



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

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

This thesis is available for Library use on the understanding that it is copyright material and that no quotation from the thesis may be published without proper acknowledgement.

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.

List of Contents

Abstract.....	2
Acknowledgements.....	4
List of contents.....	5
List of tables.....	13
List of figures.....	17
Symbols and abbreviations.....	23
Chapter 1 Introduction.....	25
Chapter 2 Review of literature.....	28
2.1 Parameters of Aerobic fitness.....	28
2.1.1 <i>Maximal and peak oxygen uptake.....</i>	28
2.1.1.1 Influence of training on peak $\dot{V}O_2$ in adults.	30
2.1.1.2 Influence of training on peak $\dot{V}O_2$ in children.....	30
2.1.1.3 Mechanistic basis of training influences.....	32
2.1.2 <i>Lactate or gas exchange thresholds.....</i>	34
2.1.2.1 Influence of training in adults.....	35
2.1.2.2 Influence of training in children.....	36
2.1.3 <i>Exercise economy.....</i>	37
2.1.3.1 Influence of training in adults.....	37
2.1.3.2 Influence of training in children.....	38
2.1.4 <i>Oxygen uptake kinetics.....</i>	38
2.1.4.1 Influence of training in adults.....	43
2.1.4.2 Influence of training in children.....	43
2.1.4.3 Mechanistic basis.....	45
2.2 Parameters of anaerobic fitness.....	48
2.2.1 <i>Influence of training in adults.....</i>	49
2.2.1.1 Mechanical power indices.....	49
2.2.1.2 Oxidative contribution.....	50

2.2.1.3	Mechanistic basis.....	50
2.2.2	<i>Influence of training in children</i>	51
2.2.2.1	Mechanical power indices.....	52
2.2.2.2	Oxidative contribution.....	52
2.2.2.3	Mechanistic basis.....	53
2.3	Training criteria	54
2.3.1	<i>Aerobic training</i>	55
2.3.2	<i>Anaerobic training</i>	55
2.3.3	<i>Training modality specificity</i>	56
2.4	Thesis objectives	58
Chapter 3	General methods	59
3.1	Participants	59
3.2	Sexual maturity and age at peak height velocity	60
3.3	Anthropometry	61
3.4	Habituation	61
3.5	Incremental ramp tests	62
3.5.1	<i>Equipment</i>	62
3.5.2	<i>Protocol</i>	62
3.6	Square wave transition	63
3.6.1	<i>Equipment</i>	63
3.6.2	<i>Protocol</i>	63
3.7	Wingate anaerobic tests	64
3.7.1	<i>Equipment</i>	64
3.7.2	<i>Protocol</i>	65

3.7.2.1	Optimal applied force.....	66
3.7.2.2	Initiation of WAnT from a rolling start.....	66
3.8	Measurement of gas exchange parameters.....	67
3.9	Measurement of cardiovascular parameters.....	67
3.10	Measurement of muscle oxygenation parameters.....	69
3.11	Measurement of blood lactate concentration.....	70
3.12	Determination of the gas exchange threshold and 40%Δ work.....	71
3.13	Determination of flywheel inertia and power output calculation.....	72
3.14	Analysis of $\dot{V}O_2$ response.....	73
3.15	Analysis of heart rate response.....	75
3.16	Analysis of [HHb] response.....	76
3.17	Analysis of the cardiovascular and metabolic response patterns.....	76
3.18	Allometric scaling.....	77

Chapter 4 Study 1 - Cardiovascular responses to ramp incremental exercise in trained and untrained girls: a preliminary study

4.1	Introduction.....	78
4.2	Methods.....	79
4.2.1	<i>Participants and anthropometry.....</i>	79
4.2.2	<i>Exercise protocol.....</i>	81

4.2.3	<i>Exercise test measurements</i>	81
4.2.4	<i>Data analysis</i>	82
4.2.5	<i>Statistics</i>	82
4.3	Results	83
4.4	Discussion	85
4.5	Conclusions	87

Chapter 5 Study 2 - Influence of training status and exercise modality on pulmonary O₂ uptake kinetics in pre-pubertal girls

