that *every* event in the world has all 3 of these dimensions. For example, one can look at any event in life from the point of view of the "I" (how I personally see and feel about the event); from the point of view of "we" (how both I and others see the event); and as an "it" (or the objective facts of the event). An integrally informed path will take all these dimensions into account, and thus arrive at a more comprehensive approach about whatever phenomenon. Fundamentally, it is these dimensions "I", "we" and "it" that are called the 4 quadrants, the foundation of the integral framework; for clarification, the 4th quadrant occurs when "it" is divided into singular "it" and plural "its" (Wilber, 2006).

Figure 8.2 is a schematic of the 4 quadrants. It shows the "I" (the inside of the individual), the "it" (the outside of the individual), the "we" (the interior of the collective) and the "its" (the exterior of the collective). In other words, the 4 quadrants are the 4 fundamental perspectives of any occasion; they turn out to be the inside and the outside of the individual and the collective.

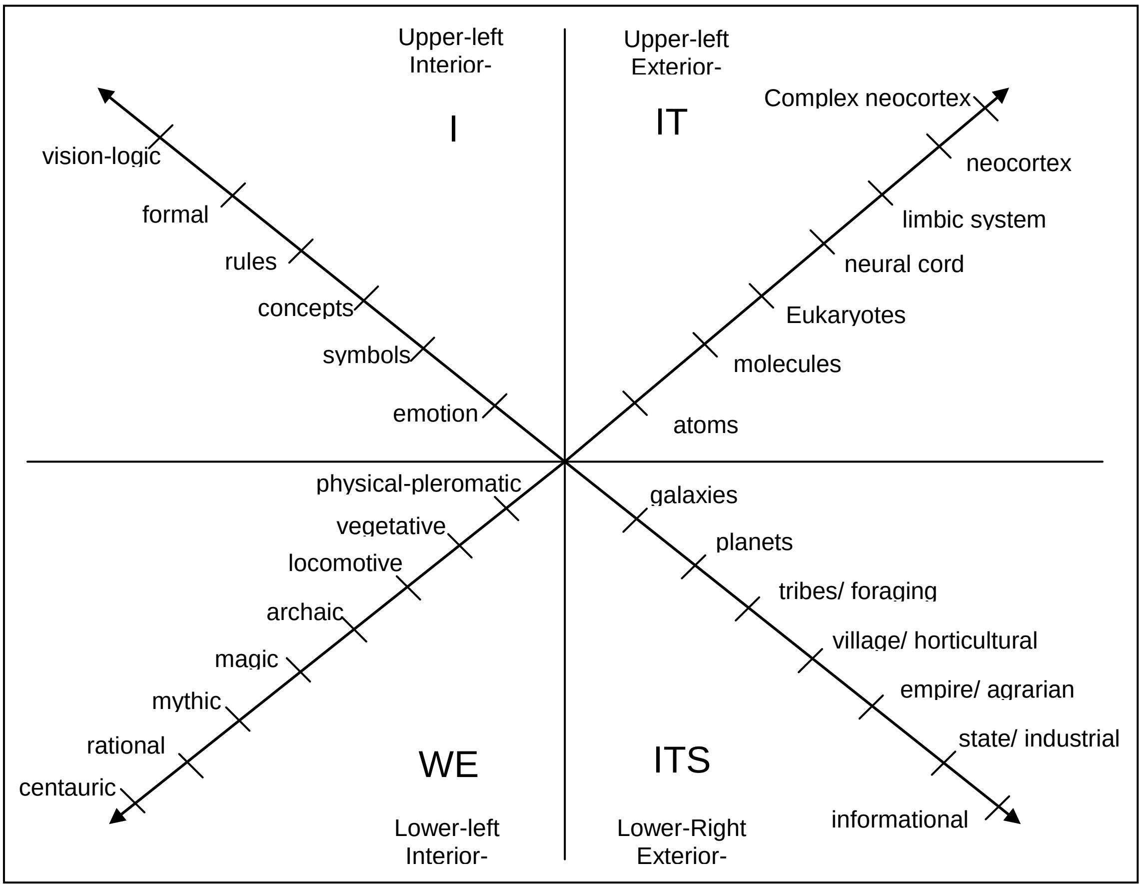

Figure 8.2 – From Integral Spirituality, by Ken Wilber, © 2006 by Ken Wilber. Reprinted by arrangement with Shambhala Publications Inc., Boston, MA. www.shambhala.com.

In the Upper-left quadrant (interior of the individual) there are thoughts, feelings, sensations and so on (all described in 1st-person terms). Conversely, when looking at an individual *from the outside*, in the terms not of subjective awareness but objective science, there are neurotransmitters, a limbic system, the neo-cortex, complex molecular structures, cells, organ systems, DNA, and so on – all described in 3rd-person objective terms. The Upper-right quadrant is therefore what any individual event looks like from the outside. This especially includes its physical behaviour, material components, matter and energy, and its concrete body. How an organism looks like from the outside is however, not the same as it does from the inside; i.e. from the outside one finds neurotransmitters, cells, proteins, etc, but from the inside there are no proteins, but instead, feelings, desires, consciousness, all described in terms of 1st-person immediateness. In this case, both views are right, since they are different views of the same experience (Wilber, 2006).

The "we's" represent not just individual, but group (collective) or collective consciousness; further, not just subjective but intersubjective awareness – or culture in the broadest sense. Likewise, every "we" has an exterior, i.e. what it looks like from the outside (Lower-right quadrant perspective). The Lower-left is often known as the cultural dimension (inside awareness of the group – its worldviews, shared values, shared feelings, and so forth), whereas the Lower-right is the social dimension (exterior forms and behaviours of the group, which are studied as 3rd-person science such as systems theory) (Wilber, 2006).

To say that all phenomenon have 4 quadrants (simply "I", "we" and "it" dimensions) is to really try to include all the important possibilities, i.e. 1st-, 2nd-, and 3rd-person perspectives. As such, IOS can be used to bring clarity, care and comprehensiveness to most situations, be it in terms of understanding overtraining and BO, in terms of business, etc. Most important of all, IOS can be used to improve dialogue (Wilber, 2006). Someone using IOS in sports science will talk more easily and effectively with sport physiologists ("it" perspective), sport psychologists ("I" perspective), or qualitative researchers ("we"). In other words, the splits between quantitative and qualitative, or positivists and post-modernists, researchers respectively will start fading and thus open the dialogue that should help each epistemologies to grow.

8.2.2. The application of IOS to overtraining and burnout research

By looking closely at the models described in *table 8.1,* it is possible to realise that all 3 models have embedded the 3 main quadrant perspectives ("I", "It" and "We") within them (*figure 8.3*). There are issues within the 3 models that relate to the "I" perspective (Upper-left quadrant; subjective) – the athlete's personality, anxiety, self-esteem and more. Further, the same models also emphasize relationships between coach, parents and parents that are part of the cultural realm, i.e. Lower-left quadrant issues, or "we" issues (intersubjective). Further, they all include issues that relate to the singular "it" perspective (objective), with the athlete's physiological and biochemical responses to training (Upper-right quadrant). In regards the "its" perspective (Lower-right quadrant; interobjective), only Richardson et al.'s (2008) model has included it; issues on this perspective are related to the social organization of sport, to moving away from home, having a new coach, to the amount of time spent training, access to doctors, physiotherapists, facilities, etc. With the IOS, it is now possible to bring all the 3 models together in a simpler way, whereby the different perspectives can be included in a clearer and more complete framework.

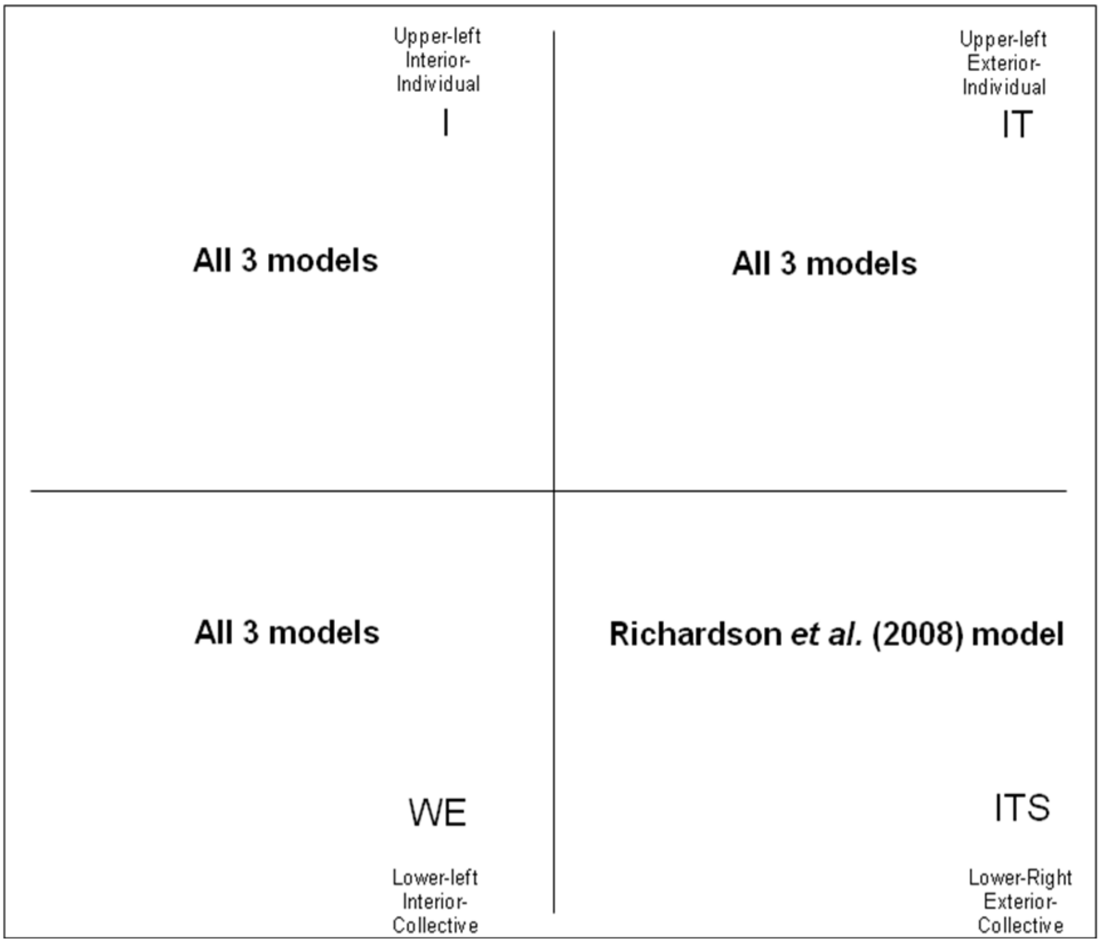

Figure 8.3 – Perspectives that have been considered in the previous OT models and how they fit with Wilber's (1997) model.

Importantly, the decision to use IOS in sports science is by no means to state that the other models are wrong. To the contrary, they all address issues that include 3 main perspectives (quadrants), with Richardson *et al.'s* (2008) being the most complete, with all 4 perspectives acknowledged. The problem is that they keep the discipline knowledge in fixed boundaries, and do not give the freedom to look for interactions between all main perspectives. By doing so they limit the understanding one can gain because the important connections between factors may be ignored, and consequently the understanding will be incomplete. *Figure 8.4* provides an example of the application of the IOS model to overtraining and burnout based on the findings of our work, and *figure 8.5* shows the main findings of this thesis in the context of Wilber's (1997) model.

