

Copyright is owned by the Author of the thesis. Permission is given for a copy to be downloaded by an individual for the purpose of research and private study only. The thesis may not be reproduced elsewhere without the permission of the Author.

**Performance and physiological consequences of roll dynamics during  
cross-country mountain bike racing.**

A thesis presented in partial fulfilment of the requirements for

**The Doctor of Philosophy *via publication***

**in**

**Sport & Exercise Science**

**Massey University, Manawatu Campus, New Zealand**

**Paul William Macdermid**

**2015**

**STUDENT DECLARATION**

I hereby declare that this thesis is my own work and does not, to the best of my knowledge, contain material from any other source unless due acknowledgement is made. The thesis was completed under the guidelines set out by Massey University's College of Health, for the degree of Doctorate of Philosophy and has not been submitted for a degree or diploma at any other academic institution.

Candidate: .....

Date: .....

## ABSTRACT

**Background:** Understanding the interaction between physical work done and subsequent physiological responses is key to the prescription of optimal training. Olympic format cross-country mountain bike racing presents unique challenges with regards to understanding the relationship between propulsive and non-propulsive work, the interaction with performance, and associated physiological responses.

**Aims:** The aims of this thesis were to: 1) Determine the nature of work demand during simulated cross-country mountain bike racing; 2) Quantify vibration exposure during cross-country mountain biking and the interaction of bike-body in the subsequent energy dissipation; 3) Establish additional work done and physiological responses to riding on surface-terrain variations; 4) Investigate technological interventions designed to reduce vibration exposure during cross-country mountain biking and the interaction with performance and cycling economy.

**Methods & Results:** To address these aims four original experimental investigations involving two descriptive elements and four experimental interventions were conducted.

**Study 1:** Participants (n=7) completed a submaximal treadmill test on bicycles in order to establish the power:oxygen uptake relationship, which when combined with an ergometer maximal ramp test, enabled the prediction of oxygen demand during the field and thus estimations of aerobic and anaerobic contributions to work done. Field work involved participants riding at race pace on a cross-country mountain bike course whilst cadence, power output, oxygen consumption, heart rate, speed and geographical position were recorded. The data show power output and cadence to be highly variable with one power surge every 32 s and a supramaximal effort (greater than power associated with  $\dot{V}O_{2\max}$ ) every 106 s. The majority of time ( $20.7 \pm 8.3$  %) was spent pedalling at a low velocity-high force, whilst physiological

variables  $\% \dot{V}O_{2\max}$  ( $77 \pm 5 \%$ ) and  $\% HR_{\max}$  ( $93 \pm 2 \%$ ) were consistently elevated to a high level throughout the lap. Importantly, the results identified that terrain significantly affected power output ( $70.9 \pm 7.5$  vs  $41.0 \pm 9.2 \%$   $W_{\max}$ );  $\% \dot{V}O_{2\max}$  ( $80 \pm 2$  vs  $72 \pm 4 \%$ ) but not  $\% HR_{\max}$  ( $94 \pm 2$  vs  $91 \pm 1 \%$ ) for uphill and downhill, respectively. Accordingly, it was hypothesised that there was an additional non-propulsive physical stress during downhill riding, affording less recovery compared to road cycling.

*Study 2:* Participant (n=8) completed one lap of a cross-country track at race pace under two conditions (26" vs 29" wheels) whilst tri-axial accelerometers located on the bicycle (handlebar and seatpost) and the rider (wrist, ankle, lower back, and forehead) recorded accelerations (128 Hz) to quantify vibrations over the whole lap and for terrain specific sections (uphill vs downhill). The result showed that significant vibration attenuation occurred from locations at the bike and bike-body interface compared to the lower back and forehead. The reduction of accelerations at the lower back and forehead implies additional non-propulsive, muscular challenges which may limit recovery during periods of non-propulsive load.

The hypothesis that 29" wheels would reduce vibration exposure was inconclusive as 29" wheels proved to be significantly quicker ( $p=0.0020$ ) compared to 26" wheels even though no difference was found between power output ( $p=0.3062$ ) and heart rate ( $p=0.8423$ ). As such the greater velocity incurred by 29" wheels may have caused the greater vibration exposure seen in the 29" wheels.

