Enhancing athletic performance through high-intensity interval training and sodium bicarbonate supplementation

Matthew W. Driller
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School of Human Life Sciences, University of Tasmania, Australia.

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Primary Supervisor: Dr. James Fell
Statement of Originality and Ethical Conduct

I, Matthew Driller certify that this work is entirely my own effort except where otherwise acknowledged. I also certify that, to the best of my knowledge and belief, the work is original and has not been previously submitted for any other award, nor does the thesis contain any material that infringes copyright. This thesis may be made available for loan and limited copying in accordance with the Copyright Act 1968.

The research associated with this thesis abides by the international and Australian codes on human and animal experimentation, the guidelines by the Australian Government's Office of the Gene Technology Regulator and the rulings of the Safety, Ethics and Institutional Biosafety Committees of the University.

Matthew Driller

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SUPERVISOR ENDORSEMENT

Date: 27/02/2012
Abstract

Introduction: Metabolic acidosis is a by-product of the energy production process required during high-intensity exercise, and it is thought to play a part in influencing muscle function and fatigue. Consequently, the efficacy of an athlete’s intra- and extra-cellular buffering systems may influence their performance during an exercise task. These buffering systems can be enhanced through exercise training and nutritional supplementation. Therefore, the purpose of this series of studies was to investigate combined training and sodium bicarbonate (NaHCO₃) supplementation techniques for enhancing performance in well-trained athletes.

Study 1. The aim of this study was to evaluate high-intensity interval training (HIT) for improving performance in already well-trained athletes. To achieve this we compared traditional rowing training (CT) to HIT in state-representative rowers. Following baseline testing (2000 m rowing test, incremental rowing test) 10 rowers were randomly allocated to HIT or CT, which they performed seven times over a 4-week period, after post-treatment testing the rowers were allocated to the alternative training method, completing a cross-over design. The HIT produced significantly greater improvements in 2000 m time, 2000 m power and relative VO₂ peak when compared to CT (P < 0.05). It was concluded that four weeks of HIT improves 2000 m time-trial performance and relative VO₂ peak in competitive rowers, more than CT.

Study 2. After establishing that HIT was effective in improving rowing performance the next step was to investigate if the combination of HIT and NaHCO₃ supplementation could further enhance performance. However, the research literature was still equivocal as to the most effective method of NaHCO₃ supplementation. Consequently, the aim of Study 2 was
to compare acute NaHCO₃ loading with serial NaHCO₃ loading (split doses over three days) in well-trained cyclists to establish which method was best for producing performance improvements and enhanced acid-base balance with minimal side effects. Eight male cyclists completed three tests in a double blind, randomised design over a three week timeframe: acute NaHCO₃ loading (AL), serial NaHCO₃ loading (SL) and a placebo loading condition (P). Following each loading protocol, cyclists completed a 4-min performance test on a cycling ergometer. Both the AL and SL trials produced a significantly higher average power in the 4-min test when compared to the P trial ($P < 0.05$), with no significant difference between AL and SL trials ($P = 0.29$). The improvements in performance associated with the SL trial were despite any changes to the measure blood-gas variables (pH and HCO$_3^-$). It was concluded that SL may provide a convenient and practical alternative approach for athletes preparing for competition; however, AL was the most effective for altering acid-base balance as well as improving performance with minimal negative side-effects, and was deemed the most appropriate method to use when combing HIT and NaHCO₃.

**Study 3.** With appropriate protocols for both HIT and NaHCO₃ loading in well-trained athletes confirmed, the aim of Study 3 was to combine these two strategies and investigate whether there was any additive benefit when used in a chronic training setting. Subjects were 12 elite rowers preparing for international competition. Following baseline testing, rowers were allocated to either NaHCO₃ (ALK) or a placebo (PLA) group (sodium chloride matched for equimolar sodium content). Both groups performed 8 HIT sessions over a 4-week period. Prior to each HIT session, subjects were required to ingest NaHCO₃ or a placebo substance. The 2000 m time-trial performance improved after 4 weeks of HIT; however, there were no statistically significant performance improvements ($P > 0.05$)
attributable to the NaHCO₃ supplementation during HIT training of fixed volume and intensity.

**Study 4.** Due to the results from Study 2 and 3, along with some inconsistencies in the literature regarding the influence of NaHCO₃ loading on athletic performance, it was hypothesised that a possible reason for lack of performance improvements after NaHCO₃ supplementation was the use of sodium chloride (NaCl) as a placebo. The sodium content has been proposed to provide some performance benefits, possibly through blood volume shifts, obscuring some of the benefits associated with NaHCO₃ supplementation, limiting its use as a valid placebo substance. Therefore the aim of Study 4 was to compare NaHCO₃ and NaCl to a physically inert substance by evaluating the haematocrit changes and their influence on high-intensity cycling performance. Subjects undertook three tests in a random, double-blind design over a one week timeframe: NaHCO₃ loading (SB), NaCl loading (SC) and dextrose loading (D). Following each loading protocol, subjects completed a 2-min performance test on a cycling ergometer. The SB trial produced a significantly higher ($P < 0.01$) mean power (W) in the 2-min test when compared to the SC and D trial with no significant difference between SC and D trials ($P > 0.05$). It was concluded that the HCO₃⁻ not the Na⁺ was primarily responsible for providing any ergogenic benefit during high-intensity exercise performance.