Upper-left Interior- I Self-esteem issues Anxiety issues Mood states at training/ competition Tendency to give-up if not winning: "in it to win it" mentality Fear of failure Expressed emotions: stress, anger, fear, etc Performance-based self-esteem Questionnaires: TDS, ABQ, RPE	Upper-left Exterior- I Performance at competition Depressed immune system Disturbed hormonal system Depressed maximal lactates Heart rate variability Stroop test Biochemical analysis (blood and saliva)
Power relations: coach, parents and peers Relationships within opponents Training mentality: "the more the better"? Cultural sporting ideals and expectations from self, coaches, parents and peers Coach/ parents communication Identity issues: entrapment W Lower-left Interior-	Competitive structure Training/ competition facilities Access to doctors/ physiotherapists/ sport Psychologists, etc Travel distance to training and competition Club and athlete/ family finances Coach/ parents/ athlete education Club issues: finances, staff, etc IT Lower-Right Exterior-

Figure 8.4 – Application of the IOS model to overtraining and burnout research.

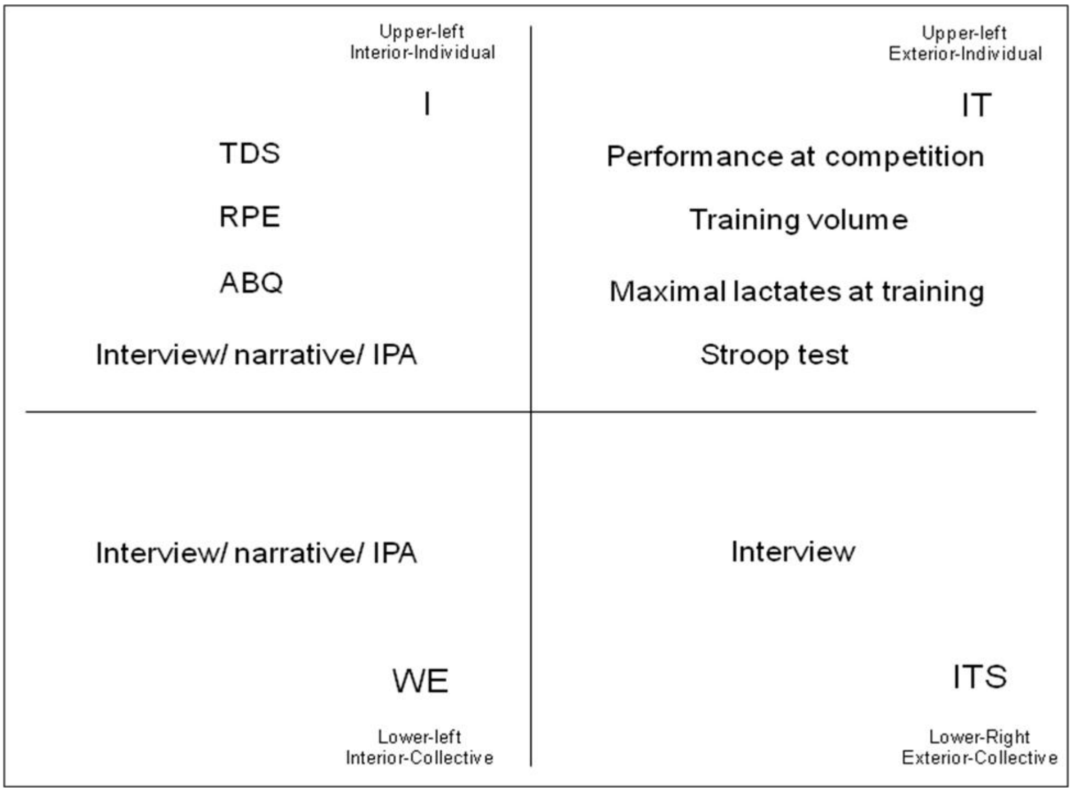

Figure 8.5 – Thesis main tools and methodologies used and how they fit with IOS.

This model may bring a more efficient approach to the previous developed models in OT and BO research because it clearly allocates to each of the perspectives where the different issues belong, making it easier for a coach or sports scientist to determine possible causes of the lack of performance and OT. It is thus possible to identify the main issues present for an athlete and, by raising awareness of the other quadrants investigate how they are "working" together to influence the current state of the athlete. In the other models the information is spread apart and the connections between the different issues are hard to understand; the latter brings difficulties if one wants to understand what are the most important factors to work with, in a single athlete, which consequently impedes what should be done to help an athlete recover.

Wilber's model could easily be used by coaches since "all" they need to do is to raise their own awareness of the different quadrants and ask the required questions / collect the relevant information of their athletes. As such, they could care for their athletes by taking into account all the factors that relate to culture, social structures and the athletes' psychology and physiology profiles, to glean an integrated understanding of the phenomenon. For example, if an athlete is showing signs of mal-adaptation all quadrants need to be considered (*figure 8.4*). The Upper-right quadrant ("it" perspective) should look at performance, physical and physiological responses to training, health issues, growth and maturational issues, etc. The Upper-left quadrant ("I" perspective) should investigate: anxiety, self-esteem, training mentality, and more. The Lower-right quadrant ("its" perspective) can look at the social organization of sport, financial issues with the athlete's family, sponsorship issues, media coverage, amateur or professional sport, etc. Finally, the Lower-left quadrant should investigate relationships with athletes, coaches and parents, identity issues, cultural issues within the sport, and anything relating to the "we" perspective. This model may therefore facilitate the choice of which aspects should be focused upon to help recover the OT /BO athlete.

To exemplify how the IOS can be used to understand BO in a single athlete, Kate's case study (*chapter 7*) can be deconstructed and interpreted accordingly; Kate's cultural background, an example of a "we" perspective (she had a sporty father who was in the Armed Forces), was a contributing factor that made her take up competitive swimming. Her "I" perspective can be understood by acknowledging her father and mother's mentality of being "in it to win it" and the importance of sporting success, which was passed to Kate, resulting in a strong unidimensional identity based on swimming, with self-esteem intrinsically linked to sporting success. The self and family culture surrounding her sport ("I" and "We" perspectives, respectively) combined with the culture of swimming itself propagated by the coach ("We" perspective) encouraged her to perform large volumes of intense training ("It" perspective). Events such as Phil being sacked from the club or when she left home to train at Rulletta College, (both "Its" perspective) coincided with periods of chronic illness ("It" perspective) that affected her swimming ("It" perspective since she underperformed). Hence it is possible to understand the complex, fluid and clouded nature of the antecedents of OT/ BO in a single individual, but just as importantly, understand that without this big picture view of the problem the truth will be hard to uncover and the athlete left with less chances to recover.

CHAPTER IX

Conclusions and future directions

9.1. Final concluding comments

With the majority of OT and BO research having undertaken a unidisciplinary approach, this inevitably led to a narrow view of the phenomenon. Consequently, this thesis investigated overtraining and burnout using a holistic perspective, subsequently delivering a more rounded understanding of the problem. The introduction of IOS provides a logical and guiding framework to help bring together the strands of a multidisciplinary approach, demonstrating the interconnectedness between contributing factors. This work is, to the best of our knowledge, the first that has attempted to utilise an integral framework (i.e. combined the areas of physiology, psychology and qualitative inquiry) with young OT and BO athletes, and gave evidence of how complex a phenomenon it is, with its multiple contributing factors. In addition, this work also emphasized the importance of using an individualized approach to study OT and BO, and to help athletes optimize their training in order to be protected from OT and BO. This only serves to underline how important it is that any efforts to screen or prevent OT/ BO embrace an individualized and yet integral vision.

9.2. Future directions

This work can be explored in the future by applying the integral model and its 4 quadrants to research into OT and BO. Since this work directly related to training optimization, sports scientists should also be receptive to its application in the latter domain. More longitudinal studies on training optimization, OT and BO should be done and data analysed individually. A battery of tests should be used (physiological and psychological), together with a qualitative investigation project running in parallel. In regards the latter, athletes, parents and coaches should be interviewed so that an insight into the inter-subjective realm of relationships that are significant for the sport can be attained. As such, a project that will look into overtraining and burnout prevention/ recovery, will inevitably also investigate ways of optimizing training, making this work very important for coaches, athletes, parents and sports scientists in order to prevent OT and BO, and ultimately take athletes to their highest potentials.

CHAPTER X

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APPENDICES

APPENDIX 1

RPE scale

Ratings of Perceived Exertion

rating	description
6	
7	Very, Very Light
8	
9	Very Light
10	
11	Fairly Light
12	
13	Somewhat Hard
14	
15	Hard
16	
17	Very Hard
18	
19	Very, Very Hard
20	Maximal Exertion

Appendix 2

Training Distress Scale

- TRAINING DISTRESS SCALE -

Name: ____________________________ Date: _____/_____/2008

---

*Below is a short list of words that describe feelings that people have. Please read each one carefully. Then, circle the number that best describes **HOW YOU HAVE BEEN FEELING DURING THE PAST WEEK, INCLUDING TODAY.***

1 - Not at all; 2 - A little; 3 - Moderately; 4 - Quite a bit; 5 - Extremely

---

1.	Peeved	**1**	**2**	**3**	**4**	**5**
2.	Sad	**1**	**2**	**3**	**4**	**5**
3.	Unworthy	**1**	**2**	**3**	**4**	**5**
4.	Miserable	**1**	**2**	**3**	**4**	**5**
5.	Bad-tempered	**1**	**2**	**3**	**4**	**5**
6.	Worthless	**1**	**2**	**3**	**4**	**5**
7.	Guilty	**1**	**2**	**3**	**4**	**5**

Appendix 3

Athlete Burnout Questionnaire

- Athlete Burnout Questionnaire -

Name: ______________________________ Date: _____/_____/2008

Rate how often (past month) you have experienced each item on a 5-point Likert scale:

1 – almost never; 2 – rarely; 3 – sometimes; 4 – frequently; 5 – almost always

Item #	Subscale	Item text
1	RA	I'm accomplishing many worthwhile things in swimming:
2	E	I feel so tired from my training that I have trouble finding energy to do other things:
3	D	The effort I spend in sport would be better spent doing other:
4	E	I feel overly tired from my swimming participation:
5	RA	I am not achieving much in swimming:
6	D	I don't care as much about my swimming performance as I used to:
7	RA	I am not performing up to my ability in swimming:
8	E	I feel "wiped out" from swimming:
9	D	I'm not into swimming as I used to be:
10	E	I feel physically worn out from swimming:
11	D	I feel less concerned about being successful in sport than I used to:
12	E	I am exhausted by the mental and physical demands of swimming:
13	RA	It seems that no matter what I do, I don't perform as well as I should:
14	RA	I feel successful at swimming:
15	D	I have negative feelings towards swimming:

Appendix 4

DALDA Questionnaire

Name: ______________________________ Date: _____/_____/_________

D.A.L.D.A.