*Study 3:* Participants (n=7) ascended a tar-sealed road climb and a singletrack off-road climb of identical length and gradient at the same speed. Tri-axial accelerometers (128 Hz) located at the handlebar, wrist, ankle, seat post, lower back, and forehead were used to quantify vibration exposure while power output, cadence, heart rate and oxygen consumption were used to determine work done and physiological cost. Accelerations signified ( $P<0.0001$ ) greater

vibration exposure for off-road compared to tar-sealed riding and post-hoc analysis identified differences at the bike and bike-body interface but not the lower back and forehead. This indicates a greater non-propulsive component in the form of vibration damping to off-road cycling compared to road cycling, reflected by significant increases in work done ( $280 \pm 69$  vs  $312 \pm 74$  W;  $p=0.0003$ ). This was associated with a greater rate of oxygen consumption ( $48.5 \pm 7.5$  vs  $51.4 \pm 7.3$  ml·kg<sup>-1</sup>·min<sup>-1</sup>;  $p=0.0033$ ) and a higher heart rate ( $161 \pm 10$  vs  $170 \pm 10$  bpm;  $p=0.0001$ ) for tar-sealed road and off-road conditions, respectively. These findings advocate that technological interventions aimed at decreasing vibration exposure could increase cycling economy and therefore improve performance.

*Study 4:* Participants ( $n=8$ ) completed a lap of a cross-country mountain bike circuit under two conditions (hardtail and full suspension) incorporating the same downhill section twice and separated by a forestry road climb. The participants were asked to complete the downhill sections at race pace while the climb was performed at a power output associated with respiratory compensation point. The aim of this was to control physiological variables at the start of the second downhill. Tri-axial accelerometers (located at the handlebar, wrist, ankle, seat post, lower back, and forehead) were used to quantify vibration exposure while simultaneous power output, cadence, heart rate and oxygen consumption measurements enabled assessment of work done and physiological response. Performance was determined by time to complete the overall lap and specific sections.

Physiological demand of loaded downhill riding (2<sup>nd</sup> descent) was greater than unloaded (1<sup>st</sup> descent) ( $p<0.0001$ ). Full suspension decreased total vibration exposure ( $p<0.01$ ) but had no effect on performance times ( $p=0.9697$ ) or power outputs ( $p=0.8600$ ) whilst post-hoc analysis identified trial differences (downhill 1 vs downhill 2) in power output ( $p<0.0001$ ) but not for time ( $p>0.05$ ). Interestingly, the reduction of non-propulsive work did not affect oxygen consumption ( $p=0.9840$ ), heart rate ( $p=0.9779$ ) or cycling economy ( $p=0.9240$ ).

**Conclusions:** This thesis demonstrates that surface-terrain negatively affects cycling economy, presenting greater physiological responses as a consequence of increased non-propulsive work. This is likely due to vibration damping throughout the soft tissue of the limbs in order to protect the central nervous system. Reductions in vibration exposure diminished work done and physiological response for surface controlled interventions, yet mechanical system modifications capable of reducing exposure were unable to alter physiological response to work done.

## ACKNOWLEDGEMENTS

I would like to express my thanks to all those that have helped in the completion of this thesis:

To Steve and Phil, the consummate cycling enthusiasts who embraced the sport of cross-country mountain biking and guided me through the course of study and became good friends in the process. Phil – for all those hours you spent with me in front of the computer exploring the possibilities of Matlab and Math in relation to sports analysis. I certainly look at things from a different perspective now. Steve, for keeping me on the straight and narrow, avoiding all the tangents, adding your experience and expertise to the papers and even getting on the bike and participating at busy times.

To all those that participated and persevered with their participation in my studies. Thanks for your time and camaraderie in the enjoyment of exploring your sport. Hopefully, you all learnt something in the process.

Fiona, who was always there to bounce ideas off, trial protocols, read through proposals and manuscripts to make sure they made sense. I can't thank you enough.