5.1	Introduction	88
5.2	Methods	90
5.2.1	<i>Participants</i>	90
5.2.2	<i>Measurements of peak $\dot{V}O_2$ and GET</i>	90
5.2.3	<i>Constant work rate tests</i>	91
5.2.4	<i>$\dot{V}O_2$ kinetics analysis</i>	92
5.2.5	<i>HR kinetics analysis</i>	93
5.2.6	<i>Statistics</i>	93
5.3	Results	93
5.4	Discussion	98
5.4.1	<i>Peak physiological responses</i>	98
5.4.2	<i>Sub-maximal physiological responses: cycle exercise</i>	100
5.4.3	<i>Sub-maximal physiological responses: upper body exercise</i>	100
5.4.4	<i>Influence of exercise modality on $\dot{V}O_2$ kinetics</i>	103
5.5	Conclusion	103

Chapter 6 Study 3 - Influence of training status and exercise modality on pulmonary O₂ uptake kinetics in pubertal girls

6.1 Introduction.....	105
6.2 Methods.....	107
6.2.1 <i>Participants.....</i>	107
6.2.2 <i>Incremental test.....</i>	108
6.2.3 <i>Constant work rate tests.....</i>	109
6.2.4 <i>Measurements.....</i>	110
6.2.5 <i>$\dot{V}O_2$ kinetics analysis.....</i>	111
6.2.6 <i>[HHb] and HR kinetics analysis.....</i>	112
6.2.7 <i>Statistics.....</i>	112
6.3 Results.....	113
6.3.1 <i>$\dot{V}O_2$ kinetics.....</i>	114
6.3.2 <i>[HHb] kinetics.....</i>	115
6.3.3 <i>HR kinetics.....</i>	116
6.4 Discussion.....	118
6.4.1 <i>Ramp incremental exercise.....</i>	118
6.4.2 <i>Constant work rate tests: influence of training status.....</i>	119
6.4.3 <i>Constant work rate tests: influence of exercise modality.....</i>	121
6.5 Conclusion.....	123

Chapter 7 Study 4 - Influence of training and maturity status on the cardiopulmonary responses to ramp incremental cycle and upper body exercise in girls

7.1 Introduction.....	124
7.2 Methods.....	126
7.2.1 <i>Participants and anthropometry.....</i>	126

7.2.2	<i>Experimental procedures</i>	127
7.2.3	<i>Experimental measures</i>	128
7.2.4	<i>Data Analysis</i>	129
7.3	Results	131
7.3.1	<i>Effects of training</i>	132
7.3.2	<i>Interaction between maturity and training status</i>	136
7.4	Discussion	136
7.5	Conclusions	140

Chapter 8 Study 5 - The influence of training and maturity status on girls' responses to short-term, high intensity upper and lower body exercise

8.1	Introduction	141
8.2	Methods	142
8.2.1	<i>Participants</i>	142
8.2.2	<i>Anthropometry</i>	143
8.2.3	<i>Experimental protocols and measures</i>	144
8.2.4	<i>Data analysis</i>	145
8.2.5	<i>Statistical analysis</i>	145
8.3	Results	146
8.3.1	<i>Influence of training status</i>	146
8.3.2	<i>Interaction of training status with maturity</i>	150
8.4	Discussion	150
8.4.1	<i>Influence of training status</i>	151
8.4.2	<i>Interaction of training status with maturity</i>	154
8.5	Conclusions	154