DAILY ANALYSIS OF LIFE DEMANDS FOR ATHLETES

RESPOND BY CIRCLING the appropriate response alongside each item.

a = worse than normal **b = normal** **c = better than normal**

PART A

1.	a	b	c	Diet
2.	a	b	c	Home-life
3.	a	b	c	School/college/work
4.	a	b	c	Friends
5.	a	b	c	School Training
6.	a	b	c	Climate
7.	a	b	c	Sleep
8.	a	b	c	Recreation
9.	a	b	c	Health

PART B

1.	a	b	c	Muscle pains
2.	a	b	c	Techniques
3.	a	b	c	Tiredness
4.	a	b	c	Need for rest
5.	a	b	c	Supplementary work
6.	a	b	c	Boredom
7.	a	b	c	Recovery time
8.	a	b	c	Irritability
9.	a	b	c	Weight
10.	a	b	c	Throat
11.	a	b	c	Internal
12.	a	b	c	Unexplained aches
13.	a	b	c	Technique strength
14.	a	b	c	Enough sleep
15.	a	b	c	Between session recovery
16.	a	b	c	General Weakness
17.	a	b	c	Interest
18.	a	b	c	Arguments
19.	a	b	c	Skin rashes
20.	a	b	c	Congestion
21.	a	b	c	Training effort
22.	a	b	c	Temper
23.	a	b	c	Swellings
24.	a	b	c	Likeability

25. a b c Running nose

Appendix 5

Information sheet – Study 1

School of Sport and Health Sciences

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Devon

Telephone +44 (0) 1392 264724
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Web www.ex.ac.uk/sshs/

INFORMATION SHEET – Overtraining in Young Athletes

Thank you for showing interest in our study. This sheet will tell you more about the study and what we would like you to do. Please read this carefully before deciding whether or not to take part.

What is the research about?

We are looking for volunteers to help us with a research project into overtraining in young athletes. Overtraining can occur when the balance between exercise and rest is not correct, and this may lead to fatigue and poor performance. We want to learn more about this condition in young athletes and what we can do to help stop it happening.

Who is taking part?

Any athlete aged between 11 to 18 years, who is playing sport on a regular basis.

What will you be asked to do?

After we have received signed consent from the athlete and their parent / caregiver, he/she will then be asked to complete a questionnaire on Overtraining in Young Athletes. The questions are related to their sport, how much training they do, competitions, whether they have ever experienced periods of fatigue, how they balance school personal and sporting commitments.

The questionnaire will be anonymous and the researcher will keep the data provided safely at the University. No subject will be able to be individually identified by his or her results.

When will he/she do the study?

He/she can complete the questionnaire at a time that's best for them.

Can your child change his/her mind?

He/she can stop participating in the study at any time, without giving any reason. This will not affect the relationship with the research team or the football club in any way.

What will be done with the collected information?

All the results we will collect will be stored on a computer. We will write the findings of the study up for other scientists to read but your information will remain confidential.

What do I do next?

If you have any more questions about the study you can contact Nuno Matos or Dr. Richard Winsley at the numbers or emails below. If you have read and understood everything that is required to take part in the study, please can you both (Parent and young athlete) sign the attached consent form. The **consent forms** and **questionnaire** should be returned to **your coach** or **Simon Hayward** at your football club.

This project has been reviewed and approved by the Ethics Committee
of the School of Sport and Health Science

Appendix 6

Consent forms – Study 1

Children's Health and Exercise Research Centre

CONSENT FORM FOR PARENTS/ GUARDIANS

The research has been explained to me in an accompanying letter and I understand that my child will be asked to complete a specifically designed questionnaire for the study. I understand my child will not have to visit the laboratory for purpose of being tested. The results will be stored on computer in a coded form and individual results will be confidential to the research group.

I know that:

1. My child's participation in the project is entirely voluntary;

2. My child is free to withdraw from the project at any time without giving reason or affecting his/her relationship with either the research team or the school;

3. Any raw data on which the results of the project depend will be retained in secure storage;

4. The results of the project may be published but my anonymity will be preserved.

I agree to my child ____ participating in a research project concerned with training practices and personal life issues in young athletes.

Signed: ____ (Parent/ Guardian)

Date: ___________________

This project has been reviewed and approved by the Ethics Committee of the School of Sport and Health Sciences.

SCHOOL OF SPORT AND HEALTH SCIENCE

STUDY: Training Practices in Young Athletes

CONSENT FORM FOR PARTICIPANTS

I have read the Information Sheet concerning this project and understand what it is about. All my questions have been answered to my satisfaction. I understand that I am free to request further information at any stage.

I know that:

1. My participation in the project is entirely voluntary
2. I am free to withdraw from the project at any time without giving a reason and this will not be a problem
3. The answers that I give will be kept securely and I understand that only the researchers will have access to my answers
4. The results of the project may be published but my anonymity will be preserved.

Having read the information sheet and consent form for participants, I consent to participate in this study by signing below.

Signed:
Date:

This project has been reviewed and approved by the Ethics Committee of the School of Sport and Health Science

Appendix 7

Overtraining Questionnaire – Study 1

- SPORTS QUESTIONNAIRE –

Thank you for agreeing to complete this questionnaire.

Please answer the questions as accurately as possible by thinking about the current season you are in, or if you are in a rest period between seasons then the previous season.

Answer all the questions in each of the 5 sections**.**

Some questions <u>need you to circle the number/ option</u> that most accurately represent what you feel. Other questions <u>need you to write your answer</u>.

SECTION 1

Write in the space provided or circle the number that best reflects your answer

---

1. Date of Birth: **_________________** (dd/mm/yyyy)

2. What gender are you? **1-Male** **2-Female**

3. What is your main sport? **____**

4. How many hours per day do you play this sport (*approximately*)?

1-Up to 30min **2-Between 30 minutes and 1 hour** **3-Between 1 and 2 hours** **4-Between 2 and 3 hours** **5-More than 3 hours**

5. How many days per week are you involved in this sport (*a combination of playing or practicing/ training/ competing*)?

1 **2** **3** **4** **5** **6** **7**

6. For how many years have you been involved in this sport (*play/ practice/ train/ compete etc*)?

1-Less than 2 years **2-Between 2 and 4 years** **3-Between 4 and 6 years** **4-Between 6 and 8 years**

5-Between 8 and 10 years **6-More than 10 years**

7. How long have you been involved in regular athletic training (*train/ competition*)?

1-Less than 2 years **2-Between 2 and 4 years** **3-Between 4 and 6 years** **4-Between 6 and 8 years**

5-Between 8 and 10 years **6-More than 10 years**

8. At what level are you competing? *(tick all that apply)*

1-Club **2-County** **3-Regional** **4-National** **5-International**

9. What stage of the training year are you currently in?

1-Pre-season **2-Season** **3-Off-season**

SECTION 2

Circle the number that best reflects your answer to each question:

1- agree strongly; 2- agree; 3- neither agree or disagree; 4- disagree; 5- disagree strongly

10. I normally feel very tired after a normal training session.	**1**	**2**	**3**	**4**	**5**
11. I normally feel very tired the day after having competed.	**1**	**2**	**3**	**4**	**5**
12. I perceive my training to be harder and take more effort than before	**1**	**2**	**3**	**4**	**5**
13. When I wake up in the morning I feel my muscles are heavy and stiff	**1**	**2**	**3**	**4**	**5**
14. I feel I get enough sleep each night	**1**	**2**	**3**	**4**	**5**
15. I sleep well when I am in a period of very intensive training.	**1**	**2**	**3**	**4**	**5**

16. I sleep well when I am in a period of competitions.	**1**	**2**	**3**	**4**	**5**
17. I feel that during periods of very intensive training and/or competitions I tend to get more colds, flu, or chest infections.	**1**	**2**	**3**	**4**	**5**
18. I think that what I eat is very important to my sporting performance.	**1**	**2**	**3**	**4**	**5**
19. I deliberately avoid eating some foods because I think it is bad for my training/ sport	**1**	**2**	**3**	**4**	**5**
20. I eat certain foods because other people tell me it will help me with my training/ sport.	**1**	**2**	**3**	**4**	**5**
21. I enjoy competing.	**1**	**2**	**3**	**4**	**5**
22. I feel confident when I compete.	**1**	**2**	**3**	**4**	**5**
23. I feel intimidated by the opponents when I compete.	**1**	**2**	**3**	**4**	**5**
24. I feel anxious before important competitions.	**1**	**2**	**3**	**4**	**5**
25. Winning is important to me.	**1**	**2**	**3**	**4**	**5**
26. I think winning is important to help improve my confidence.	**1**	**2**	**3**	**4**	**5**
27. I think that I do better at my sport when I am in a relaxed frame of mind.	**1**	**2**	**3**	**4**	**5**
28. I think that when I have changes in mood due to training and/or stress in my personal life it affects my performance.	**1**	**2**	**3**	**4**	**5**
29. In general, I enjoy my training sessions.	**1**	**2**	**3**	**4**	**5**
30. I feel comfortable in speaking with my coach about personal issues in my life (*e.g. family, school, friends, etc*.).	**1**	**2**	**3**	**4**	**5**
31. I think that I am involved in deciding my training schedule.	**1**	**2**	**3**	**4**	**5**
32. I decide what goals I want to achieve in my sport (*e.g. becoming a professional or an Olympic athlete*).	**1**	**2**	**3**	**4**	**5**

33. I think that I am doing enough training to meet my goals.	**1**	**2**	**3**	**4**	**5**
34. I think that training more will allow me to reach higher goals.	**1**	**2**	**3**	**4**	**5**
35. I put pressure on myself to achieve my sporting goals.	**1**	**2**	**3**	**4**	**5**
36. I have no pressure from my father/ step-father/ male guardian about how well I do in my sport.	**1**	**2**	**3**	**4**	**5**
37. I have no pressure from my mother/ step-mother/ female guardian about how well I do in my sport.	**1**	**2**	**3**	**4**	**5**
38. I have no pressure from my coach about how well I do in my sport.	**1**	**2**	**3**	**4**	**5**
39. I have no pressure from my other relatives about how well I do in my sport.	**1**	**2**	**3**	**4**	**5**
40. I have no pressure from my teachers about how well I do in my sport.	**1**	**2**	**3**	**4**	**5**
41. I have no pressure from my friends about how well I do in my sport.	**1**	**2**	**3**	**4**	**5**
42. I think that what I eat is very important to my sporting performance.	**1**	**2**	**3**	**4**	**5**
43. I feel confident in my future as an athlete.	**1**	**2**	**3**	**4**	**5**
44. My sport is the most important thing in my life.	**1**	**2**	**3**	**4**	**5**
45. I enjoy spending time with my family.	**1**	**2**	**3**	**4**	**5**
46. I enjoy spending time with my friends.	**1**	**2**	**3**	**4**	**5**
47. At the time I am motivated to train / compete.	**1**	**2**	**3**	**4**	**5**
48. I am motivated to keep on training / competing in the future.	**1**	**2**	**3**	**4**	**5**
49. I cope well with balancing my schoolwork and training schedule.	**1**	**2**	**3**	**4**	**5**
50. I cope well with the work at school and the tiredness from training.	**1**	**2**	**3**	**4**	**5**
51. I recover quickly after competition.	**1**	**2**	**3**	**4**	**5**
52. I recover quickly from injuries.	**1**	**2**	**3**	**4**	**5**

53. I recover quickly from illnesses.	**1**	**2**	**3**	**4**	**5**
54. I do everything my coach asks me to.	**1**	**2**	**3**	**4**	**5**

SECTION 3

Circle the number that best reflects your answer to each question: **1- Never; 2- infrequently; 3- sometimes; 4- frequently; 5- all the time**