## TABLE OF CONTENTS

<b>STUDENT DECLARATION .....</b>	<b>ii</b>
<b>ABSTRACT.....</b>	<b>iii</b>
<b>ACKNOWLEDGEMENTS .....</b>	<b>vii</b>
<b>TABLE OF CONTENTS.....</b>	<b>viii</b>
<b>LIST OF TABLES .....</b>	<b>x</b>
<b>LIST OF FIGURES .....</b>	<b>xi</b>
<b>ABBREVIATIONS .....</b>	<b>xiii</b>
<b>SUBMISSIONS AND PUBLICATIONS .....</b>	<b>xiv</b>
Publications.....	xiv
Conference Presentations.....	xv
Industry Media.....	xv
<b>CHAPTER ONE: INTRODUCTION .....</b>	<b>1</b>
<b>CHAPTER TWO: REVIEW OF THE LITERATURE .....</b>	<b>4</b>
Descriptive Characteristics of Elite XCO-MTB Athletes.....	4
Physiological Correlates of performance in XCO-MTB.....	7
Work done and the physiological consequences during XCO-MTB.....	10
Non-propulsive work.....	14
<b>CHAPTER THREE: THESIS STRUCTURE .....</b>	<b>19</b>
Aims and Hypothesis.....	21
<b>CHAPTER FOUR: STUDY ONE .....</b>	<b>25</b>
<b>MECHANICAL WORK AND PHYSIOLOGICAL RESPONSES TO SIMULATED CROSS-COUNTRY MOUNTAIN BIKE RACING.....</b>	<b>25</b>
Abstract.....	26
Introduction .....	27
Methods.....	29
Results .....	34
Discussion .....	37
Conclusion.....	43
Practical Implications .....	43
Tables.....	44
Figures .....	46
<b>CHAPTER FIVE: STUDY TWO .....</b>	<b>51</b>
<b>TRANSFERANCE OF 3D ACCELERATIONS DURING CROSS-COUNTRY MOUNTAIN BIKING.....</b>	<b>51</b>
Abstract.....	52
Introduction .....	53
Methods.....	56
Results .....	60
Discussion .....	63
Practical applications.....	67
Figures.....	69
Tables.....	74

<b>CHAPTER SIX: STUDY THREE</b> .....	<b>78</b>
THE EFFECTS OF VIBRATIONS EXPERIENCED DURING ROAD VS OFFROAD CYCLING.....	78
Abstract.....	79
Introduction .....	80
Methods.....	82
Results .....	86
Discussion .....	88
Conclusion.....	91
Tables.....	92
<b>CHAPTER SEVEN: STUDY FOUR</b> .....	<b>96</b>
THE IMPACT OF UPHILL CYCLING AND BICYCLE SUSPENSION ON DOWNHILL PERFORMANCE DURING CROSS-COUNTRY MOUNTAIN BIKING.....	96
Abstract.....	97
Introduction .....	98
Methods.....	101
Results .....	106
Discussion .....	110
Conclusion.....	115
Figures .....	116
Tables.....	120
<b>CHAPTER EIGHT: SUMMARY OF FINDINGS</b> .....	<b>121</b>
Overview of work .....	121
Summary.....	122
Limitations of Thesis .....	127
Future Directions .....	129
Conclusion.....	131
<b>REFERENCES</b> .....	<b>133</b>
<b>APPENDICES</b> .....	<b>145</b>
Appendix 1 .....	146
Appendix 2 .....	157
Appendix 3 .....	167
Appendix 4 .....	177
Appendix 5 .....	184
Appendix 6 .....	185
Appendix 7 .....	186
Appendix 8 .....	190
Appendix 9 .....	193

