MUSCULOSKELETAL AND PHYSIOLOGICAL PROFILE OF ELITE AND RECREATIONAL SURFERS: INJURIES AND SPORTS SPECIFIC SCREENING

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A thesis submitted to Bond University in fulfilment of the requirements for the degree of Doctor of Philosophy (PhD)

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2015

Department of Physiotherapy, Faculty of Health Sciences and Medicine
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ABBREVIATIONS

Abbreviations used Throughout This Thesis

- DEXA: Dual Energy X-ray Absorptiometry
- DF: Dorsiflexion
- ER: External Rotation
- HHD: Hand-Held Dynamometer
- HPC: High Performance Centre
- hr: Hour
- IR: Internal Rotation
- min: Minute
- PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses
- ROM: Range of Motion
- s: Second
- \( \text{VO}_{2\text{max}} \): Maximum Oxygen Consumption Value
- \( \text{VO}_{2\text{peak}} \): Peak Oxygen Consumption Value
- vs.: Versus
- WCT: World Championship Tour
- WQS: World Qualifying Series

Units of Measurement

- cm: Centimetre
- kg: Kilogram
- L: Litre
- m: Meter
ml  Millilitre
mmol Millimole
N   Newtons
W   Watt

**Statistical Abbreviations and Symbols**

CI  Confidence Interval
ICC Intra class Correlation Coefficient
U   Mann Whitney U Test
M   Mean
N   Total Sample
n   Sub-Sample
p   Probability Value
r   Pearson Product-Moment Correlation Coefficient
$r^2$ Coefficient of Determination; measure of strength of relationship
$r_s$ Spearman Rank Order Correlation
SD  Standard Deviation
SEM Standard Error of Measurement
SRD Smallest Real Difference
t   T-test Statistic
$\chi^2$ Chi-Square Test Statistic
DECLARATION OF AUTHORSHIP

“This thesis is submitted to Bond University in fulfilment of the requirements of the degree of Doctor of Philosophy (PhD). This document represents my own original work towards this degree and contains no material which has been previously submitted for a degree or diploma at this University or any other institution, except where due acknowledgement is made”.

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DECLARATION OF AUTHOR CONTRIBUTION

All the co-authors on the papers indicated in the following table have approved these works for inclusion in James Furness’s doctoral thesis.

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Signatures

James Furness (doctoral candidate)

Professor Wayne Hing (primary supervisor)

A/Prof Mike Climstein (secondary supervisor)
A/Prof Allan Abbott

Dr Jeremy Sheppard

A/Prof Sean Newcomer

Scott Johnstone
RESEARCH OUTPUTS ARISING FROM THIS THESIS

Peer-Reviewed Publications


Published and Presented Conference Abstracts


Additional Publication by the Author Relevant to the Thesis but not Forming Part of it

ACKNOWLEDGMENTS

Over the past three and a half years, my thoughts and time have been completely dedicated to this project. What a journey it has been, the skills I have obtained and the growth I have gone through is evident through this document. I first started this project unmarried and renting...I am now married with a mortgage and have a four-month-old baby.

This project was always about combining my two passions in life, surfing and physiotherapy. I always remember a conversation I had with a patient of mine a few years back. I asked him what the key to happiness was; his reply, “You need to make your passion your work”. Three and a half years have flown by mainly because I have done that very thing.

There are so many people who have helped me complete this thesis and I will start with my primary supervisor, Professor Wayne Hing. Wayne is definitely a mentor in my life and his guidance in this work has been crucial. Wayne has an incredible ability to see the “big picture”; he would constantly challenge and encourage me to ensure I have considered the structure of my document or manuscript. His attention to detail is another skill that has been installed into my work. Wayne, I have a huge amount of respect for you and I thank you for allowing me to conduct research in such a new and unexplored area.

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My wife “Katrina” has constantly been there for me. So often, when I have lacked confidence you have been quick to remind me of my achievements over the last few years. Your ability to put things into perspective has helped de-stress me.

Finally I wanted to dedicate this to thesis to Tony McClean. Tony was the person who introduced me to surfing and was a great friend and mentor. Tony’s love for surfing was contagious and soon enough I was a full-blown surf addict. Tony passed away in 2008 following a flash flood in the Mangatepopo river while canyoning on a school trip. Tony was a teacher at the time, and when the river began to flood he tied himself to a
disabled teen in a bid to save him. This display of love and bravery will forever resonate with me. I am sure you would be proud of this work!
ETHICAL APPROVAL

The Bond University Human Research Ethics Committee (RO 1540 and RO 1610) approved two ethics applications. Copies of ethical approval and informed consent forms are found in Appendix 1.
ABSTRACT

It is well known that physical activity and sport participation can have a positive effect on an individual’s physical and psychological status. This is in-line with the current priorities of the World Health Organisation, which are to increase activity, nutrition and healthy living. However, along with the positive effects of sport participation it can often result in injury. Severe or poorly rehabilitated musculoskeletal conditions can often result in long-term degenerative changes leading to disability. Musculoskeletal conditions result in the third highest cause of disability in the world and the highest cause of disability within Australasia. More recently a trend has grown towards screening athletes; musculoskeletal, biomechanical, physiological and general health. These measures are taken to provide a profile, identify strengths and weaknesses, and provide recommendations to both prevent future injury and or improve performance. To our knowledge, no surf specific screening tool exists in the sport of surfing. Although surfing is currently practiced world-wide with an estimated 37 million surfers, scientific research has been severely neglected.