55. How often do you feel your muscles are heavy and stiff?	**1**	**2**	**3**	**4**	**5**
56. Do your muscles ever feel sore 12 hours or more after a training session?	**1**	**2**	**3**	**4**	**5**
57. How often do you have problems sleeping (*e.g. falling asleep, waking up during night, waking up early*)?	**1**	**2**	**3**	**4**	**5**
58. How often do you get injured?	**1**	**2**	**3**	**4**	**5**
59. How often do you get infections like a sore throat, colds, fever, flu, runny nose, etc?	**1**	**2**	**3**	**4**	**5**
60. Do you ever lose your appetite when you are in a period of hard training?	**1**	**2**	**3**	**4**	**5**
61. Do you ever lose your appetite when you are in a period of important competitions?	**1**	**2**	**3**	**4**	**5**
62. How often do you use mental exercises as part of your preparation (e.g. imagery, relaxation techniques)	**1**	**2**	**3**	**4**	**5**

63. If you practice mental exercises which exercise(s) do you use? ____

____

64. How often do you think your training is exciting and fun?	**1**	**2**	**3**	**4**	**5**
65. Do you ever feel in a bad mood when you are in a period of hard training?	**1**	**2**	**3**	**4**	**5**
66. Do you ever feel sad or like crying when you are in a period of hard training?	**1**	**2**	**3**	**4**	**5**

67. Do you ever feel that you cannot be bothered towards what is happening around you during periods when you are training a lot?	**1**	**2**	**3**	**4**	**5**
68. Have you ever had periods of weeks where you feel extremely tired every day?	**1**	**2**	**3**	**4**	**5**

SECTION 4

Circle the number that reflects your answer to each question: ***1- very bad; 2- bad; 3- neither bad or good; 4- good; 5- very good***

69. How do you feel when you do not perform as well as you expected?	**1**	**2**	**3**	**4**	**5**
70. How do you feel when you do not perform as well as your parents/ guardians expected?	**1**	**2**	**3**	**4**	**5**
71. How do you feel when you don't perform as well as your coach expected?	**1**	**2**	**3**	**4**	**5**
72. How do you feel when you don't perform as well as your training / playing-partners expected?	**1**	**2**	**3**	**4**	**5**
73. What do you think your relationship is like with your coach?	**1**	**2**	**3**	**4**	**5**
74. What do you think your relationship is like with your training / playing partners?	**1**	**2**	**3**	**4**	**5**
75. What do you think your relationship is like with your father / stepfather / male guardian?	**1**	**2**	**3**	**4**	**5**
76. What do you think your relationship is like with your mother / stepmother / female guardian?	**1**	**2**	**3**	**4**	**5**
77. What do you think your relationship is like with your other relatives?	**1**	**2**	**3**	**4**	**5**

SECTION 5

78. How much time (in hours per week) do you give to other interests or hobbies (e.g. reading, watching TV, shopping, etc.)?

1 - Less than 5 hours **2 - Between 5 and 10 hours** **3 - Between 10 and 15 hours** **4 - Between 15 and 20 hours**

5 - Between 20 and 25 hours **6 - Greater than 25 hours**

79. Who in your life is mostly responsible for preparing the food you eat?

1 - Parent / caregiver **2 - Sports coach** **3 – Yourself**

4 - Other *(please detail who)*: ____

80. Who in your life is mostly responsible for setting your training plan?

1 - Parent / caregiver **2 - Sports coach** **3 – Yourself**

4 - Other *(please detail who)*: ____

81. Have you ever lost weight for no apparent reason? **YES** **NO**

82. If yes, how much (in Kg) weight did you lose?

1- Less than 2kg **2- Lost between 2 and 3 kg** **3- Lost more than 3 kg** **4 – Not applicable**

83. Do you keep a training diary with information relating to your training? **YES** **NO**

84. What types of facts do you keep a note of in your training diary (e.g. distance covered, intensity, number of colds, mental or emotional concerns, etc.)? ____

____

85. Have you ever been through periods in your training when you could not cope with the intensity/ loads required of you? **YES** **NO**

86. Have you ever had a time when you felt very fatigued every day and your performance significantly decreased for long periods of time (e.g. weeks to months) even though you were training? **YES** **NO**

87. If you answered yes to **question 86**, how many episodes do you remember having had? ____

88. If you answered yes to **question 86**, roughly how long did these episodes tend to last for? **1 – Less then 1 month** **2 – Between 1 to 2 months** **3 – Between 2 and 3 months** **4 – Between 3 and 6 months** **5 – Between 6 months and 1 year** **6 – N/A**

89. If you answered yes to **question 86**, did this reduce your motivation to keep on training? **YES** **NO** **Not applicable**

90. If you answered yes to **question 86** above, can you write down what your feelings and emotions were like during this time?

____

____

91. For the past 2 weeks or more, despite training regularly, have you been feeling extremely tired everyday and has your performance significantly decreased? **YES** **NO**

92. Do you play / practice any other sports apart from your main sport (may be as part of a school team or local club)? If you do, try to estimate how many hours per week you spend doing each sport? Please state the sport(s) and hours per week.

SPORT 1: _____________________ approximate number of hours/ week: _______________

SPORT 2: _____________________ approximate number of hours/ week: _______________

SPORT 3: _____________________ approximate number of hours/ week: _______________

93. Please enter any other comments you may have or additional information regarding your responses to any of the above questions in this box

____

____

____

Appendix 8

Information letters – Study 2

UNIVERSITY OF EXETER

SCHOOL OF SPORT AND HEALTH SCIENCES

INFORMATION LETTER - PARENTS

Dear Parent/ Guardian

Thank you for showing interest on having your child to take part in this project. This sheet will tell you a bit more about the study and what we would like to do. Please read this carefully before deciding if you want your child to take part.

What is the research about?

This project is aimed to help us understand how young athletes, specifically swimmers respond physically and mentally to training loads during a complete training season, and how they cope with personal life stress during this time.

We want to learn more about how swimmers cope with the high demands of swimming training/ competition and personal life stress so that we can better advise coaches on how to understand their athletes' responses and from there prescribe training on a more efficient way.

Also, we want to be able to counsel athletes on how to increase self-awareness in relation to the way they respond to training/ competition and life stress.

Finally, we want to inform parents on how to help their sons to deal with the tiredness from training/ competition and life demands, so that athletes will feel better emotional support and understanding, and consequently, take their potential to greater standards.

Who is taking part?

Twelve swimmers from Exeter City Swimming Club who have been practicing this sport on a regular basis for more than 4 years.

Your son will be asked to:

1. Provide a saliva sample once a month before your training session. The saliva analysis will tell us how your immune and hormonal systems are responding to training;
2. Provide a monthly record of how your heart is working. This will be taken in the morning of your week rest day, immediately after waking up and will take 10 minutes;
3. Complete 2 questionnaires once a month before your training session. One of the questionnaires is to do with how you cope with the stress from training and personal life and the other questionnaire addresses emotional intelligence, which has to do with how you perceive your owns and other people's emotions.
4. Three out of the 12 swimmers will be randomly invited to take part in 1 qualitative interview at the end of the year. The interview will involve issues about the athlete's sporting past experiences, how he sees himself in the sport and how he copes with the demands from sport and daily life. The interview will last no longer than 60 minutes and will be organised at a time that is convenient to the athlete. The information generated by the interviews may lead to dissemination via publication in leading journals. As a part of this ongoing process, extracts of interview data may be published in the future but no details about any person (s) within the study will be divulged from which they could be identified. Furthermore, at no times during the study will the name of the school or members within the school be identifiable and I will ensure that any information concerning those individuals taking part within the study remains confidential between my supervisor Dr. Richard Winsley and myself. In addition, and in case of need a number of support services (relevant to the participants) will be available.

5. During the performance test (7 x 200-m) your son will be asked to provide 7 blood fingertips taken from your finger. At the same time, exercising heart rates and how intense your son perceives the exercise, will be recorded.

4. When will he/she do the study?

He/ she will be involved in this study during 11 months, which is how long the competitive season lasts. The first data collection will start on the 1st week of September 2007 and the last bit of data collection will happen on the last week of the season (either last week of July or first week of August).

5. Can he/she change his/her mind?

He/ she can stop participating in the study at any time needing only to speak with the swimming coach or myself. As soon as I am informed I will cancel all the data your child has provided. Importantly, this will never affect his/ her relationship with the research team or your swimming club.

6. What will be done with the collected information?

All the results we will collect will be stored on a computer. No one will be told your son's individual results. We will write the study up for other scientists to read but your son's information will remain confidential.

7. What do I do next?

If you have any more questions about the study you can contact myself, Nuno Matos or Dr. Richard Winsley at the numbers below. If you have read and understood everything that we would like your child to do please sign the consent form I have provided you with.

This project has been reviewed and approved by the Ethics Committee of the School of Sport and Health Science

UNIVERSITY OF EXETER

SCHOOL OF SPORT AND HEALTH SCIENCES

INFORMATION LETTER - ATHLETES

Dear Athlete,

Thank you for showing interest in taking part in the study. This sheet will tell you a bit more about the study and what we would like to do. Please read this carefully before deciding if you would like to take part.

1 - What is the research about?

This project is aimed to help us understand how young athletes, specifically swimmers like you respond physically and mentally to training loads during a complete training season, and how they cope with personal life stress during this time.

We want to learn more about how swimmers cope with the high demands of swimming training/ competition and personal life stress so that we can better advise coaches on how to understand their athletes' responses and from there prescribe training on a more efficient way.

Also, we want to be able to counsel athletes on how to increase self-awareness in relation to the way they respond to training/ competition and life stress.

Finally, we want to inform parents on how to help their sons to deal with the tiredness from training/ competition and life demands, so that athletes will feel better emotional support and understanding, and consequently, take their potential to greater standards.

2 - Who is taking part?

Twelve swimmers from Exeter City Swimming Club who have been practicing this sport on a regular basis for more than 4 years.

3 - What will I be asked to do?

You will be asked to:

1. Provide a saliva sample once a month before your training session. The saliva analysis will tell us how your immune and hormonal systems are responding to training;
2. Provide a monthly record of how your heart is working. This will be taken in the morning of your week rest day, immediately after waking up and will take 10 minutes;
3. Complete 2 questionnaires once a month before your training session. One of the questionnaires is to do with how you cope with the stress from training and personal life and the other questionnaire addresses emotional intelligence, which has to do with how you perceive your owns and other people's emotions.
4. Three out of the 12 swimmers will be randomly invited to take part in 1 interview at the end of the year. The interview will involve issues about the athlete's sporting past experiences, how he sees himself in the sport and how he copes with the demands from sport and daily life.
5. During the performance test (7 x 200-m) you will be asked to provide 7 blood fingertips taken from your finger. At the same time, your exercising heart rate and how intense you perceive the exercise will be recorded.

4. When will I do the study?

You will be involved in this study during 11 months, which is how long your competitive season lasts. The first data collection will start on the 1st week of September 2007 and the last bit of data collection will happen on the last week of the season (either last week of July or first week of August).

5. Can I change my mind?

You can stop participating in the study at any time needing only to speak with myself. In case you would prefer, you can speak with your coach or your parents, so that they inform me and I will cancel all the data you have provided. Importantly, this will never affect your relationship with the research team or your swimming club.

6. What will be done with the collected information?

All the results we will collect will be stored on a computer. No one will be told your individual results. We will write the study up for other scientists to read but your information will remain confidential.

