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# Quantification and description of braking during mountain biking using a novel brake power meter 

A thesis presented in partial fulfilment of the requirements for the degree of

## Doctor of Philosophy

in

## Sport \& Exercise Science

at Massey University, Palmerston North, New Zealand.

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Bachelor of Science in Exercise Science
Master of Science in Exercise Science

## 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. This thesis was completed under the guidelines set by Massey University's College of Health, for the degree of Doctor of Philosophy and has not been submitted for a degree or diploma at any other academic institution.

Candidate: $\qquad$

Date: $\qquad$

## Foreword

When I came to New Zealand to do my PhD, I wasn't very sure of what I wanted to study. I knew I wanted to study mountain biking, but it's such a diverse sport with many genres, and I really had no clear direction of where my studies would go. However, one thing was for sure: I was in the right place!

My supervisory team had what I felt was a good mixture of specialities within Sport \& Exercise Science, and the further I went through my research, the more I understood the perfect mixture of talent surrounding me. Strangely, while this same team had previously paved the way to new ideas in mountain biking research, I was given full liberty to shape my own ideas and make my own mistakes.

The brake power meter idea was born during an actual mountain bike competition. I found myself racing against my supervisor, Steve, who was much more fit than myself. As we continued the race and I could hear Steve's squeaky brakes, I knew the only reason I was able to keep up with him was for not braking myself.

Rather than being told it was a silly idea to measure braking for my PhD, I was taught how to apply for funding, given advice on what kind of variables we should measure, and had conversations on how we might run experiments. It was these kinds of events that taught me the depth of expertise and highly innovative scientists I'm surrounded by.

I've been tested more than I ever expected throughout this process, but have gained knowledge and experience beyond that of sports experiments.

Thank you for believing in me.

## Acknowledgements

Thank you to my family and friends for motivating me and assuring me that this process will be worth it in the end. GUNAX LBH GB ZL FGVAXL.

Thank you to Giant Bicycles NZ and Crank It Cycles for their generous equipment support in each experimental study and for my own cycling adventures.

Thank you to Massey Ventures Limited, Massey University and SENSITIVUS Gauge for supporting the commercial advancement of the Brake Power Meter.

This is for the haters.

## Publications \& Presentations

## Publications


#### Abstract

Miller, M. C., Fink, P. W., Macdermid, P. W., \& Stannard, S. R. (2017). Validation of a normalized brake work algorithm designed to output a single metric to predict nonpropulsive mountain bike performance. (IN REVIEW).


Miller, M. C., Fink, P. W., Macdermid, P. W., \& Stannard, S. R. (2017). Calculation of brake power during skidding in road and off-road cycling conditions. (IN REVIEW).

Miller, M. C., Macdermid, P. W., Fink, P. W., \& Stannard, S. R. (2017). Magnitude differences in braking variables and their effects on performance when comparing experienced and inexperienced mountain bikers navigating and isolated off-road turn. (IN REVIEW).

Miller, M. C., Fink, P. W., Macdermid, P. W., \& Stannard, S. R. (2017). Quantification of brake data acquired with a brake power meter during simulated cross-country mountain bike racing. Sports Biomechanics (IN PRESS).

Miller, M. C., Fink, P. W., Macdermid, P. W., Perry, B. G., \& Stannard, S. R. (2017). Validity of a device designed to measure braking power in bicycle disc brakes. Sports Biomechanics, 1-11.

Macdermid, P. W., Miller, M. C., Fink, P. W., \& Stannard, S. R. (2017). The effectiveness of front fork systems at damping accelerations during isolated aspects specific to cross-country mountain biking. Sports Biomechanics, 1-13.

Miller, M.C., Macdermid, P. W., Fink, P. W., and Stannard, S. R., (2017). Performance and physiological effects of different descending strategies for cross-country mountain biking. European Journal of Sport Science, 17(3): p. 279-285.

Macdermid, P. W., Fink, P. W., Miller, M. C., and Stannard, S., (2017). The impact of uphill cycling and bicycle suspension on downhill performance during cross-country mountain biking. Journal of Sports Sciences, 1-9.

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Miller, M. C., Moir, G. L., \& Stannard, S. R. (2014). Validity of using functional threshold power and intermittent power to predict cross-country mountain bike race outcome. Journal of Science and Cycling, 3(1), 16.