## LIST OF TABLES

<b>TABLE 1.1.</b> STRUCTURE OF THE THESIS AND SUMMARY OF THE AIMS COVERED BY EACH CHAPTER .....	20
<b>TABLE 2.1.</b> LABORATORY TEST CHARACTERISTICS OF THE SUBJECTS (N=7) FOR THE SUB-MAXIMAL TREADMILL TEST AND THE MAXIMAL ERGOMETER TEST. WHERE RESULTS ARE GIVEN PER KG THIS REFERS TO TOTAL WEIGHT OF THE INDIVIDUAL SUBJECTS CLOTHING, BIKE PLUS POWERMETER AND THE PORTABLE GAS ANALYSER. ....	44
<b>TABLE 2.2.</b> MEAN $\pm$ SD FOR PERFORMANCE, MECHANICAL AND PHYSIOLOGICAL MEASURES SAMPLED THROUGHOUT THE FIELD TRIAL AND SEPARATED BASED ON TERRAIN (HILL (H) AND DOWNHILL (DH)) AND ORDER AS DEPICTED IN FIGURE 1. ....	46
<b>TABLE 3.1.</b> MEAN $\pm$ SD FOR PERFORMANCE VARIABLES MEASURED THROUGHOUT THE FIELD TRIAL AND SEPARATED BASED ON TERRAIN (HILL (H) AND DOWNHILL (DH)) FOR THE DEPICTED ORDER. ....	74
<b>TABLE 3.2.</b> MEAN $\pm$ SD FOR MAXIMUM FREQUENCY (HZ) OF ACCELERATIONS AT POINTS OF CONTACT BETWEEN BIKE-BODY DURING A XCO-MTB LAP, AND SEPARATED FOR TERRAIN, FREQUENCY BANDING AND WHEEL SIZE.....	75
<b>TABLE 3.3.</b> MEAN $\pm$ SD FOR MAGNITUDE ( $G^2$ ) AT MAXIMUM FREQUENCY OF ACCELERATIONS AT POINTS OF CONTACT BETWEEN BIKE-BODY DURING A XCO-MTB LAP, AND SEPARATED FOR TERRAIN, FREQUENCY BANDING AND WHEEL SIZE.....	76
<b>TABLE 3.4.</b> MEAN $\pm$ SD FOR HALF FREQUENCY OF ACCELERATIONS AT POINTS OF CONTACT BETWEEN BIKE-BODY DURING A XCO-MTB LAP, AND SEPARATED FOR TERRAIN, FREQUENCY BANDING AND WHEEL SIZE.....	77
<b>TABLE 4.1.</b> MEAN $\pm$ SD FOR MAXIMUM FREQUENCY (HZ) AND MAGNITUDE ( $G^2$ ) OF ACCELERATIONS DURING THE HILL CLIMB, SEPARATED FOR FREQUENCY BANDING AND CONDITION.....	92
<b>TABLE 5.1.</b> MEAN $\pm$ SD FOR LABORATORY RAMP TEST.....	120