7. What do I do next?

If you have any more questions about the study you can contact myself, Nuno Matos or Dr. Richard Winsley at the numbers below or you can ask your mum or dad to phone us. If you have read and understood everything that we want you to do please sign the consent form I have provided you with.

This project has been reviewed and approved by the Ethics Committee of the School of Sport and Health Science.

Appendix 9

Consent forms – Study 2

UNIVERSITY OF EXETER

SCHOOL OF SPORT AND HEALTH SCIENCES

CONSENT FORM FOR PARENTS/ GUARDIANS

The research has been explained to me in an accompanying letter. I understand that my child will be asked to provide non-invasive (saliva) and invasive (capillary blood samples) physiological data, and to complete 3 different types of questionnaires. I understand my child will have to visit the laboratory for purpose of being tested. The results will be stored on a computer in a coded form and individual results will be confidential to the research group.

I know that:

1. My child's participation in the project is entirely voluntary;
2. My child is free to withdraw from the project at any time without giving reason or affecting his/her relationship with either the research team or the school;
3. Any raw data on which the results of the project depend will be retained in secure storage;
4. The results of the project may be published but my anonymity will be preserved.

I agree to my child ____ participating in a research project concerned with training practices and personal life issues in young athletes.

Signed: ____ (Parent/ Guardian)

Date: __________________

This project has been reviewed and approved by the Ethics Committee of the School of Sport and Health Sciences.

SCHOOL OF SPORT AND HEALTH SCIENCES

STUDY: Monitoring a training season in young swimmers

CONSENT FORM FOR PARTICIPANTS

I have read the Information Sheet concerning this project and understand what it is about. All my questions have been answered to my satisfaction. I understand that I am free to request further information at any stage.

I know that:

1. My participation in the project is entirely voluntary
2. I am free to withdraw from the project at any time without giving a reason and this will not be a problem
3. The data that I provide will be kept securely and I understand that only the researchers will have access to my answers
4. The results of the project may be published but my anonymity will be preserved.

Having read the information sheet and consent form for participants, I consent to participate in this study by signing below.

Signed:

Date:

This project has been reviewed and approved by the Ethics Committee of the School of Sport and Health Science

Appendix 10

Fat percentage calculations

Jackson and Polock (1980) equation for determination of body density and body composition in women

$$\mathbf{D = 1.06095 - 0.0006952 * SKF_1 + 0.0000011 * SKF_2 - 0.0000714 * X_1}$$

$$\mathbf{\% \ Fat = (495/ D) - 450}$$

D – body density

$\mathbf{SKF_1}$ – sum of triceps, suprailiac, abdominal and crural skinfolds

$\mathbf{SKF_2}$ – SKF_1^2

$\mathbf{X_1}$ - age

Reference:

Jackson, A., & Polock, M. (1980). Generalized equations for predicting body density of women. *Medicine and Science in Sport and Exercise*, **12** (3), p. 175-182.

Appendix 11

FINA scale

FINA (2004) performance calculations

FINA performance calculations are based on a mathematical model that attributes a score independent of technique or distance swam. The calculations relate to the average performance attained in the past decades from the world's 10 best times in each event (FINA, 2004).The times are corrected every 4 years and validated at the beginning each Olympic cycle, establishing a score in relation to either short- (25 m) or long-course (50 m) performances. The formula used consists of a 3rd degree polynom (cubic curvilinear):

$$\textbf{FINA score} = 1000 * (B/T)^3$$

B –reference time from the respective data base

T – time of the event to be determined

Reference:

FINA, 2004. Fina Points Scoring, retrieved from the World Wide Web 15th of January 2009, from http://www.swimrankings.net/files/FINA%20Point%20Scoring.pdf

Appendix 12

7 x 200m Step Test

7 x 200 m step test

The protocol used was based on Pyne and colleagues (2000) method for control and assessment of elite swimmers' performance. This protocol consists on 7 sets of 200 m swim going on every 5 minutes. Swimming velocity is to improve 5 seconds for each set, with the 7th repletion having to be 5 seconds away from the athlete's personal best.

Reference:

Pyne, D., Maw, G., & Goldsmith, W. (2000). Protocols for the physiological assessment of swimmers. In Gore, C. (Ed.), *Physiological Tests for Elite Athletes*, Human Kinetics.

Appendix 13

Information letter – Study 3

School of Sport and Health Sciences

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INFORMATION LETTER – PARENTS/ ATHLETES

Dear Athlete,

Thank you for showing interest in taking part in the study. This sheet will tell you a bit more about the study and what we would like to do. Please read this carefully before deciding if you would like to take part.

1 - What is the research about?

This project is aimed to help us understand how young swimmers like you respond physically and mentally to an intensive week of training, and how they respond 2 weeks after.

By learning more about how swimmers cope mentally and physically with the demands of swimming training/ competition, we will be better able to advise coaches, parents and doctors about how to avoid pushing you too far and becoming overtrained.

2 - Who is taking part?

We would like to study eight swimmers from Exeter City Swimming Club who have been practicing this sport on a regular basis for more than 4 years.

3 - What will I be asked to do?

Basically, you will be tested at 3 different settings; one will be in our sports science laboratories (located in St. Lukes Campus, Heavitree Rd, University of Exeter), the other at the swimming pool, and finally you will also have to complete some measures at your own home.

Testing in the labs will involve:

1. Anthropometric measures (sitting and standing height, weight, and 4 skinfolds that will allow us to determine the % of fat that is in your body).
2. Completion of 3 different questionnaires; the 1st will inform us about how you cope with stress, the 2nd about how aware you are of your own emotions and the others surrounding you, and the 3rd will assess athlete burnout.
3. Completion of a 2-min psychometric test that will inform us about your cognitive capacity when having to answer as quickly as possible to very simple tasks.
4. A 10-minute measure of your resting heart rate whilst lying down (5 minutes) and standing (another 5 minutes).

Testing in the swimming-pool will involve:

1. A 5 minute sample of your saliva (taken 4 times during the study) to analyse how your immune system and hormonal system are working. This will be done just before you go in the water in between 6:45pm and 7:00pm.
2. Completion of the 7x200m swimming step-test; this will involve collecting a blood fingertip taken from your finger at the end of each 200m, and measurement of your heart rate and rates of perceived exertion throughout the test.

Training camp testing:

1. You will be tested **EVERY** day of the 6-days training camp.
2. Every day you will have to complete 4 questionnaires, one of which has already been described above (measures your psychological profile). The second questionnaire is about how you are coping with the daily life demands during the week, the 3rd is about how you rate the evening training session in terms of perception of effort, and finally the 4th questionnaire (**will be answered at home before bedtime**) is about your recovery after completing the day of training.

4. When will I do the study?

The study will start Saturday 11th of October and will be finished by Monday 17th of November – 5 week period.

5. Can I change my mind?

You can stop participating in the study at any time needing only to speak with myself. If you would prefer, you can speak with your coach or your parents, so that they inform me and all your data will be deleted from the study. Importantly, this will never affect your relationship with the research team or your swimming club.

6. What will be done with the collected information?

All the results we will collect will be stored on a computer. No one will be told your individual results. We will write up the findings for publication and for other scientists to read but your information will remain confidential.

7. At what point will I know about my individual results?

You will be given all the information about the collected data only at the end of the study. The reason for not giving feedback about the results is because it could bias the outcome of the study by creating changes in your behaviour due to the results of your own data. We need to wait until the end of the study so that then we can advise you, your team mates, your coach and parents.

8. What do I do next?

If you have any more questions about the study you can contact myself, Nuno Matos, or Dr. Richard Winsley at the numbers below or otherwise you can ask your parents/guardians to phone us. If you have read and understood everything that we want you to do please sign the consent form provided and return this to your coach or myself, on one of my visits to the swimming pool.

This project has been reviewed and approved by the Ethics Committee of the School of Sport and Health Science.

Appendix 14

Consent forms - Study 3

Children's Health and Exercise Research Centre

CONSENT FORM FOR PARENTS/ GUARDIANS

The research has been explained to me in an accompanying letter and I understand that my child will be asked to do a series of testing that will involve: completion of 6 different questionnaires, measurement of anthropometric body parameters, completion of a psychometric test, collection of 4 saliva samples, collection of fingertip blood samples, and measurement of heart rates at rest and during exercise. I understand also that my child will have to visit the laboratory for purpose of being tested. The results will be stored on a computer in a coded form and individual results will be confidential to the research group.

I know that:

1. My child's participation in the project is entirely voluntary;
2. My child is free to withdraw from the project at any time without giving reason or affecting his/her relationship with either the research team or the school;
3. Any raw data on which the results of the project depend will be retained in secure storage;
4. The results of the project may be published but my anonymity will be preserved.

I agree to my child ____ participating in a research project concerned with the acute responses to swim training in young athletes.

Signed: ____ (Parent/ Guardian)

Date: ___________________

This project has been reviewed and approved by the Ethics Committee of the School of Sport and Health Sciences.

SCHOOL OF SPORT AND HEALTH SCIENCES

STUDY: Acute Responses to a 5-Week Training Period

CONSENT FORM FOR PARTICIPANTS

I have read the Information Sheet concerning this project and understand what it is about. All my questions have been answered to my satisfaction. I understand that I am free to request further information at any stage.

I know that:

1. My participation in the project is entirely voluntary
2. I am free to withdraw from the project at any time without giving a reason and this will not be a problem
3. The answers that I give will be kept securely and I understand that only the researchers will have access to my answers
4. The results of the project may be published but my anonymity will be preserved.

Having read the information sheet and consent form for participants, I consent to participate in this study by signing below.

Signed: ____

Date: ____/_____/ _______

This project has been reviewed and approved by the Ethics Committee of the School of Sport and Health Science

Appendix 15

Session-RPE questionnaire

Session Rates of Perceived Exertion (RPE) Scale

Name: ________________________________ **Date:** _____/_____/2008

HOW HARD WAS YOUR SESSION? ***Answer 30 minutes after completion of the session!*** *Circle the number that best describes the overall difficulty of the exercise session.*

Score	
0	Rest
1	Really easy
2	Easy
3	Moderate
4	Sort of hard
5	Hard
6	
7	Really hard
8	
9	Really, really hard
10	Just like my hardest race

Appendix 16

Perceived Recovery Scale

Perceived recovery scale

Name: ________________________________ **Date:** _____/_____/2008

HOW HARD WAS YOUR SESSION? ***Answer before bedtime!*** *Circle the number that best describes your recovery for the previous 24 hours, including your last night's sleep.*

Score

6

7 Very, very poor recovery

8

9 Very poor recovery

10

11 Poor recovery

12

13 Reasonable recovery

14

15 Good recovery

16

17 Very good recovery

18

19 Very, very good recovery

20

Appendix 17

Information letters – Study 4

School of Sport and Health Sciences

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INFORMATION LETTER - PARENTS

Dear Parent/ Guardian

Thank you for showing interest on having your child to take part in this project. This sheet will tell you a bit more about the study and what we would like to do. Please read this carefully before deciding if you want your child to take part.

1. What is the research about?

This project is aimed to help us understand how young athletes, specifically swimmers cope with personal life stresses alongside their training. By learning more about how swimmers cope with the demands of swimming training/ competition and personal life stresses, we will be better able to advise coaches, parents and doctors about factors that might cause child athletes to become overtrained. Finally, we want to inform parents on how to help their children deal with the tiredness from training/ competition and life demands, so that athletes will feel they are better emotionally supported and understood, allowing them hopefully to reach their full potential.

