The Influence of Training Status on the Physiological Responses to Exercise of Young Girls

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to the University of Exeter
as a thesis for the degree of Doctor of Philosophy in
Sport and Health Sciences,
October 2010

I certify that all material 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.

Abstract

Exercise training represents a potent stimulus to the parameters of aerobic and anaerobic fitness in adults; whether the same is true in young girls is unclear. For some parameters, such as peak oxygen uptake, the influence of training status remains controversial whilst for other parameters, such as oxygen uptake kinetics, the influence of training status remains simply uninvestigated in young girls. Despite this lack of empirical evidence, it has been suggested for some time now that children may lack trainability and that this may be related to the presence of a maturational threshold below which significant adaptations to training cannot occur. This suggestion requires investigation, not least because the findings of some studies which appear to support this contention may in reality be a reflection of the use of an inappropriate test modality for the investigation of training status influences. The purpose of this thesis was therefore to determine the physiological trainability of girls at different stages of maturation and to investigate the interaction between training status, maturity and exercise modality. To achieve this purpose a series of 5 studies was completed, in which trained and untrained girls completed ramp incremental exercise, constant-work-rate exercise and Wingate exercise on two exercise modalities, one upper (arm crank) and one lower body (cycle). During these tests, cardiovascular, respiratory, metabolic and mechanical power parameters were assessed. In response to ramp incremental exercise, trained girls were shown to have a higher peak $\dot{V}O_2$, SV and $\dot{Q}$ at all stages of maturity, along with an altered SV and fractional muscle oxygen extraction pattern, irrespective of exercise modality. The importance of exercise modality was evident during heavy intensity constant-work-rate exercise in pre-pubertal girls, where training status was only associated with significant influences on $\dot{V}O_2$ kinetics (faster phase II time constant in trained girls) during upper body ergometry. In contrast, pubertal trained girls had faster $\dot{V}O_2$ kinetics during both exercise modalities, an influence which may suggest both central and peripheral adaptations to the delivery and utilisation of oxygen. Exercise modality was also revealed to be an important factor in the demonstration of training status influences during a 30 s Wingate test, with trained girls at all stages of maturity exhibiting higher mechanical power indices during upper body ergometry only. An influence of training status was also evident in the lower fatigue index found in the trained girls at all stages of maturity during both modalities, but no influence was found in the oxidative contribution to the Wingate test. None of these studies revealed an influence of maturity status in determining the magnitude of training status

effects. Overall, the 5 studies encompassed within this thesis demonstrate that children are trainable and that this is not moderated by maturity.

Acknowledgements

First, to my supervisors, Professor Andy Jones, Dr Jo Welsman and Dr Ann Rowlands, I would like to express my gratitude for their extensive knowledge, support and patient guidance. Circumstance meant I had the privilege of working with three supervisors, each of which has inspired and taught me so much, not least the diverse ways in which to supervise! I would also like to thank Dr Kerstin Stoedefalke for her enthusiasm and encouragement and who presented me with the opportunity to undertake this PhD.

I am indebted to all the volunteers who helped me during the long months (/years!) of testing, both those who completed the tests and those who helped in their implementation. With regard to the latter, I owe a special thanks to Rebecca Willcocks, who gave up her time selflessly to help me conduct, and recover from, my testing. Her friendship is the reason I have a thesis to present.

Finally, my deepest gratitude goes to my parents and my newlywed husband, Stuart. No words are adequate to express the amount I owe to your unwavering love, encouragement and belief. To each I owe this thesis.

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according to FINA points. Only those parameters for which there were significant correlations are shown

Table 9.5 Performance times reported in previous studies to investigate swimming performance predictors in children compared to 2010 Devon County Qualifying Times. Note the considerably slower times of the previous studies swimmers

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Symbols and Abbreviations

O_2	Oxygen
$\dot{V}O_2$	Oxygen uptake
$\dot{V}O_2$ max	Maximal oxygen uptake
RER	Respiratory exchange ratio
Min	Minute
$\dot{Q}$	Cardiac output
$a - \bar{v}O_2$ difference	arterial-venous oxygen difference
SV	Stroke volume
HR	Heart rate
[HHb]	Deoxygenated haemoglobin and myoglobin
LT	Lactate threshold
CO_2	Carbon dioxide
$\dot{V}CO_2$	Carbon dioxide output
$\dot{V}_E$	Minute ventilation
GET	Gas exchange threshold
PCr	Intramuscular phosphocreatine
τ	Time constant
MLSS	Maximal lactate steady state
CP	Critical power
%Δ	% difference between GET and peak $\dot{V}O_2$
Δ	Delta change
ATP	Adenosine triphosphate
NIRS	Near infrared spectroscopy
WAnT	Wingate anaerobic test
PP	Peak power
MP	Mean power
FI	Fatigue index
PFK	Phosphofructokinase
^{31}P-MRS	P-31 magnetic resonance spectroscopy
pH_i	intracellular pH
P_i	Inorganic phosphate

METs	Metabolic equivalents
ACSM	American College of Sports Medicine
T	Trained girls
UT	Untrained girls
RPM	Revolutions per minute
BSA	Body surface area
SV_i	Stroke volume index
w	Weight of Monark flywheel
r	Distance from the axis of rotation to the point of suspension
I	Inertia of the flywheel
l	Length of suspending wires
ω	Angular velocity
T_i	Inertial torque
T_r	Resistive torque
SD	Standard deviation
s	Seconds
A_1	Amplitude of the primary component
δ	Time delay
ANCOVA	Analysis of covariance
ANOVA	Analysis of variance
BMI	Body mass index
PHV	Peak height velocity
WR	Work rate
[lactate]	concentration of lactate
$b\cdot min^{-1}$	Beats per minute
$l\cdot min^{-1}$	Litres per minute
$ml\cdot kg^{-1}\cdot min^{-1}$	Millilitres per kilogram per minute
$ml\cdot m^{-2}$	Millilitres per metre squared
$ml\cdot m^{-2}\cdot min^{-1}$	Millilitres per metre squared per minute
W	watts
N	Newtons
m	Metres
n	Sample size
r	Pearson's correlation coefficient

CI	Confidence interval
MRT	Mean response time