## LIST OF FIGURES

FIGURE 1.1: 2013 UCI PIETERMARITZBURG XCO-MTB WORLD CHAMPIONSHIP COURSE SCHEMATIC AND PROFILE. WHERE, * SIGNIFIES TECHNICAL SECTION; → UPHILL WITH HILLS NUMBERED (H1...); --> DOWNHILL WITH DOWNHILLS NUMBERED (DH1...)	2
FIGURE 2.1: MEAN ± SD BODY MASS INDEX FOR THE MALE MEDAL WINNERS FROM THE LAST FOUR OLYMPIC GAMES.	6
FIGURE 2.2: IMAGES SHOWING THE TECHNICAL NATURE OF MODERN DAY XCO-MTB EVENTS DURING STUDY 4 OF THIS THESIS AND INSERTS AT THE 2012 SUMMER OLYMPIC GAMES.	6
FIGURE 2.3: CATEGORISATION OF TIME SPENT DURING SPECIFIC INTENSITY ZONES DURING XCO-MTB RACING BASED ON LABORATORY DETERMINED SUBMAXIMAL THRESHOLDS (AT AND IAT). HEART RATE BASED DATA TAKEN FROM IMPELLIZZERI <i>ET AL</i> , 2002 AND POWER OUTPUT FROM STAPELFELDT <i>ET AL</i> , 2004.	12
FIGURE 2.4: IMAGE SHOWING THE HUMAN BODIES RESONANCE FREQUENCY RANGES OF VARIOUS BODY SECTIONS WHILST SEATED ON A XCO-MTB	16
FIGURE 4.1: COURSE OUTLINE FOR THE XCO-MTB LAP USED DURING THE STUDY. WHERE $\mathcal{P}$ INDICATES START AND FINISH, ⇒ REFERS TO A CLIMB AND ➔ SIGNIFIES A DESCENT. NUMBERS ENCIRCLED 1-7 ON THE MAP ARE RELATED TO CLIMBS OR DESCENTS HIGHLIGHTED ON THE SCHEMATIC PROFILE OF THE COURSE. SECTION CHARACTERISTICS ARE PROVIDED IN THE TABLE BELOW THE SCHEMATIC PROFILE.	46
FIGURE 4.2: DATA RECORDED (MEAN ± SD) OVER THE START STRAIGHT AND AVERAGED EVERY 5 S. A. POWER OUTPUT PROFILE (W), B. POWER OUTPUT PROFILE ( $W \cdot \Sigma KG^{-1}$ ), C. OXYGEN DEFICIT ( $L \cdot MIN^{-1}$ ), AND D. ESTIMATED AEROBIC AND ANAEROBIC CONTRIBUTION TO WORK DONE (%).	47
FIGURE 4.3: FREQUENCY DISTRIBUTION (MEAN ± SD) FOR PHYSIOLOGICAL VARIABLES DURING THE FIELD TEST REPRESENTED AS PERCENTAGES OF MAXIMUM FROM LABORATORY TESTS FOR A. % $VO_{2\ MAX}$ ; B. % $HR_{\ MAX}$ ; AND WORK VARIABLES C. % $W_{\ MAX}$ ; AND D. CADENCE (RPM).	48
FIGURE 4.4: AN INDIVIDUAL SUBJECTS DATA OVER THE WHOLE LAP FOR: A. ALTITUDE (M), POWER OUTPUT ( $W \cdot KG^{-1}$ ), % $VO_{2\ MAX}$ , AND % $HR_{\ MAX}$ AVERAGED OVER 5 S PERIODS FOR THE WHOLE FIELD TEST DURATION, WITH THE AVERAGE POWER (HORIZONTAL DASHED LINE) AND NORMALIZED POWER (HORIZONTAL SOLID LINE); B. QUADRANT ANALYSIS SEPARATED BY THE MEAN EFFECTIVE PEDAL FORCE AND CIRCUMFERENTIAL VELOCITY OF THAT SUBJECT, AT RESPIRATORY COMPENSATION POINT FROM LABORATORY TEST AND INDICATING THE DIFFERENCE BETWEEN HILL AND DOWNHILL SECTIONS.	49
FIGURE 4.5: MEAN SD SURGE ANALYSIS FOR SUBJECTS (N=7) OVER THE WHOLE LAP AND BASED ON TOTAL WEIGHT OF SUBJECT, BIKE AND GAS ANALYSER.	50
FIGURE 5.1: COURSE OUTLINE FOR THE XCO-MTB LAP USED DURING THE STUDY. WHERE $\mathcal{P}$ INDICATES START AND FINISH, ⇒ REFERS TO A CLIMB AND ➔ SIGNIFIES A DESCENT. NUMBERS ENCIRCLED 1-3 ON THE MAP ARE RELATED TO CLIMBS OR DESCENTS HIGHLIGHTED ON THE SCHEMATIC PROFILE OF THE COURSE. SECTION CHARACTERISTICS ARE PROVIDED IN THE TABLE TO THE RIGHT OF THE SCHEMATIC PROFILE.	69
FIGURE 5.2: A PHOTOGRAPH DEPICTING ACCELEROMETER LOCATIONS DURING THE TRIAL.	70
FIGURE 5.3: MEAN ± S AMPLITUDE (RMS) FOR A. TOTAL; B. VERTICAL; AND C. HORIZONTAL COMPONENTS OF ACCELERATION OVER THE WHOLE LAP. □ SIGNIFIES 26" WHEEL TRIAL WHILE ■ SIGNIFIES 29" WHEELS.	71
FIGURE 5.4: MEAN ACCELERATION EXPRESSED AS RMS FOR ACCELEROMETER LOCATIONS FOR DIFFERENT TERRAIN SEGMENTS AS DESCRIBED IN FIGURE 1 (H1 = UPHILL 1; DH1 = DOWNHILL 2; H2 = UPHILL 2; DH2 = DOWNHILL 2). A. TOTAL ACCELERATION FOR 26" WHEELS; B. TOTAL ACCELERATION FOR 29" WHEELS; C. VERTICAL ACCELERATION FOR 26" WHEELS; D. VERTICAL ACCELERATION FOR 29" WHEELS; E. HORIZONTAL ACCELERATION FOR 26" WHEELS; F. HORIZONTAL ACCELERATION FOR 26" WHEELS.	72
FIGURE 5.5: SPECTRAL ANALYSIS OF VERTICAL ACCELERATIONS FOR SUBJECT 3 DURING THE DIFFERENT SECTIONS OF THE COURSE. WHERE, A. IS UPHILL 1; B. IS DOWNHILL1; C. IS UPHILL 2; AND D. IS DOWNHILL 2	73
FIGURE 6.1: MEAN ± SD AMPLITUDE (RMS) FOR A. TOTAL; B. VERTICAL; AND C. HORIZONTAL COMPONENTS OF ACCELERATION OVER THE CLIMB. □ SIGNIFIES THE TAR-SEALED ROAD CONDITION, WHILE ■ SIGNIFIES SINGLE-TRACK OFF-ROAD CONDITION.	93
FIGURE 6.2: MEAN ± SD FOR HALF FREQUENCY DATA FROM SPECTRAL ANALYSIS FOR EACH CONDITION (TAR-SEALED ROAD □ AND THE SINGLE-TRACK OFF-ROAD ■) AND ACCELEROMETER POSITION.	94
FIGURE 6.3: MEAN ± SD FOR A. POWER OUTPUT (W); B. $VO_2$ ( $ML \cdot MIN^{-1} \cdot KG^{-1}$ ); AND C. HEART RATE (BPM) FOR BOTH THE TAR-SEALED ROAD □ AND THE SINGLE-TRACK OFF-ROAD ■.	95
FIGURE 7.1: COURSE OUTLINE AND PROFILE SIGNIFYING THE TERRAIN SPLIT SECTIONS FOR THE FIELD TRIAL USED IN THIS STUDY.	116
FIGURE 7.2: MEAN ± SD FOR A. TIME (S) ; B. POWER OUTPUT (W) FOR TERRAIN SEGMENTS AS DESCRIBED IN FIGURE 1 (DH1 = DOWNHILL 1; H1 = UPHILL 1; DH2 = DOWNHILL 2). □ SIGNIFIES HARDTAIL (HT) WHILE ■ SIGNIFIES FULL SUSPENSION CONDITION.	116
FIGURE 7.3: COMPARISONS BETWEEN HARDTAIL (HT) AND FULL SUSPENSION (FS) FOR: A. TOTAL ACCELERATIONS FOR DOWNHILL 1 (DH1); B. TOTAL ACCELERATIONS HILL 1 (H1); C. TOTAL ACCELERATIONS DOWNHILL 2 (DH2); D. VERTICAL ACCELERATIONS DOWNHILL 1 (DH1); E. VERTICAL ACCELERATIONS FOR HILL 1 (H1); F. VERTICAL	