2. Who is taking part?

We would like to interview 3 athletes from the main group of twelve swimmers from Exeter City Swimming Club who have engaged in this study.

3. How do you know if your son will participate in the study?

Two out of the 12 swimmers will be randomly selected to take part in an interview during the sports season; at the time of selection your child will be told whether he /she is participating or not.

4. What will my child be asked to do?

He/ she will be asked to discuss issues about their past sporting experiences, how they see themselves in the sport and how they cope with the demands from sport and daily life. The interviewer will be Mr Nuno Matos. There are no right or wrong answers. It is their experiences, and what they want to tell us about them that we wish to hear. The interview will last no longer than 60 minutes and will be organised at a time that will be convenient to your child. The interview will take place at the swimming pool in a quiet and private place, but open so that people around will be able to see us.

5. What if your child feels uncomfortable during the interview?

The information your child provides is under his/ her control and he/ she is free to decline to answer any question. Should your child feel uncomfortable about any issues that are raised, he/ she is free to change the topic, interrupt the interview for a while, or stop the interview altogether. Furthermore, your child is free to leave the study at any time, without having to give a reason and without incurring displeasure or penalty. Importantly, this will never affect his/ her relationship with the research team or swimming club. We are academically trained personnel and not medical practitioners or therapists: in the unlikely event that your child was to become distressed during or after the interview, we will be able to direct them to a number of professional support services that are available.

6. Is it confidential?

I will ensure that any information concerning your son will remain confidential between my supervisors Dr. Richard Winsley and Dr Brett Smith, and myself. The information generated by the interviews may lead to dissemination via publication in academic journals. As a part of this ongoing process, extracts of interview data may be published in the future but no details about any person (s) or swim club institution within the study will be divulged from which they could be identified. Furthermore, at no times during the study will the name of the members within the club be identifiable. You and your son/ daughter are most welcome to request a copy of the tapes, transcripts, and/or published papers should you so wish.

7. When will my son do the study?

The study will be conducted on the second half of the competitive season (2007/ 2008).

8. What do I do next?

If you have any more questions about the study you can contact myself, Nuno Matos, or Dr. Richard Winsley at the numbers below. If you have read and understood everything that we want you to do please sign the consent form provided and return this to the swimming coach or myself, at one of my visits to the swimming pool.

Parent Signature: ______________________________________

This project has been reviewed and approved by the Ethics Committee
of the School of Sport and Health Science

School of Sport and Health Sciences

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INFORMATION LETTER - PARENTS

Dear Parent/ Guardian

Thank you for showing interest on having your child to take part in this project. This sheet will tell you a bit more about the study and what we would like to do. Please read this carefully before deciding if you want your child to take part.

1. What is the research about?

This project is aimed to help us understand how young athletes, specifically swimmers cope with personal life stresses alongside their training. By learning more about how swimmers cope with the demands of swimming training/ competition and personal life stresses, we will be better able to advise coaches, parents and doctors about factors that might cause child athletes to become overtrained. Finally, we want to inform parents on how to help their children deal with the tiredness from training/ competition and life demands, so that athletes will feel they are better emotionally supported and understood, allowing them hopefully to reach their full potential.

2. Who is taking part?

We would like to interview 2 athletes from the main group of twelve swimmers from Exeter City Swimming Club who have engaged in this study.

3. How do you know if your son will participate in the study?

Three out of the 12 swimmers will be randomly selected to take part in an interview during the sports season; at the time of selection your child will be told whether he /she is participating or not.

4. What will my child be asked to do?

He/ she will be asked to discuss issues about their past sporting experiences, how they see themselves in the sport and how they cope with the demands from sport and daily life. The interviewer will be Mr Nuno Matos. There are no right or wrong answers. It is their experiences, and what they want to tell us about them that we wish to hear. The interview will last no longer than 60 minutes and will be organised at a time that will be convenient to your child. The interview will take place at the swimming pool in a quiet and private place, but open so that people around will be able to see us.

5. What if your child feels uncomfortable during the interview?

The information your child provides is under his/ her control and he/ she is free to decline to answer any question. Should your child feel uncomfortable about any issues that are raised, he/ she is free to change the topic, interrupt the interview for a while, or stop the interview altogether. Furthermore, your child is free to leave the study at any time, without having to give a reason and without incurring displeasure or penalty. Importantly, this will never affect his/ her relationship with the research team or swimming club. We are academically trained personnel and not medical practitioners or therapists: in the unlikely event that your child was to become distressed during or after the interview, we will be able to direct them to a number of professional support services that are available.

6. Is it confidential?

I will ensure that any information concerning your son will remain confidential between my supervisors Dr. Richard Winsley and Dr Brett Smith, and myself. The information generated by the interviews may lead to dissemination via publication in academic journals. As a part of this ongoing process, extracts of interview data may be published in the future but no details about any person (s) or swim club institution within the study will be divulged from which they could be identified. Furthermore, at no times during the study will the name of the members within the club be identifiable. You and your son/ daughter are most welcome to request a copy of the tapes, transcripts, and/or published papers should you so wish.

7. When will my son do the study?

The study will be conducted on the second half of the competitive season (2007/ 2008).

8. What do I do next?

If you have any more questions about the study you can contact myself, Nuno Matos, or Dr. Richard Winsley at the numbers below. If you have read and understood everything that we want you to do please sign the consent form provided and return this to the swimming coach or myself, at one of my visits to the swimming pool.

Parent Signature: ______________________________________

This project has been reviewed and approved by the Ethics Committee
of the School of Sport and Health Science

Appendix 18

Consent forms – Study 4

School of Sport and Health Sciences

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CONSENT FORM FOR PARENTS/ GUARDIANS

The research has been explained to me in an accompanying letter. I understand that over the duration of the study my child will be asked to give an interview. I understand that all personal data will be kept in a locked cabinet in a designated secure storage data space and that individual results will be confidential to the research group.

I know that:

1. My child's participation in the project is entirely voluntary;

2. My child is free to withdraw from the project at any time without giving reason or affecting his/her relationship with either the research team or us;

3. Any raw data on which the results of the project depend will be retained in secure storage;

4. The results of the project may be published but my child's anonymity will be preserved.

I agree to my child ______________________________________ participating in a research project concerned with training practices and personal life issues in young athletes.

Signed: ____ (Parent/ Guardian)

Date: __________________

This project has been reviewed and approved by the Ethics Committee of the School of Sport and Health Sciences.

School of Sport and Health Sciences

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CONSENT FORM FOR PARTICIPANTS

Name of participant: ______________________________

Name of interviewer: ______________________________

	Circle as appropriate
Have you read the information sheet?	YES / NO
Have you had the opportunity to ask questions about the study?	YES / NO
Have you received satisfactory answers to your questions?	YES / NO
Have you understood the nature of the project?	YES / NO
Do you understand that you are free to withdraw from the study at any time without having to give a reason for withdrawing and without affecting you relationship with us, your coach or your club?	YES / NO
Do you understand that there may be risks involved?	YES / NO
Have these been discussed with you adequately?	YES / NO
Do you understand that: The interviews will be recorded The interviews transcripts may be used for publication and conference presentations Your identity will not be revealed at any time or in any publication	YES / NO
I agree that the generated data can be used in future publications	YES / NO
Do you agree to take part in this study?	YES / NO

Signed (participant): ______________________________

Signed (interviewer): ______________________________

This project has been reviewed and approved by the Ethics Committee of the School of Sport and Health Science

Appendix 19

Interview transcript

Interview transcript

Nuno: Imagine your life as a book divided in chapters; can you give me a brief resume of how you would divide these chapters?

Kate: What my life or my swimming life?

N: If you want to separate these 2 is fine. Just imagine from when you were born until now imagine your life as a book and you want to divide it in chapters.

K: Ok (insecure laughter).

N: If you wanna make into 2 books you can, it's up to you.

K: Ok (insecure laughter). I was born, and then we leaved down here for 3 years, and then moved to America, lived over there for 4 years, and Morgan, my younger brother was born over there. Then we came back over here, and then Cubby was born, then we moved house (insecure laughter), stayed in Boudleigh and then started swimming at Exmouth.

N: What age?

K: At eight, and then when I was 10 I decided that I was leaving to go to Kelly College and leaved there until I was 11. Then I had a year at there, swimming and stuff and that wasn't very practical. And then I moved to the biggest school and I had 2 years there, but then I got ill, in the second year, so I was off school for 9 months and then came home and swam for Exmouth and I've been there for 3 years now and I've just finished my exams!

N: So if I'd ask you just to make the main chapters how do you think you would divide it.

K: Chapter 1 would be being born to moving to America, chapter 2 would be in America, chapter 3 would be moving back, chapter 4 would be at Kelly, and then chapter 5 would be back at Exmouth until now.

N: Now can you tell me about your sport from when you started it until the present.

K: Started when I was 9, went to Exmouth.

N: Why did you start it?

K: I don't know… I just… I've always liked swimming and I was the best in my class at primary school, so I got into swimming and then I was alright and then I was like in top lane at X Club with all the older boys so then I moved to Ruletta College and then I stayed there for a while, then I got really ill cause I was doing too much training and then I came…

N: How old were you when you became very ill?

K: 12. at 12 till I was about 13 I was very ill and then came home, joined X Club I did quite well with Phil, and then…

N: How long were you with Phil?

K: 2 and a bit years and then Steve just came until now.

N: Ill jump onto another area. I would like you to tell me what is motivation for you, what it means to you, how can you describe it?

K: What makes you get up at half 5 in the morning. I don't know… the drive behind going training, carrying on.

N: Where do you think it comes from?

K: Don't know. I think it depends on you, what kind of person you are, and what you have done, like if you haven't been brought up to become competitive or… unlazy (laughter), I don't think you have as much motivation and it's harder to motivate yourself to do something. I think it’s like, it’s your parents, they’re either like, they’re in it to win it, or they’re just there to taking part.

N: What is your part?

K: In it to win it! Definitely (laughter)!

N: Right, what does coping mean to you?

K: Coping means handling a situation, not necessarily well but handling it so that things don’t go badly, where you don’t get ill or, I don’t know… something along those lines

N: What about high intensity training?

K: High intensity means lots of training, at high level.

N: What is that like?

K: Hard (raise in tone of voice). Hard work. And a lot of it. Yeah.

N: How much hard work?

K: I think it would probably be a week at school, with pool mornings and 5 evenings, about 9 sessions, which are all quite mead to high intensity training, not easy, 9 sessions.

N: Have you done this in the past?

K: Yes. I did it with Phil, only with Phil, 8 sessions a week. I mean that was kind of a bit hard…

N: How many mornings was that?

K: 3 and then Sundays a bit later.

N: Ok, what about how you motivate yourself to cope with high intensity training and competitions.

K: Hmm you have to have a target or a specific time that you want to be able to hit, or like just get PBs, not necessarily beat A time, you have to have something to work for I think or to beat the person (in secure laughter).

N: Or beat the person…

K: Yeah.

N: So is that how you bring motivation to yourself?

K: Yeah.

N: Either thinking of your opponent or have a target time?

K: Yeah. That's it.

N: what about when you don't perform and ends up not being what you expected. How do you react emotionally?