## Conference Presentations

Matthew C. Miller, Philip W. Fink, Paul W. Macdermid, Steven R. Stannard (2017). The utilization of a bicycle brake power meter for cross-country mountain biking. Australian Strength and Conditioning Association, Gold Coast, Australia, 10-12 Nov

Matthew C. Miller, Paul W. Macdermid, Philip W. Fink, Steven R. Stannard (2016). Performance and physiological effect of different pacing strategies for mountain bike racing. European College of Sports Science, Vienna, Austria, July 9

Matthew C. Miller, Chad A. Witmer, Gavin L. Moir, Shala E. Davis (2014). The Predictive Validity of Critical Power and Functional Threshold Power for Mountain Bike Race Performance. Tsukuba Summer Institute, Tsukuba University, Japan, July 23

Matthew C. Miller, Chad A. Witmer, Gavin L. Moir, Shala E. Davis (2014). The Predictive Validity of Critical Power and Functional Threshold Power for Mountain Bike Race Performance. ACSM Annual Meeting, Orlando, FL, USA May 27-31

Emily J. Sauers, Matthew C. Miller, Benjamin Sina, Bryce J. Muth, Brandon W. Snyder, Shala E. Davis (2014). Effects of Full-fat and Fat-free Chocolate Milk On Recovery Following Endurance Running. ACSM Annual Meeting, Orlando, FL, USA May 27-31


#### Abstract

Olympic format cross country mountain biking is both physically and technically demanding. The demands of this cycling genre are in contrast to road cycling because of the demanding off-road terrain. With its many obstacles and different surfaces, riders must make their way up and over steep hills a number of times throughout a lap. It's very easy to be able to measure the performance of the riders on ascending sections of the track thanks to on-the-bike personal power meter that measure the propulsive work rates in the pedals. However, there is currently no commercially available method to assess the way the rider handles the bike on descending sections. This thesis first highlighted the differences in physiological demand of descending on off-road versus on-road (Chapter 4). An interesting finding in Chapter 4 also showed that riders might be able to save energy by adopting a coasting strategy down hills. This caused the researchers to question the bicycle handling attributes that might allow this, which led to the development and validation of a device designed to measure how the rider uses the brakes while riding/racing (Chapter 5). From there, we completed an investigation akin to the early mountain biking descriptive studies (Chapter 6), but instead of focusing on data related to respiratory and metabolic load, the brake power meter was employed. The finding that braking patterns were related to mountain biking performance was not surprising, but being the first team to quantify this was very exciting. Since most of the braking was occurring on the descents in that study, we examined the differences in braking between training groups on an isolated turn (Chapter 7). The finding that inexperienced riders use their brakes differently-and that this results in reduced performance-left no doubt to the importance of braking. From there, we revisited the method used to calculate rear brake power, since current methods led to inaccurate measurement during skidding


(Chapter 8). This thesis culminated with the exploration of an algorithm that could quickly and easily describe mountain bike descending performance with one single metric (Chapter 9); the hope is that the normalized brake work algorithm should increase the utility of the brake power meter for training purposes and post-competition performance analysis. Overall, this thesis highlights the need, importance and utility of a bicycle brake power meter to assess mountain bike performance.

## List of Abbreviations

ANOVA - analysis of variance
AT - aerobic threshold
CP - critical power
DH - downhill (descending) terrain
$E_{K}$ - kinetic energy
F - force
FTP - Functional threshold power
HR - heart rate
I - inertia
IP - intermittent power
J - joule
LT - lactate threshold
FLAT - flat terrain
m - meters
$\omega$ (omega) - angular velocity
OBLA - onset of blood lactate
r-radius
RCP - respiratory compensation point
rad - radians
RMS - root mean square
s - seconds
SD - standard deviation
t-time
$\tau$ - torque
TRIMPS - training impulse
UP - uphill (ascending) terrain
v - velocity
$\mathrm{VO}_{2}$ - volume of oxygen uptake
W - watt
$W^{1}$ - anaerobic work capacity
XCO-MTB - Olympic format cross-country mountain bike racing