ACCELERATIONS FOR DOWNHILL 2 (DH2); G. HORIZONTAL ACCELERATIONS FOR DOWNHILL 1 (DH1); G. HORIZONTAL ACCELERATIONS FOR HILL 1 (H1); F. HORIZONTAL ACCELERATIONS FOR DOWNHILL 2 (DH2). □ SIGNIFIES HARDTAIL (HT) WHILE ■ SIGNIFIES FULL SUSPENSION CONDITION. .... 117

FIGURE 7.4: MEAN ± SD FOR A. HEART RATE (HR); B. OXYGEN CONSUMPTION (VO2); C. CYCLING ECONOMY (CE) FOR DIFFERENT TERRAIN SEGMENTS AS DESCRIBED IN FIGURE 1 (DH1 = DOWNHILL 1; H1 = HILL 1; DH2 = DOWNHILL 2). □ SIGNIFIES HARDTAIL WHILE ■ SIGNIFIES FULL SUSPENSION CONDITION. .... 118

FIGURE 7.5: FIVE SECOND AVERAGE DATA FOR A. HEART RATE (HR), AND B. OXYGEN CONSUMPTION (VO2) FOR DOWNHILL 1 AND DOWNHILL 2 FOR BOTH CONDITIONS. ● SIGNIFIES DOWNHILL 1 FOR THE HARDTAIL; ● DOWNHILL 1 FOR FULL SUSPENSION; ■ DOWNHILL 2 FOR HARDTAIL; AND ■ DOWNHILL 2 FOR FULL SUSPENSION..... 119

FIGURE 8.1: MEAN VERTICAL ACCELERATIONS (G) EXPERIENCED BY PARTICIPANTS DURING A XCO-MTB LAP PERFORMED AT RACE PACE FOR ACCELEROMETER LOCATIONS: ANKLE, HANDLEBAR, SEATPOST, WRIST, LOWER BACK, AND FOREHEAD. THE SIZE OF THE CIRCLES ARE IN PROPORTION. .... 124

