

EDITH COWAN UNIVERSITY

School of Exercise, Biomedical and Health Sciences

Does training with PowerCranks™ affect economy of motion, cycling efficiency, oxygen uptake and muscle activation patterns in trained cyclists?

Masters Thesis

Jack Burns

(BSc. Sports Science)

This thesis is presented in fulfilment of the requirements for the degree of

Master of Science (Sports Science)

Supervisor: Dr Paul Laursen

Associate Supervisor: Dr Greig Watson

Date of Submission: 5th June, 2008

EDITH COWAN UNIVERSITY

USE OF THESIS

This copy is the property of Edith Cowan University. However the literary rights of the author must also be respected. If any passage from this thesis is quoted or closely paraphrased in a paper or written work prepared by the user, the source of the passage must be acknowledged in the work. If the user desires to publish a paper or written work containing passages copied or closely paraphrased from this thesis, which passages would in total constitute an infringing copy for the purposes of the Copyright Act, he or she must first obtain the written permission of the author to do so.

DECLARATION

I certify that this thesis does not, to the best of my knowledge and belief:

- (i) incorporate without acknowledgment any material previously submitted for a degree or diploma in any institution of higher education.
- (ii) contain any material previously published or written by another person except where due reference is made in the text; or
- (iii) contain any defamatory material.

I also grant permission for the Library at Edith Cowan University to make duplicate copies of my thesis as required.

Signature:

Date:

ACKNOWLEDGEMENTS

I would like to dedicate this thesis to the memory of David Deverell, my Pop, who still remains a strong driving force in my life and someone I miss very much.

Firstly, I would like to thank my supervisors, Paul Laursen and Greig Watson, who have provided much support and advice throughout the development and writing of this thesis. Their friendship has been something that I am very grateful for.

I would also like to strongly acknowledge the support of Jeremiah Peiffer and Chris Abbiss whose assistance in everything from project development to data collection and thesis write up has been invaluable. I am truly in debt to both for their kindness and friendship.

Thankyou also to all the Staff and Postgraduate Students at the University for generously offering your support, advice and above all, friendship.

Thankyou to the subjects for without their time and efforts this project would not of have happened.

To my Family, Dad, Mum and Ray, Gran, Luke and Fern. Their support of me in my educational pursuits has been generous and selfless. I simply can not thank you enough.

To Meredith, thankyou for your support and friendship.

Abstract

PowerCranks™ are claimed to increase economy of motion and cycling efficiency by reducing the muscular recruitment patterns that contribute to the resistive forces occurring during the recovery phase of the pedal stroke. However, scientific research examining the efficacy of training with PowerCranks™ is lacking. Therefore, the purpose of this study was to determine if five weeks of training with PowerCranks™ improves economy of motion (EOM), gross efficiency (GE), oxygen uptake (**Error! Bookmark not defined.** $\dot{V}O_2$) and muscle activation patterns in trained cyclists. Sixteen trained cyclists were matched and paired into either a PowerCranks™ (PC) or Normal Cranks (NC) training group. Prior to training, all subjects completed a graded exercise test (GXT) using normal bicycle cranks. Additionally, on a separate day the PC group performed a modified GXT using PowerCranks™ and cycled only until the end of the 200W stage (PCT). During the GXT and PCT, $\dot{V}O_2$, $\dot{V}CO_2$ and \dot{V}_E were measured to determine EOM, GE and $\dot{V}O_{2max}$. Integrated electromyography (iEMG) was also used to examine selected muscular activation patterns. Subjects then repeated the tests following the completion of training on their assigned cranks. No significant improvements were observed for EOM, GE, $\dot{V}O_{2max}$ or iEMG in either the PC or NC group when subjects were cycling with normal cranks during the GXT. Likewise, no significant training effects were observed when PC subjects cycled with PowerCranks™ during the PCT. PC group subjects were significantly less efficient and economical, before and after training when cycling with PowerCranks™ compared to cycling with normal cranks. The results from this study do not support benefits claimed by PowerCranks™, however further research is needed to examine the influence of training with PowerCranks™ on various physiological variables over a more prolonged training duration.