K: Hmm… normally I get angry and decide not going to swim cause if not I always come back to that so (insecure laughter)… but yeah, I don't like doing badly. I don't cope with losing very well either (insecure smile).

N: How do you see yourself in the future?

K: I don't know I probably I still be going to the pool obviously, training at hopefully high level, quite a lot but, I don't see myself like going to the Olympics (laughs), I don't…

N: So you see yourself practicing something that would keep you fit and healthy… would that mean being out of competition…

K: I don't know if I'm good enough then yeah, I guess I could probably do competitions. I'd quite like to do masters competition. They sound quite fun. And if it was like to do a job in the future I'd quite like to be a trainer or something. I would like to do that. I wouldn't like to be a fat coach.

N: So if you would be a coach you wouldn't like to be a fat coach…

K: Yeah, I don't think that sounds very good. I don't think it sends a very good message (laughs). Like if you're going on about being healthy and exercising, and eating properly and then I think you're being a hypocrite because you're not doing anything about it, and you're contradicting yourself (laughs).

N: What about the areas in your life that you think swimming influences on a positive way?

K: Appearance, that's probably the biggest one, and you're like, physique. Like you're not fat, like you're not obese. I don't know I just think that's quite a good thing.

N: Why do you think that's important?

K: I don't know. Cause I guess if you weren't, you just would have quite a lot of problems that would go along with that, health issues, being bullied, I don't know… along those lines. I think sometimes it's quite good to use it as stress release, doing a sport. Like if you feel really angry you can just smash up and down the pool. I don't know, it gives you something over other people to say that you are like a national level swimmer and they don't have anything to say. They just go home and watch TV.

N: How does that make you feel in relation to other people?

K: Makes me feel like good. Makes me feel like I don't know, fit and healthy. So I think it's quite a good thing.

N: What about the areas in your life that affect and influence swimming on a negative way.

K: Timings, like you always have to train, never get a social life and sometimes you want to do something and then you can't because you've got like competition and your training. I don't know, sometimes like if you're doing, if you go away for like a week in a training camp and you don't get to see anyone for a week, you're bored, and then you go away it's a bit complicated. Being able to be careful about what you're doing, like alcohol, and drugs and stuff, not that you I would do anything (laughs), but just if you would do it, you couldn't like do it, it would obviously affect your diet; I don't really think that affects my diet, apart from my knowing of what's good for you and what's bad for you.

N: Do you think swimming has a negative effect on your diet or your swimming?

K: I don't know. Sometimes it has affected my eating, like you're eating at half 9 or 10 o'clock at night, that's bad for you, and that's not the best of things, but, apart from that, I think it's ok. Sometimes it messes up your body clock as well, because you hardly get any sleep and you go to bed late, get up early, and then if you can't get into normal routines it's really hard. Like I wake up at 5am every morning, just cause… I wake up (laughs). I just wake up now normally. I wake up to go to training but then I wake up every morning, I just look at the clock I see what day is and I go back to sleep.

N: I heard you speaking about the lack of opportunities that many times you have, in terms of not being able to socialize more. How do you feel in relation to how much commitment you put into swimming and then suddenly you can't be with your friends. How do you see yourself, do you think you are missing a lot, do you think you should have more time?

K: Depends on what's going on really and how much you trained. Its like if you decide that you want to go all the way and you're prepared to put it in then you're gonna have to suffer, like you'll burn. I don't know, I think it's quite good that if you just be like, become really praised from the people who usually see you. They're like an extended family in a way. They're like the first people you see in the morning and then the last people you see at night. I wouldn't change things. I wouldn't like get rid of them so I could be a person to my owner self, which is stupid cause you need more friends, friends that are similar to you, and they know like what you're going through and stuff like that.

N: How does your motivation change when you lose or win in competition?

K: I think it depends on how much you lose or win by. If you win I think it's good cause it proves that your training methods are working so I just carry on doing that but if you loose… If I loose by a little bit it just makes me angry and so I just train more and want to beat whoever or go in back or but if I loose and I don't get my time by miles then I just don't go training for a while (insecure laughter).

N: How much time are you away from training

K: I don't know. I haven't swam that badly, apart from this year but I kind of expected it this year because of the amount of training, or the lack of training I mean we have been doing, so I knew it would be bad anyways but, I don't know.

N: Did it ever happen to you that you weren't happy and you didn't want to go swimming for a week or for a month.

K: At nationals, the 1st time I went to nationals.

N: Was that with Phil?

K: Yeah, first time I went to Nationals I was about 10 seconds away from my PB. I just didn't swim the rest of the summer and I started again in September, so I missed 2 weeks of training and then we had 2 weeks of holydays, so I missed like a month.

N: What motivates you to train and compete?

K: I don't know. I think now I only train and compete because it's what I do (laughs). I don't know I just wanna swim for a long time and carry on. I don't know I just thing its bad to not have something to do, while others just seat at home id rather go training, have a sport, fill the day up.

N: What if is something that doesn't necessarily involve physical activity?

K: I think if it's productive, makes you think and stimulates you then I think it's alright. But if it's just watching the TV, that's not good. I don't know, for me personally it's physical activity, something that actually produces a large amount of work. Like if you have learnt a language and you're an obese I think that doesn't make you feel really good, or like step dance or art it's better then just not going there and not showing to people. And I think you have to be good at these things for it to benefit you.

N: Now tell me about your relationships with the people that are most influential in your swimming.

K: My parents… my dad's quite good, he just accepts everything, like if I do badly he'll just go "Oh never mind", and if I do well then I do and he goes "well done!". Whereas my mum just gets annoyed when I do badly, and then she gets really happy when I do well (insecure laughter). I don't know. She's just extra pushy if you don't do well, like she was definitely patronizing, she used to be really annoying about it, and now she's ok. I think she's kind of accepted that I'm not gonna win every race I go.

N: Phil or Steve?

K: Steve.

N: You can speak about both, it's up to you.

K: I don't know, I used to get unwell with Phil and I used to like his training but then I used to… I don't know I used to get on well with him half the time and then I didn't the other half cause I used to talk back to him all the time when I didn't agree with what he was saying or doing. And I don't think he liked that because he likes being in charge, but he kind of knew that I'd always be like that and he expected it in the end I think, cause he knew what he was doing as well and he knew he was like annoying me (laughs). So like if someone does something wrong and then he starts everyone doing the all set again… I used to get really angry, and I used to stop and I would refuse to do the set again cause I hadn't done nothing wrong. He knew that would make me angry. So in the end he did to the others and just left me, but then other people stopped with me cause they didn't like it… but I did like Phil. Towards the end I didn't so much but I think that was only cause he was really… I don't think he was interested into swimming towards the end, cause his girlfriend left and stuff and then Steve came… I like Steve… he's a bit quiet, he's very quiet actually, and you can see that he's annoyed sometimes and he stands on the pool side like, I don't know, just staring at us and shaking his head, but he wont ever tell us what's wrong. He would just be like "right, another 100m", which sometimes annoys me cause he should tell us and then we could actually make it better, but he is nice, and he's quiet nice when you don't do well, he doesn't like disown you (insecure laughter), and he's nice about when you can't make it to training and stuff, he doesn't like tell you off and ignores you like Phil used to do. But I don't think his training works for me personally. Not that I think it's too easy its just that I don't think there's enough of it, or at the intensity it should be at, cause he does do hard sets but its just once every month probably, or twice every week.

N: So what would say you have the best relationship; is it with Steve or was it with Phil? Taking into account that obviously Steve has only been coaching you for one year, so…

K: I don't know, because personally I prefer Steve, but then I got better results and more from Phil, and I think that was from his training methods and the way he took the sessions, but Steve's a nice person (smiles), if that makes sense…

N: What about your team mates how's the relationship with them?

K: Yeah, I think it's really good… yeah, I don't know… I've always been the oldest distance swimmer, and now Rita has come and we got on really well, we're just twins (smiles), together, so we're always doing the sets together but Rita gets quite annoyed sometimes.

N: Why?

K: Because she gets really annoyed about the fact that we always have to do more than the others and then she like screams at me and gets angry but that's just quite silly.

N: Now can you tell me how do you think other people see you in swimming?

K: I think I come across as I'm a bit overconfident, due to… I don't know… high practice sometimes and I don't really think that people take it seriously but… I do but then I don't want to just be swimming with my life, but then I think that quite a lot of people think like that as well.

N: Are you saying that other people have the idea that you just want to swim in your life?

K: No, I'm saying that quite a lot of other people don't have that approach to swimming that they want it to be their life.

N: Is that what you want?

K: No, I don't want swimming definitely to be the one thing my life, and I don't think that there are many people at the swimming club who would want it to be their life. I don't know, I like swimming (laughs) and my friends, they're all quite nice, and everyone in the club gets on quite well. Sometimes there are parents' interferences…

N: Can you tell me about one example where parents interfered?

K: When we got told off for leaving the changing rooms in a mess and it wasn't us, it was the younger ones and we got told off that by a mum when it was actually her daughter who made most of the mess, and quite a few people complained about it.

N: So all these relationships in swimming, how do you feel they impact on you as a swimmer?

K: I don't know I think its good in some ways, otherwise it would always have gone wrong, I would've quit swimming and nobody would know, so I think it's a good time that things must be ok, that's the way it goes… I don't know. If I didn't get on with the swimmers or the coach then I'd probably just leave, so… I do… I don't know… I'd have the other side of life, like going out with friends, boyfriend.

N: Do you miss that other part of life?

K: No I don't. I don't think I feel it that much because I still can have it, its quite easy to fit it around, well not quite easy but its doable to fit around, don't know…

N: Can you speak about the pressures that you have from your parents.

K: I don't think there's so much any pressures anymore. Last year and the beginning of this year I think. But then this year you didn't know whether the pool would be working. I dropped 13 seconds, but I think they knew that I wouldn't get them, so in way there was no way around it, but I'd still like to see myself swimming when I'm 25. It probably will be. I won't stop swimming.

N: If you would be a swimmer when you were 25 why would you do it? Would it be because of your mum or dad?

K: No, it's because I actually like swimming. I like training. I don't like racing at all. I hate racing.

N: Why not?

K: I don't know… I don't like the pressure, I get really nervous, I don't know, I've always hated racing, but I like training.

N: How do you think racing could be improved to make you like it?

K: I don't know, I like racing not low level but like, I like doing relays and be there and stuff but, I don't know, its more fun and there's less pressure on you cause you're in a team, that's what I really don't like the persons all being on you I don't cope that well (insecure laughter)…

N: What about pressures from your coach?

K: Phil I think would put quite a lot of pressure cause he knew that we'd just do it. Cause we used to do our national times in training and stuff, but we used to never get them in racing, so he'd always just get like really annoyed. But I think that helped cause we knew that we would get our times, even if we didn't we knew that we would some time. I don't think there's any pressures from Steve really. I don't like it when like you don't know that if you don't get the times he will be disappointed as well, I don't know but… I don't like that, but it's gonna happen.

N: So Steve doesn't pressure you?

K: No, I think Steve is just enough amount of pressure.

N: Is that how a coach should be?

K: Yeah, he definitely doesn't pressure you that much. Personally that works, unless you can't work under pressure, and quite a lot of people do but I think you need to get to know your swimmers to know if they respond to like… pressurized swimming (laughs).

N: What about pressures from your team-mates; do you have any?