**Conclusions:** The findings from these studies suggest that independently, both HIT and NaHCO₃ supplementation can improve high-intensity exercise performance in well-trained athletes. However, this thesis provides the first study to investigate the combination of these two techniques in highly-trained athletes and provides evidence that such an approach does not lead to additional performance gains in this population; however, further research is warranted. The findings from the final study of the thesis suggest that it is the HCO₃⁻ content in NaHCO₃ which is likely to facilitate performance benefits more so than
the Na⁺ content. The findings of the studies included in this thesis are applicable to high-intensity exercise performance in the context of high-level athletic competition. The research adds to the knowledge base regarding practical information for athletes and coaches in terms of novel NaHCO₃ loading and interval training protocols while providing likely performance outcomes.
Publications Arising From This Thesis

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Peer Reviewed Conference Proceedings


Awards/Grants


Statement of Candidate Contribution

This thesis comprises four research investigations which have been completed almost entirely by Matthew Driller (the candidate). The candidate designed the studies, coordinated and supervised all data collection, analysed the data, and prepared all manuscripts. The contributions of all parties to each of the four studies are detailed below.

Study one: The effects of high-intensity interval training in well-trained rowers

- Mr Matthew Driller: lead role in study design, data collection, statistical analysis and first author on manuscript (70%)
- Dr James Fell: assisted with study design, data collection and manuscript revision (20%)
- Dr Andrew Williams: assisted with study design, data collection, statistical analysis and manuscript revision (5%)
- Mr John Gregory: assisted with data collection (2.5%)
- Dr Cecilia Shing: assisted with data collection and manuscript revision (2.5%)

Study two: The effects of serial and acute NaHCO₃ loading in well-trained cyclists

- Mr Matthew Driller: lead role in study design, data collection, statistical analysis and first author on manuscript (80%)
- Dr James Fell: assisted with study design and manuscript revision (10%)
- Mr John Gregory: assisted with data collection (5%)
- Dr Andrew Williams: assisted with statistical analysis and manuscript revision (5%)
Study three: The effects of chronic sodium bicarbonate loading and interval training in highly-trained rowers

- Mr Matthew Driller: lead role in study design, data collection, statistical analysis and first author on manuscript (80%)
- Dr James Fell: assisted with study design, statistical analysis and manuscript revision (10%)
- Mr John Gregory: assisted with data collection (5%)
- Dr Andrew Williams: assisted with statistical analysis (5%)

Study four: The effects of NaHCO₃ and NaCl loading on performance

- Mr Matthew Driller: lead role in study design, data collection, statistical analysis and first author on manuscript (65%)
- Dr James Fell: assisted with study design, statistical analysis and manuscript revision (10%)
- Mr Sam Howe: assisted with data collection and manuscript revision (10%)
- Mr Phillip Bellinger: assisted with data collection and manuscript revision (10%)
- Dr Andrew Williams: assisted with statistical analysis and manuscript revision (5%)
There was one further study that was directly related to this thesis and it appears in the appendices (Appendix I). The study was derived from blood collected during the conduct of study one. Therefore, the candidate completed all data collection but did not perform the first draft of the final manuscript and as such has not been included as part of the body of the thesis. The contribution to the study is listed below:

**Study five: The effects of high-intensity interval training on plasma adiponectin in well-trained rowers**

- Dr Cecilia Shing: data collection, statistical analysis and first author (40%)
- Mr Matthew Driller: assisted with data collection and manuscript revision (30%)
- Dr James Fell: assisted with data collection and manuscript revision (15%)
- Ms Jess Webb: assisted with data collection, analysis of blood, and manuscript revision (10%)
- Dr Andrew Williams: assisted with data collection and manuscript revision (5%)

We the undersigned agree with the above stated “proportion of work undertaken” for each of the above published (or submitted) peer-reviewed manuscripts contributing to this thesis:

Signed: _______________  
Candidate

Signed: __________________________  
Dr. James Fell  
Supervisor  
School Of Human Life Sciences  
University of Tasmania

Signed: ___________________  
Professor Madeleine Ball  
Head of School  
School of Human Life Sciences  
University of Tasmania

Date:  27/02/2012
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I would like to acknowledge Dr Johann Edge. Johann’s work provided the inspiration for some of the studies in this thesis. Johann was kind enough to provide me with advice when I was designing some of my studies. Unfortunately, in March 2010, Johann passed away in a cycling accident. I feel honoured to have known him and privileged that I could carry on some of the work he started.

To my parents, thank you for supporting me in pursuing my career in sports physiology, even if you didn’t know there was such a thing and would prefer I got a “real job”. Thank you also for instilling in me the importance of hard work.
Lastly, I would like to thank my wife, Kirsty. It’s been a trying journey over the last 5 years - but we made it! Thank you for encouraging me to finish this thing and for letting me follow my dreams. Hopefully, we can now spend some more weekends together!
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