TABLE OF CONTENTS

USE OF THESIS	2
DECLARATION	3
ACKNOWLEDGEMENTS	4
Abstract	5
List of Tables	9
List of Figures	10
CHAPTER 1: INTRODUCTION	11
1.1 Background	11
1.2 Significance of the study	13
1.3 Purpose of the study	13
1.4 Research Questions	14
1.5 Hypotheses	14
1.6 Definitions of Selected Terms	15
CHAPTER 2: LITERATURE REVIEW	16
2.1 Introduction	16
2.2 Background	16
2.3 Foot/Pedal Interface	18
2.3.1 Early Advancements	18
2.3.2 Verbal and Visual Feedback as a Mechanism of Improvement	18
2.3.3 Muscle Mapping in Cycling	19
2.3.4 Pedalling Symmetry	20
2.3.5 Remediation of Problems in Bicycling Pedalling	21
2.3.6 Toe Clips and Cleats (The case for and against)	21
2.4 Physiological Adaptations to Endurance Exercise Training	23
2.4.1 Electromyography and Muscular Adaptations	24
2.4.2 Summary	28

2.5 Pedal Crank Innovations	28
2.5.1 PowerCranks™	29
2.6 Conclusion	31
CHAPTER 3: METHODS	32
3.1 Participants.....	32
3.2 Design	32
3.3 Procedure	35
3.3.1 Maximum Voluntary Isometric Contractions	36
3.3.2 Graded Exercise Test.....	36
3.3.3 PowerCranks™ Test	39
3.3.4 Training Programme	40
3.4 Statistical Analysis.....	41
CHAPTER 4: LIMITATIONS AND DELIMITATIONS.....	42
4.1 Limitations	42
4.2 Delimitations.....	42
CHAPTER 5: RESULTS	43
5.1 Subject Characteristics.....	43
5.2 Economy and Efficiency for PowerCranks™ Group vs. Normal Cranks Group on Normal Cranks.....	44
5.2.1 Economy and Efficiency for PowerCranks™ Group on Normal Cranks vs. PowerCranks™ Group on PowerCranks™	44
5.3 Integrated Electromyography and Muscle Circumference	46
5.3.1 Integrated Electromyography.....	46
5.3.2 Muscle Circumference	47
5.4 Oxygen Uptake, Thresholds, Cadence and Power Outputs	47
5.5 Heart Rate and RPE	49

CHAPTER 6: DISCUSSION.....	50
6.1 Economy and Efficiency.....	50
6.2 Muscle Activation.....	52
6.3 Oxygen Consumption, Peak Power Output and Ventilatory Thresholds	57
CHAPTER 7: CONCLUSIONS AND RECOMMENDATIONS.....	59
7.1 Conclusions and Practical Implications.....	59
7.2 Recommendations for Further Research.....	60
CHAPTER 8: REFERENCES	61
CHAPTER 9: APPENDIX	67
9.1 Appendix A: Statistical Data	67
9.2 Appendix B: Information Letter and Informed Consent Documents	71
9.3 Appendix C: Subject Advertisement	76

List of Tables

Table 1. Scale for determining the magnitude of effect sizes in strength training research.....	43
Table 2. Subject Characteristics.....	45
Table 3. Pre- and post-study variables of muscle activation for the normal cranks and PowerCranks™ groups during the graded exercise test and PowerCranks™ group during the PowerCranks™ test.....	48
Table 4. Pre- and post-study variables of upper and lower leg muscle girths for the normal cranks and PowerCranks™ groups.....	49
Table 5. Pre- and post-study variables of maximal oxygen uptake, peak power output as well as the first and second ventilatory thresholds for the normal cranks and PowerCranks™ groups during the graded exercise test.	50
Table 6. Pre- and post-study variables of heart rate (200W level), RPE (200W level) and sessional RPE for the normal cranks and PowerCranks™ groups during the graded exercise test and PowerCranks™ test	51
Table 7. Two-way ANOVA ($p < 0.05$) p-values for group x time comparison, pre- to post-training.....	69
Table 8. One-way ANOVA ($p < 0.05$) p-values for pre- to post-training comparison for normal cranks and PowerCranks™ groups.....	71

List of Figures

Figure 1. The first version of the safety bicycle.....	18
Figure 2. Diagrammatic interpretation of EMG studies of pedal stroke with toe clips in seated position.....	21
Figure 3. Force effectiveness patterns versus crank angle for a U.S. national team cyclist pedalling at 350W, 90 revs·min ⁻¹	23
Figure 4. Muscle activation patterns for eight muscles of the leg monitored during steady state cycling.....	26
Figure 5. The PowerCranks™ device.....	31
Figure 6. Study design.....	36
Figure 7. Pre- and post-study variables of gross efficiency and economy for the normal cranks and PowerCranks™ groups for the graded exercise test and PowerCranks™ test at 200 W.....	47