Chapter 9	Summate discussion.....	156
9.1	Training volume and the influence of training status.....	156
9.2	Maturity and the influence of training status.....	158
9.3	Exercise modality and the influence of training status.....	159
9.4	Predictors of performance.....	161
9.5	Study limitations.....	168
9.6	Future Directions.....	170
9.7	Final conclusions.....	173
Chapter 10	References.....	175
Chapter 11	Appendices.....	210
Appendix 1A	Study 1 Information Sheet.....	211
Appendix 1B	Studies 2 & 3 Information Sheet – Untrained Girls....	213
Appendix 1C	Studies 2 & 3 Information Sheet – Trained Girls.....	216
Appendix 1D	Studies 4 & 5 Parent/Guardian Information Sheet.....	219
Appendix 1E	Studies 4 & 5 Participant Information Sheet.....	222
Appendix 2A	Study 1 Consent & Assent Form.....	225
Appendix 2B	Studies 2 & 3 Consent Form.....	227
Appendix 2C	Studies 2 & 3 Assent Form.....	228
Appendix 2D	Studies 4 & 5 Consent Form.....	229
Appendix 2E	Studies 4 & 5 Assent Form.....	230
Appendix 3	General Health Questionnaire.....	231
Appendix 5	Tanner Stage Maturity Self-Assessment.....	232

List of Tables

Chapter 3 General methods

Table 3.1 Intraobserver coefficients of variation for repeat measurements of skinfolds at each site

Table 3.2 Intraclass correlation coefficients and coefficients of variation for pre-pubertal and pubertal girls during repeat transitions to heavy intensity, lower body exercise

Table 3.3 Intraclass correlation coefficients and coefficients of variation for pre-pubertal and pubertal girls during repeat transitions to heavy intensity, upper body exercise

Chapter 4 Cardiovascular responses to ramp incremental exercise in trained and untrained girls: a preliminary study

Table 4.1 Anthropometrical characteristics of participants

Table 4.2 Physiological responses to unloaded pedalling in trained and untrained girls

Table 4.3 Peak physiological responses to an incremental ramp exercise in trained and untrained pre-pubertal girls

Chapter 5 Influence of training status and exercise modality on pulmonary O₂ uptake kinetics in pre-pubertal girls

Table 5.1 Morphological characteristics of participants

Table 5.2 Peak physiological responses to exercise on a cycle and upper body ergometer in trained and untrained girls

Table 5.3 Oxygen uptake kinetics and blood [lactate] during heavy-intensity exercise on a cycle and upper body ergometer in trained and untrained girls

Table 5.4 Heart rate kinetics during heavy-intensity exercise on a cycle and upper body ergometer in trained and untrained girls

Chapter 6 Influence of training status and exercise modality on pulmonary O₂ uptake kinetics in pubertal girls

Table 6.1 Physical characteristics of participants

Table 6.2 Peak physiological responses to exercise on a cycle and upper body ergometer in trained and untrained girls

Table 6.3 Oxygen uptake kinetics and blood [lactate] during heavy-intensity exercise on a cycle and upper body ergometer in trained and untrained girls

Table 6.4 Deoxyhemoglobin/myoglobin kinetics during heavy intensity exercise on a cycle and upper body ergometer in trained and untrained girls

Table 6.5 Heart rate kinetics during heavy-intensity exercise on a cycle and upper body ergometer in trained and untrained girls

Chapter 7 The influence of training and maturity status on the cardiopulmonary responses to ramp incremental cycle and upper body exercise in girls

Table 7.1 Participants' anthropometric characteristics

Table 7.2 Peak pulmonary gas exchange parameters for ramp incremental exercise on a cycle and upper body ergometer in trained and untrained girls according to sexual maturity status

Table 7.3 Peak cardiovascular parameters for ramp incremental exercise on a cycle and upper body ergometer in trained and untrained girls according to sexual maturity status

Chapter 8 The influence of training and maturity status on girls' responses to short-term, high intensity upper and lower body exercise

Table 8.1 Participants' anthropometric characteristics

Table 8.2 Mechanical power indices in trained and untrained girls at 3 stages of maturity during a lower and upper body WAnT

Table 8.3 Peak oxygen uptake and oxidative contribution to energy provision in trained and untrained girls at 3 stages of maturity during a lower and upper body WAnT

Chapter 9 Summate discussion

Table 9.1 Synopsis of results from studies 2 and 3 (chapters 5 and 6) highlighting the lower "fitness" in the untrained pubertal than pre-pubertal girls

Table 9.2 Pearson's product moment correlations describing the relationship between the parameters assessed during ramp incremental exercise (chapters 4 and 7) and performance according to FINA points. Only those parameters for which there were significant correlations are shown