FIGURE 8.2: MEAN TOTAL ACCELERATIONS (G) EXPERIENCED BY PARTICIPANTS DURING A CLIMB IDENTICAL IN LENGTH AND GRADIENT BUT DIFFERING IN SURFACE (TARSEALED VS OFF-RD) PERFORMED AT THE SAME SPEED WITH ACCELERATIONS MEASURED AT: ANKLE, HANDLEBAR, SEATPOST, WRIST, LOWER BACK, AND FOREHEAD. THE SIZE OF THE CIRCLES ARE IN PROPORTION..... 125

**ABBREVIATIONS**

ANOVA:	Analysis of Variance
AT:	Anaerobic Threshold
BM:	Body Mass
BMI:	Body Mass Index
BPM:	Beats per minute
CV:	Coefficient of Variation
DH:	Downhill
H:	Hill
HR:	Heart Rate
IAT:	Individual Anaerobic Threshold
ISO:	International Standard Organisation
MTB:	Mountain Bike
O <sub>2</sub> :	Oxygen
OBLA:	Onset of Blood Lactate Accumulation
Off-Rd:	Non-smooth (tar-sealed) surface
RCP:	Respiratory Compensation Point
Rd:	Road (tar-sealed)
RMS:	Root Mean Squared
rpm:	revolutions per minute
SD:	Standard Deviation
UCI:	Union Cycliste Internationale
$\dot{V}O_2$ :	Volume of Oxygen utilised per minute in time
$W_{\max}$ :	The maximal power output obtained over a 60 s epoch during a cycle ergometry ramp test
XCO-MTB:	Olympic Format Cross-Country Mountain Biking

## SUBMISSIONS AND PUBLICATIONS

### Publications

Macdermid, P.W., & Stannard, S. (2012). Mechanical work and physiological responses to simulated cross-country mountain bike racing. *Journal of Sports Sciences*, 30(14), 1491-1501.

Doi: 10.1080/02640414.2012.711487 (Appendix 1)

Macdermid, P.W., Fink, P.W., & Stannard, S. (2014a). The influence of tyre characteristics on measures of rolling performance during cross-country mountain biking. *Journal of Sports Sciences*, 1-9, Doi: 10.1080/02640414.2014.942682 (Appendix 2)

Doi: 10.1080/02640414.2014.942682 (Appendix 2)

Macdermid, P.W., Fink, P.W., & Stannard, S. (2014b). Transference of 3D accelerations during cross-country mountain bike racing. *Journal of Biomechanics*, 47(8), 1829-1837. Doi:

<http://dx.doi.org/10.1016/j.jbiomech.2014.03.024> (Appendix 3)

Macdermid, P.W., Fink, P.W., & Stannard, S.R. (2015). The effects of vibrations experienced during road vs off-road cycling. *International Journal of Sports Medicine*. In Press. (Appendix 4)

Macdermid, P.W., Fink, P.W., Miller, M & Stannard, S.R. (2015). The impact of uphill cycling and bicycle suspension on downhill performance during cross-country mountain biking. *Journal of Sports Sciences*. Currently Under Review. (Appendix 5)

Macdermid PW (2015) Ergonomic Interventions, Health and Injury Prevention during Off-Road Mountain Biking. *J Ergonomics* 5: e130.doi:10.4172/2165-7556.1000e130 (Appendix 9)

### **Conference Presentations**

Macdermid, P., Fink, P., Stannard, S. Quantification of vibrations during mountain biking. *Journal of Science and Cycling*, North America, 3, jul. 2014. Available at: <<http://www.jsc-journal.com/ojs/index.php?journal=JSC&page=article&op=view&path%5B%5D=99>

(Appendix 5)

### **Industry Media**

Macdermid, P., Fink, P., Stannard, S. (2013, Dec-Jan) Weight: Does it matter? *New Zealand Mountain Biker Magazine*, Issue 56 pg 84-87. (Appendix 6)

Macdermid, P., Fink, P., Stannard, S. (2013, Oct-Nov) Wheel Weight: Does it really matter? We test to find out. *New Zealand Mountain Biker Magazine*, Issue 61. (Appendix 7)

Beran, R. (Director). (2014, January 30). Our Changing World: Vibrations on Mountain Bikes (Radio Broadcast & Podcast). Radio New Zealand. Available at:  
<http://www.radionz.co.nz/national/programmes/ourchangingworld/2014>