## Table of Contents

Student Declaration. ..... i
Foreword ..... ii
Acknowledgements ..... iv
Publications \& Presentations ..... v
Abstract ..... ix
List of Abbreviations ..... xi
Table of Contents ..... xiii
List of Figures ..... xvii
List of Tables ..... xxi
Chapter 1 ..... 1
INTRODUCTION ..... 1
Chapter 2 ..... 4
REVIEW OF LITERATURE ..... 4
2.1 Demands of Olympic format cross-country mountain bike racing ..... 4
2.2 Indices of performance ..... 10
2.3 Performance analysis and technological tools. ..... 15
2.4 Descending performance ..... 23
Chapter 3 ..... 26
AIMS \& STRUCTURE ..... 26
3.1 Background ..... 26
3.2 Aims ..... 27
3.3 Thesis structure ..... 28
Chapter 4 ..... 34
PERFORMANCE AND PHYSIOLOGICAL EFFECTS OF DIFFERENTDESCENDING STRATEGIES FOR CROSS-COUNTRY MOUNTAIN BIKING. 34
4.1 Abstract ..... 34
4.2 Introduction ..... 36
4.3 Methods ..... 39
4.4 Results ..... 43
4.5 Discussion ..... 50
4.6 Conclusion ..... 53
Chapter 5 ..... 55
VALIDITY OF A DEVICE DESIGNED TO MEASURE BRAKING POWER IN
BICYCLE DISC BRAKES ..... 55
5.1 Abstract ..... 55
5.2 Introduction ..... 57
5.3 Methods ..... 60
5.4 Results ..... 69
5.5 Discussion and Implications ..... 73
5.6 Conclusion ..... 79
Chapter 6 ..... 81
QUANTIFICATION OF BRAKE DATA ACQUIRED WITH A BRAKE POWERMETER DURING SIMULATED CROSS-COUNTRY MOUNTAIN BIKING81
6.1 Abstract ..... 81
6.2 Introduction ..... 83
6.3 Methods ..... 86
6.4 Results ..... 91
6.5 Discussion and Implications ..... 97
6.6 Conclusion ..... 105
Chapter 7 ..... 107
MAGNITUDE DIFFERENCES IN BRAKING VARIABLES AND THEIREFFECTS ON PERFORMANCE WHEN COMPARING EXPERIENCED ANDINEXPERIENCED MOUNTAIN BIKERS NAVIGATING AN ISOLATED OFF-ROAD TURN...................................................................................................... 107
7.1 Abstract ..... 107
7.2 Introduction ..... 109
7.3 Methods ..... 112
7.4 Results ..... 115
7.5 Discussion ..... 122
7.6 Conclusion ..... 127
Chapter 8 ..... 128
CALCULATION OF REAR BRAKE POWER DURING SKIDDING IN ROAD AND OFF-ROAD CYCLING CONDITIONS ..... 128
8.1 Abstract ..... 128
8.2 Introduction ..... 129
8.3 Methods ..... 133
8.4 Results ..... 135
8.5 Discussion and Implications ..... 138
8.6 Limitations and Conclusion ..... 139
Chapter 9 ..... 140
VALIDATION OF A NORMALIZED BRAKE WORK ALGORITHM DESIGNEDTO OUTPUT A SINGLE METRIC TO PREDICT NON-PROPULSIVE MOUNTAINBIKE PERFORMANCE140
9.1 Abstract ..... 140
9.2 Introduction ..... 142
9.3 Methods ..... 146
9.1 Results ..... 151
9.2 Discussion and Implications ..... 155
9.3 Conclusion ..... 162
Chapter 10 ..... 163
DISCUSSION ..... 163
10.1 General discussion ..... 163
10.2 Practical applications ..... 167
10.3 Thesis limitations ..... 174
10.4 Conclusions ..... 177
Appendices ..... 178
Appendix I ..... 179
References ..... 201

## List of Figures

Figure 2.1 Elevation profile of the XCO-MTB World Championships in Canberra, Australia in 2009 was originally published by Abbiss et al. (2013). .............................. 5

Figure 2.2 Elevation profile, propulsive power output and physiological variables (heart rate and $\mathrm{VO}_{2}$ ) from one individual during a simulated XCO-MTB race. This figure appeared in Macdermid \& Stannard, 2012.