Table 9.3 Pearson's product moment correlations describing the relationship between the parameters assessed during constant-work-rate exercise (chapters 5 and 6) and performance according to FINA points. Only those parameters for which there were significant correlations are shown

Table 9.4 Pearson's product moment correlations describing the relationship between the parameters assessed during WAnT exercise (chapter 8) and performance

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

List of Figures

Chapter 1 Introduction

Figure 1.1 An excerpt from the *Physiology of Bodily Exercise* describing a training regime followed by a young male participant to prepare for a forthcoming rowing match (Lagrange, 1986)

Chapter 2 Review of literature

Figure 2.1 Typical blood lactate response pre and post a 6 week training intervention in adults. The lactate threshold, denoted by the vertical arrows, occurs at a higher running speed following training. Adapted from Carter et al. (1999)

Figure 2.2 Schematic illustration of the rise in muscle and pulmonary oxygen uptake at the onset of moderate intensity exercise. Note the mono-exponential rise of muscle $\dot{V}O_2$ in comparison to the three phase response of pulmonary $\dot{V}O_2$. The vertical dashed line at $t = 0$ represents the onset of increased work rate. Subsequent dashed vertical lines denote the transition between phases of the response. See text for details of the three phases

Figure 2.3 Schematic illustration of the characteristic pulmonary $\dot{V}O_2$ responses to a square wave transition within each exercise intensity domain. The solid vertical line represents the onset of the increased work-rate and the dotted horizontal lines represent the physiological demarcating as described in the text. Phase I has been omitted from the illustration. The slow component and its characteristics are represented by the dashed lines. Adapted from Armstrong and Barker (2009)

Figure 2.4 Schematic illustration of the oxygen deficit and the influence of altering the speed of the $\dot{V}O_2$ kinetic response. τ is the time constant of the primary phase and the coloured area represents the oxygen deficit. Note how the shaded area increases as the $\dot{V}O_2$ response slows (increasing τ)

Figure 2.5 Schematic depicting the influence of altering muscle O₂ delivery on the speed of $\dot{V}O_2$ kinetics. Decreasing O₂ delivery (right to left along the x-axis) does not influence the speed of the kinetic response (shown by τ) until a specific “tipping-point”. After this point, further decreases in O₂ delivery are associated with progressively slower kinetics. From Poole et al. (2008a)

Chapter 3 General methods

Figure 3.1 Adapted Monark for upper body ergometry

Figure 3.2 Positioning of Physioflow electrodes (red dots) on the ventral (A) and dorsal (B) skin surface. Note the repositioning of one electrode to the forehead and one to the lower ribs.

Figure 3.3 Method used to determine the inertia of the flywheel. Flywheel was suspended by 3 supporting wires of equal length

Figure 3.4 The $\dot{V}O_2$ response demonstrates considerable breath-by-breath variability, as shown in panel A. Ensemble averaging of multiple repeat transitions improves the signal to noise ratio, as shown in panel B following 5 transitions, thereby increasing the confidence associated with model derived parameters. The red line shows the monoexponential fit

Figure 3.5 Visual identification of the onset of the slow component. The vertical green line represents the onset of the slow component, evidenced by the deviation from the previously “flat” profile to a progressively increasing time constant

Chapter 4 Cardiovascular responses to ramp incremental exercise in trained and untrained girls: a preliminary study

Figure 4.1 Mean cardiovascular and $a - \bar{v}O_2$ difference responses to ramp incremental exercise. Graph A shows the cardiac output (\dot{Q}), graph B the stroke volume (SV) and graph C the arterial-venous oxygen difference ($a - \bar{v}O_2$ difference) as a function of percentage peak oxygen uptake ($\dot{V}O_2$) in trained and untrained girls. The cardiovascular variables are presented as absolute values (\pm SEM) as the response patterns were not altered by using scaled variables.