K: No I don't think so. I think there's pressures to a like if you're wasting relays and stuff or Speedo, to do it for your team I think that just motivates people more cause they don't want let your team down. I think that happens to quite a lot of people, but it takes some pressure off as well cause you're doing it with your team and not just yourself, so…

N: What does support mean to you?

K: The backing of balance to make the coach, its like helping you with the sport and try to be the best swimmer.

N: How are these people that support you? What do they mean to you in terms of support?

K: I think Phil was quite supportive cause we used to write down what we wanted, when we wanted and he used to try and get us there so I think he was quite good, but sometimes he was just annoying, like if you couldn't make training because of school or something else he would just ignore you for a week afterwards or something, but I don't think that was necessarily needed. Steve I think he's good. I think he is a nice about things, like if he knew you were doing something else he will ask about it, like how's it going, which I think is good but then I don't think… he does support you when you're racing but I think he's just a bit… soft not that it's a bad thing but its not good either. The parents… I don't know I think they're more the kind of like supporting me and driving me to training and back and feeding me and stuff.

N: What about emotionally?

K: No I don't… they're ok but I don't think they're really know what it's like. My dad I think knows more than my mum. But then my mum just gets bored of me swimming up and down. With my dad I think it's a lot better cause he knows what it's like to do a sport and training.

N: Does your dad have a background in sport and your mum doesn't?

K: Yeah. Well my mum use to be sporty but she never used to like do a sport competitively cause she would just flick around at school. But my dad like he still cycles and he runs and he's in the marines and he's quite competitive, he used to be really into rugby when he was younger, he used to be in the triathlon team and stuffs.

N: From relationships we continue to emotions. How do you feel when you swim?

K: Depends on what kind of day I've had. If I've had a good day then ill be alright… ill just swim up and down. If I'm really tired I just get annoyed and count down how long I've got left and want to get out. If someone annoys me, which they do quite regularly (insecure laughter) I get really angry.

N: Who are these people?

K: I don’t know, people from the club. I don’t know, I get annoyed for some things. Like I get annoyed if someone turns and I run into him or someone’s scrapping you, or… that makes me angry and I just feel better when I’m angry.

N: You feel better when you’re angry?

K: Yeah. I don’t know. When I’m tired I usually get angry cause someone annoys me, this city annoys me sometimes, or I just cant be bothered so I just go up and down the pool and not really paying attention to training.

N: What’s your general feeling with when you go swimming?

K: Normally I feel good. It’s just occasionally like some mornings. Like a certain morning when I wasn’t feeling right and tired, like if someone annoys me ill get angry (insecure laughter).

N: How do you feel when you don’t go to swimming?

K: Fat and lazy (insecure laughter), and like I should be doing some exercise. I think that’s all.

N: How do you think you would feel if you could not swim?

K: I’d do another sport and find a new sport and train in that one.

N: How would you feel emotionally if someone told you couldn’t swim anymore?

K: I don’t think… it wouldn’t be the end of the world but it wouldn’t be the greatest either because I swim and that’s what I do (laughs), so I would just change and do another sport. Wouldn’t be the end of the world but it wouldn’t be great…

N: How good do you think you are at understanding your own emotions?

K: I think I’m quite good, sometimes maybe not to control but good. I think I am quite good. Sometimes I get really angry but I don’t like burst up and stuff somewhere I don’t think (laughs). But yeah, guess good in controlling…

N: What about your swimming peers.

K: Yeah. Definitely. I wouldn't say… I think I'd have to talk to them a bit, like to find out what's the background and why…

N: How important do you think it is to be in control of your emotions?

K: It's very important, otherwise you end up like stabbing someone in the pool, or like hit them with a bottle around their head so yeah… I think it's quite important otherwise… so you definitely don't upset other people, like it really annoys me when people are angry and they make other people angry, which happens sometimes… that annoys me, or when someone is really upset and you're trying to cheer them up or you're nice to them or something and they just react back, which makes me angry.

N: How important you think it is to be in control of your emotions in competition?

K: I think that's very important. I don't know… sometimes I think it benefits you, like if I get on the blocks and say good luck to someone and they don't say back I get really angry and I want to bit them but its like a really petty thing, but it sometimes benefits me cause like what makes me angry makes me go faster but then sometimes if I'm like really tired I just give up half way through, which isn't too good… I'm not very good at that, racing… I hate racing…

N: In what ways your emotions affect your training and competition?

K: Positively at sometimes, negatively when… it gets to do with… I think sometimes, quite a lot sometimes I'm just feeling medium (insecure laughter), but it depends what happens while I'm there, like if I get bad splits from swimming ill just be like (sad face)…

N: Overtraining, what does it mean to you?

K: Doing too much when you can't cope with it and you either get ill or quit or stop or die. Not die (laughs), but can't cope.

N: How do you think it develops in an athlete?

K: Over long periods, well obviously not over long, long periods but quite long periods of hard work. Over 2 months probably, 2 months and over, and a lot of training. I don't think it necessarily has to be a hard year, I think it just has to be getting up, going swimming, doing something else, then swimming again, and that way over, too much, even if you're not training really hard, I think it could be even worse if it happened quicker but I still think you would be overtrained if you do it. I don't think it necessarily has to involve the physical load I think that's what contributes to it, like lack of sleep, lack of water, things that like you can't replace back into you so there's no other way.

N: If you now imagined yourself overtrained, how would you feel?

K: I think when I didn't want to go back to swimming, I dint want to do it, I didn't enjoy it anymore because I was so tired all the time. I found it really hard. This was with Phil towards the end of last year, and it was hardly any people coming because everyone was just like that, and nobody was doing well, nobody was getting their times, and everyone was just swimming, and he was kind of making the training harder so that we would benefit more but everyone just got ill, kept getting ill all the time, hardly any people at training, like one drilling which made it boring because there was no one there to talk to, the sets were boring cause when there's wasn't many swimmers he just give us single sets, so you got your own set… and it was just… boring.

N: Imagine a friend of yours is overtrained. How do you think this person would feel and how could you help this person to recover?

K: Don't know… I think if you would see that they're not getting their times and going anywhere over a long period they haven't got anywhere, so like 6 months to a year, then its obviously not working cause they're doing so much that you would just have to tell them basically to stop them going further downhill and carrying doing what they're doing, because you would just feel really tired, and I think it would stop you going out and stuff, you get ill and you are too tired then to be able to have your social life.

N: Imagine yourself 100 years ago. Do you think overtraining was already happening?

K: No I don’t think it would happen. I think it’s because people in the older days were like busier and more work to do and there wasn’t much about swimming, it didn’t happen just, so I don’t think it would happen. Like the kind of people that would get into swimming would have to be quite privileged… I think it’s a lot more competitive nowadays as well and well known. Especially nowadays with like obesity and stuff and lots of people are getting into sports cause they know things about the body that they didn’t before and everything else…

N: What do you think causes overtraining?

K: I think too much of sport, I think it runs you down, makes you tired, I don’t think it works, I think its quite hard to find the level that you should be at but all people are different I think, like I expect to Phil methods but like *Samuel*, to him works really well doing 6 sessions and swim well, or 5 sessions or whatever, so I think you just have to find it, but sometimes when you do find it and you can’t do that amount without being able to cope, you drop your work levels, or there’s not enough pool time, or you just can’t attend like you do other things to compensate. I think what you’re told and taught and what you believe, and what your parents want you to do I think that happens quite a lot in overtraining, and its like some people, I think it’s mostly the younger people that are overtrained because they don’t know how much they can cope with, what their body wants they’re not in charge for how much they do, or well they are but they can like easily be persuaded or told by their parents or coach that if they don’t do this much they wont be on that squad, sometimes like your friend joined that squad and wants to be there whatever happens so he'll just do it even if its not right for your body and you are not coping as well.

N: What does being a swimmer mean to you?

K: I don't know. It kind of gives you a purpose in life but I think rather then just watching TV you can do something constructive and you have something else to you rather then nothing, but if you're swimming I think you get more respect for doing that and I think it's a good thing, not necessarily that you have to be a swimmer but a runner or something else, like have a sport or a hobby.

N: The objects…

K: The mars bar is because I generally enjoy mars and I always eat it after I do exercise or a gum, but specially chocolate, I have quite an addiction to chocolate, even if its not good for me, but never mind. The picture with the baby is because I like people, I like babies and I like black people, and I want to go to Africa and I want to have an orphanage. Not that black people are any different from white but I just like black people (smiles). And the sports bottle, the pink sports bottle just cause I like sport. I like pink, stands out. Like I have 8 different pink bottles in all different colours but that's one of them.

N: Imagine I would take you the bottle away. How would that make you feel?

K: I don't know I guess I would just get another one (laughs).

N: What if I took the picture away and stop you going to Africa. What would you do?

K: I guess I would just have to stay here (laughs). I would find something else to do, something good…

N: What about me taking you all the chocolates you could eat?

K: I think that would be good actually I don't think I would be too upset. I would crave it but I don't think that would be really bad. That would be good probably (laughs).

N: Name me 3 objects that you don't identify with.

K: Darts. I don't like this sport. I don't think it is a sport, cause people that play it drink and are fat. They have a good eye and they can kill people… Drugs, I don't like drugs. I think they're horrible; I don't like drugs in sport either. You know the runner who did drugs and he's an Olympic runner and everyone signed a petition to say that they're not allowed to go on the Olympic team if they take drugs, and he just got himself back on the Olympic team and taken another man's place and the other man's got like pretty mad, even though he's not as fast as him. And I don't think he should have been allowed back in the team. I don't think they should've forgiven him.

N: Now I force you to identify with these objects. How would you feel?

K: I don't know. I think I would be like a really fat darts player who would drink ok and have really nice hair (laughs). I don't think I would like that. I don't like fat people either; especially fat people that know that they're fat and they don't do anything about it. I wouldn't do these things and I wouldn't try it either. You get really addicted to these. If you would force it on me id probably run away.

N: How do you think you've developed this identity to swimming?

K: I think you just gain it through starting off and then doing it for so long you like become acquainted with like everyone on the circuit, so like you know all the other swimmers and all the ones from other clubs, so its just like, I don't know, you have a reputation and people just know who you are and then you make friends so you become a swimmer.

N: How does it feel like being an athlete?

K: It's a good thing. I'd rather not be a waitress or just watch TV, I'd rather be an athlete other then a druggy or a teenage mum. Or maybe a scholar or someone really clever…

N: What would you prefer? Being a scholar or an athlete?

K: Athlete, definitely. I don't think I could be a scholar either… I'm not very academic. I'm quite, but not. I'd choose sport over that (laughs).

N: How much of your life revolves around swimming?

K: A lot. Quite a lot, yeah. Not like the main basics, like going to school but before school and after school. The good majority of the day.

N: What would you do if you couldn't swim anymore?

K: I'd try another sport. That's about all. I think I'd take another sport and do it at the level that I'm at swimming now, I wouldn't just go like once a week or something, cause I think I get bored, like when you're in holyday you get bored of doing nothing, makes you feel fat and lazy.

N: So would you not join the sport for the enjoyment of the sport?

K: Yeah I would cause I enjoy playing sport and I like meeting people there.

N: What if there was no competition in this sport would you still do it?

K: Yeah, as long as you enjoy it and I don't mean like competing anyways; couldn't feel better (smiles). I don't mean in competition. I just mean training and do the amounts I do now.

N: Anything you like to add?

K: No, was quite fun I enjoyed it (smiles).

Appendix 20

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September 22, 2010

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