Figure 2.3 Example of placement of accelerometers for use in measuring vibrations during cycling. This photo was first published by Macdermid et al. (2014)................... 9

Figure 2.4 Example of a functional (albeit dirty) propulsive power meter located within the chainring spider of a mountain bike crank set.17

Figure 2.5 Some of the cycling metrics used by cycling practitioners presented from TrainingPeaks software. It is not expected that all this data is useful to the untrained eye.
$\qquad$
Figure 2.6 Power (W; pink), heart rate (BPM; red) and elevation (Feet; grey) collected from one competitive cyclist during actual racing using TrainingPeaks software........ 20

Figure 3.1. Thesis structure schematic........................................................................ 33
Figure 4.1 Descent profiles with elevation (m) for A. DHC ${ }_{C}$ and $\mathrm{DHP}_{\mathrm{P}}(1.01 \mathrm{~km},-16.3 \%$ gradient), and B. $\mathrm{DH}_{\mathrm{R}}(1.03 \mathrm{~km},-15.7 \%)$. .................................................................. 40

Figure 4.2 Mean $\pm$ SD for values of A. Heart Rate (bpm) and B. $\mathrm{VO}_{2}\left(\mathrm{ml} \cdot \mathrm{min}^{-1} \cdot \mathrm{~kg}^{-1}\right)$ and
$\qquad$
Figure 4.3 Mean $\pm$ SD of A. heart rate $(\mathrm{bpm})$ and $\mathrm{B} . \mathrm{VO}_{2}\left(\mathrm{ml} \cdot \mathrm{min}^{-1} \cdot \mathrm{~kg}^{-1}\right)$ continuously sampled and reduced to 15 s averages.47

Figure 4.4 Comparison between $\mathrm{DH}_{\mathrm{C}}, \mathrm{DH}_{\mathrm{P}}$ and $\mathrm{DH}_{\mathrm{R}}$ for total accelerations................ 49
Figure 5.1 Non-drive side view of bike with A: data logger; B: front brake power meter; and C: rear brake power meter.

Figure 5.2 Front brake power meter mounted on bicycle fork. A: machined aluminium block mounted to standard bicycle mounting posts; B: stainless steel rod; C: stainless steel fixing pin for load cell; D: load cell housed within aluminium block; E: sliding aluminium block with F: brake caliper mounted; G: magnetometer; H: brake rotor.63

Figure 5.3. Correlation between total energy removed from the bicycle-rider system and the change in kinetic energy for A: 348 braking trials completed on a flat, tar-sealed road; and B: 60 braking trials completed on a flat dirt path.

Figure 5.4. Braking example using both front and rear brakes highlighting measurements of brake torque (A-B), angular velocity of the brake rotor (C-D) and resultant brake power (E-F). Initial velocity was $3.7 \mathrm{~m} / \mathrm{s}$ slowing a combined mass of 79.2 kg (rider plus cycling gear and bicycle) to $2.6 \mathrm{~m} / \mathrm{s}$. Sample duration was 0.9 s with a total brake work of 231 J . Mean brake power was 166 and 106 W for the front and rear brakes, respectively. ..... 76

Figure 5.5. Braking example using front brake only. Mean power was 105 and 6 W for the front and rear brakes, respectively. Sample duration was 2.9 s with a total brake work of 322.0 J . Initial velocity was $3.63 \mathrm{~m} /$ slowing a 79.2 kg mass to $1.7 \mathrm{~m} / \mathrm{s}$ with subsequent


Figure 6.1. Lap profile for XCO-MTB time trial. The track was $1,240 \mathrm{~m}$ long and had 45 m elevation gain per lap............................................................................................. 87

Figure 6.2. A. Brake Work (J), B. Brake Time (s), and C. Brake Power (W) for front (grey) and rear (black) brakes in laps 1-3. ................................................................... 94

Figure 6.3. A. lap time (s) and B. average propulsive power (W) for laps 1-3.............. 96
Figure 6.4. Example of braking and propulsive data for one participant on lap 1 (A) and lap 3 (B). The participant was a 22-year-old male weighing 68.5 kg with gear, had a VO2max of $73.1 \mathrm{ml} / \mathrm{kg} / \mathrm{min}$ and was competitive in international races. For lap 1, braking variables were $20342 \mathrm{~J}, 28.3 \mathrm{~s}$ and 719 W for brake work, brake time and brake power, respectively. Average propulsive power was 328 W with resultant lap duration of 263.3 s. For lap 3, braking variables were 18461 J, 27.0 s and 683 W for brake work, brake time and brake power, respectively. Average propulsive power was 306 W with resultant lap duration of 263.8 s . .................................................................................................. 103

Figure 7.1. Schematic representation of the off-road track and turn highlighting profiles for terrain sections (A-D= distance, gradient; $A=14.50 \mathrm{~m},-16 \% ; B=35.80 \mathrm{~m},-16 \% ; C=$
$13.65 \mathrm{~m}, 0 \% ; \mathrm{D}=13.65 \mathrm{~m}, 0 \%$ ), which were measured with a trundle wheel. Black dots represent boundary for each section.