Chapter 5 Influence of training status and exercise modality on pulmonary O_2 uptake kinetics in pre-pubertal girls

Figure 5.1 Pulmonary oxygen uptake response to a step increment in work rate from an unloaded baseline to a heavy intensity work rate ($40\% \Delta$) in a representative trained (closed circles) and untrained participant (open circles) during cycle exercise (A) and upper body exercise (B). The data are expressed as a percentage of the end exercise amplitude with the solid and dashed lines represent the mono-exponential model fit. For clarity, data are displayed as 5-s bin averages

Figure 5.2 Heart rate response to a step increment in work rate from an unloaded baseline to a heavy intensity work rate ($40\% \Delta$) in a representative trained (closed circles) and untrained participant (open circles) during A) cycle and B) upper body exercise. Data expressed as a percentage of the primary phase amplitude and the solid and dashed lines represent the mono-exponential model fit. For clarity, data are displayed as 5-s bin averages

Chapter 6 Influence of training status and exercise modality on pulmonary O_2 uptake kinetics in pubertal girls

Figure 6.1 Pulmonary oxygen uptake response to a step increment in work rate from an unloaded baseline to a heavy intensity work rate ($40\% \Delta$) in a representative trained (closed circles) and untrained participant (open circles) during A) cycle and B) upper body exercise. The data are expressed as a percentage of the end exercise amplitude. The trained girl's data are shown as closed circles and the

untrained girl's data are shown as open circles. The solid and dashed lines represent the mono-exponential model fit to the data. Note the faster τ in the trained participant during both exercise modes. For clarity, data are displayed as 5-s bin averages

Figure 6.2 Deoxyhemoglobin response to a step increment in work rate from an unloaded baseline to a heavy intensity work rate ($40\%\Delta$) in a representative trained (closed circles) and untrained participant (open circles) during A) cycle and B) upper body exercise. Data are expressed as a percentage of the primary phase amplitude, in 5-s bin averages. The solid and dashed lines represent the mono-exponential model fit to the data.

Figure 6.3 Heart rate response to a step increment in work rate from an unloaded baseline to a heavy intensity work rate ($40\%\Delta$) in a representative trained (closed circles) and untrained participant (open circles) during A) cycle and B) upper body exercise. Data are expressed as a percentage of the end exercise amplitude, in 5-s bin averages. The solid and dashed lines represent the mono-exponential model fit.

Chapter 7 The influence of training and maturity status on the cardiopulmonary responses to ramp incremental cycle and upper body exercise in girls

Figure 7.1 Graphic illustration of the method used to determine the mean response time (MRT). The solid line represents the ramp incremental increase in power output and the closed circles represent the $\dot{V}O_2$ response. Reproduced from Barstow et al. (Barstow *et al.*, 2000).

Figure 7.2 The stroke volume response pattern for a representative trained and untrained girl during cycle ergometry (see text for details). The trained girls are represented by the closed circles and solid line whilst the untrained girls are shown by the open circles and dashed line.

Figure 7.2 Deoxy [HHb+Mb] response as a function of relative work rate for a representative trained (solid circles) and untrained (open circles) girl during cycle ergometry

Chapter 8 The influence of training and maturity status on girls' responses to short-term, high intensity upper and lower body exercise

Figure 8.1 Mean power output responses for (a) pre-pubertal, (b) pubertal and (c) post-pubertal girls during lower body (Lo) and upper body (Up) exercise. Trained girls are shown with closed and untrained girls with open symbols.

Figure 8.2 Mean $\dot{V}O_2$ responses for (a) pre-pubertal, (b) pubertal and (c) post-pubertal girls during lower body (Lo) and upper body (Up) exercise. Trained girls are shown with closed and untrained girls with open symbols

Symbols and Abbreviations

O_2	Oxygen
$\dot{V}O_2$	Oxygen uptake
$\dot{V}O_2 \text{ max}$	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
$b \cdot \text{min}^{-1}$	Beats per minute
$l \cdot \text{min}^{-1}$	Litres per minute
$\text{ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$	Millilitres per kilogram per minute
$\text{ml} \cdot \text{m}^{-2}$	Millilitres per metre squared
$\text{ml} \cdot \text{m}^{-2} \cdot \text{min}^{-1}$	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