Figure 7.2. Two-way analyses for relative brake work (J/kg; A), brake time (s; B) and relative brake power (W/kg; C) for Experienced and Inexperienced groups............... 120

Figure 7.3. Example trace of relative brake power of one experienced (black) and one inexperienced (grey) riders throughout respective (A-D) sections of the track. The respective mass of each rider (plus cycling gear) was not overly dissimilar (63.6 and 64.8 kg , respectively). Relative brake work, brake time, and relative brake power were 33.36 $\mathrm{J} / \mathrm{kg}, 2.46 \mathrm{~s}$, and $13.57 \mathrm{~W} / \mathrm{kg}$ for the experienced and $37.16 \mathrm{~J} / \mathrm{kg}, 4.53 \mathrm{~s}$, and $8.21 \mathrm{~W} / \mathrm{kg}$ for the inexperienced rider, respectively. Individual braking strategies elicited performance time of 14.08 and 15.87 s for the experienced and inexperienced rider, respectively. 121

Figure 8.1. Correlation between the change in kinetic energy and adjusted energy removed from the bicycle-rider system. 136

Figure 9.1. Elevation profile of the descending track used for testing in this study. The total distance was 1.01 km with a total elevation loss of 165 m (average gradient of $16.3 \%$ ). This track was chosen based in its previous use which indicated that performance time was not dependent on propulsive work. 147

Figure 9.2. The relationship between Performance Time (s) on the mountain bike descent and A) relative brake work ( $\mathrm{J} / \mathrm{kg}$ ); B) brake time ( s ); C) relative brake power ( $\mathrm{W} / \mathrm{kg}$ ); and D) normalized brake work........................................................................................ 153

Figure 9.3. Graphical representation of normalized brake power (1/s) across a 150 m portion of the descent from one trial each by a high-performing and low-performing mountain biker. The normalized brake work was 0.13 and 0.80 for the high-performer and low-performer, respectively. The time to complete this section was 14.72 and 18.22 s for the high- and low-performer, respectively, which equated to 10.91 and $8.23 \mathrm{~m} / \mathrm{s}$, respectively 159

Figure 9.4. Frequency distribution of normalized brake power (1/s) comparing a highand low-performing mountain biker. Normalized brake power was separated in to 10 bins in $0.05 \mathrm{1} / \mathrm{s}$ steps, with values below $0.05 \mathrm{1} / \mathrm{s}$ removed from analysis and values above 0.5 $1 / \mathrm{s}$ combined in the same bin.

Figure 10.1 The Candidate with an early commercially viable prototype brake power meter. Photo c. David Wiltshire, Massey University. ................................................ 170

Figure 10.2 An example of helmet video recording of the rider's view of the trail and the braking trace completed throughout the trial. 171

## List of Tables

Table 2.1. These regression models were derived from Miller et al. (2014) and indicated the strength of cycling field tests for XCO-MTB race prediction.12

Table 5.1. Mean $\pm$ SD and range for mean power and derivatives during braking........ 70
Table 5.2. Mean $\pm$ SD and range for calculated variables of energy loss during braking.

Table 6.1. Descriptive performance data (mean $\pm$ SD) per lap of a simulated XCO-MTB time trial.

Table 6.2. Multiple regression model incorporating brake time, brake work and relative propulsive power to explain lap time 95

Table 7.1. Mean $\pm$ SD of performance and braking variables between Experienced and Inexperienced mountain bikers. 117

Table 7.2. Mean $\pm$ SD starting (Sections B-D) and maximum velocity (Sections A-D) for Experienced and Inexperienced mountain bikers. 118

Table 8.1. Mean $\pm$ SD and range for calculated variables of energy loss during braking.
$\qquad$
Table 9.1. Mean $\pm$ SD for performance and braking variables. 152