The general aim of this thesis was “To create a screening tool encompassing specific musculoskeletal and physiological tests to be utilised in a surfing population”. Therefore, an understanding of injury in the sport of surfing was needed to guide the direction of the surf specific screen. An initial literature review conducted around injury epidemiology and data collection methods highlighted the need to capture new information outside of hospital environments. Consequently, a survey (Study 1) was developed; the findings of which identified the shoulder and lumbar spine as key injury prone locations.

Understanding injury epidemiology in the sport of surfing was foundational in this research project. The next step was to physically screen a surfing cohort. Exploration of current screening techniques was needed to aid in developing a surf specific screen. A literature review identified established methodologies for physiological assessment; however there were minimal surf specific musculoskeletal studies. Several objective tests for the key injury prone locations were selected based on whether they were specific to surfing and shown to be reliable. The literature review however highlighted the lack of methods to assess the thoracic spine and the shoulder in a prone position.

Study 2 was therefore designed to determine the reliability of two new assessment methods for the shoulder and thoracic spine. It was determined following reliability
analysis that prone shoulder assessment was a reliable and sport specific method to assess a surfer’s shoulder. A surf specific test was also designed to determine thoracic mobility in the sagittal plane. This method assessed the movement change from T1-T12 by subtracting the value scored from maximal extension from the value scored from maximal flexion; reliability analysis revealed excellent ICC values.

The final aspect of this thesis involved the implementation of the surf specific screen (Study 3). The musculoskeletal and physiological profile of both a competitive and recreational surfer was presented. Several discrepancies in ROM are apparent between both cohorts (thoracic rotation, lumbar extension, hip internal rotation and ankle dorsiflexion) and when comparing the current study’s findings with previous research. This baseline data provides ROM and strength guidelines for both recreational and competitive cohorts. Longitudinal studies are needed to determine which tests may be predictors of future injuries.

The physiological profile of competitive and recreational surfers was also presented. Key performance variables ($\text{VO}_{2\text{peak}}$, peak and relative power output) were significantly higher in competitive surfers indicating this is both an adaptation and requirement in this cohort. Arm span and ape index were the anthropometric measurements that were significantly greater in the competitive group; whether this is a result of training effect or a physical predisposition is yet to be determined. This information provides insight into adaptations associated surfing subgroups and direction for clinicians dealing with these athletes.

In conclusion, this thesis provides clinicians with a surf specific screen which involves a series of reliable and surf specific physiological and musculoskeletal assessment techniques to be used individually or together. Clinicians dealing with surfers are able to utilise these results to compare against the current surfer they are treating. These findings can be used to assist with rehabilitative goals and/ or direct conditioning exercises, prevent injuries and potentially enhance performance.
THESIS STRUCTURE

This research is centred on three distinct areas specific to surfing; injury epidemiology, surf specific screening and profiling. This thesis has a unique structure; where by a literature review is presented prior to individual studies. The subsequent results from each study are presented in six papers throughout this thesis.

Chapter 1 addresses injury epidemiology and presents a literature review and Study 1. The results of Study 1 are presented in two published papers.

Chapter 2 addresses surf specific screening. The chapter provides a general review of screening methods specific to surfing. It then presents two specific literature reviews of shoulder and thoracic assessment. As a result of the reviewed literature Study 2 involves two reliability papers.

Chapter 3 addresses profiling of recreational and competitive surfers. The screening measures identified in Chapter 2 are implemented in a surfing cohort. Therefore, this chapter presents Study 3 in the form of two papers. The first paper presents the musculoskeletal profile and the second paper presents the physiological profile of recreational and competitive surfers.

Chapter 4 then summarises the key findings from each individual chapter, presents study limitations, clinical applications and further directions for research. Finally, the thesis conclusions are presented. To provide further clarity Figure 1 presents an illustration of the overview of the thesis.
Figure 1: Illustration of Thesis Overview
THESIS RATIONALE

Surfing is both a recreational and competitive sport practiced globally and within Australia. In comparison to most mainstream sports there appears to be a paucity of research in the area of surfing. The limited research has predominantly focussed around physiological testing and injury epidemiology. To our knowledge there is minimal research performed around surf specific screening and subsequent profiling at both competitive and recreational levels.

A surf specific screen implemented in a surfing cohort would essentially provide three main outcomes. Firstly an overall profile of both a recreational and competitive surfer would be attained. This will allow for identification of adaptions (positive or negative) as a result of participating in surfing. Secondly it will provide reference data for both recreational and competitive surfers relating to musculoskeletal and physiological testing. Thirdly, it would provide information to clinicians working with this type of athlete and direct appropriate exercise prescription.

Therefore prior to designing a surf specific screen, key information around injury specific to surfing needed to be attained (addressed in Chapter 1 and Study 1). In conjunction with understanding injury in the sport of surfing, specific and reliable assessment techniques needed to be selected to include in the surf specific screen. To do this previous assessment methods in the sport of surfing needed to be explored and evaluated (addressed in Chapter 2 and Study 2). Finally, by implementing a surf specific screen in a surfing cohort the above outcomes are achieved (addressed in Chapter 3 and Study 3). Therefore, this rationale provided the foundation for the Thesis Aims below.

**Thesis Aim**

To create a screening tool encompassing specific musculoskeletal and physiological tests to be utilised in a surfing population.

**Specific Aims**

The specific aims in relation to the first three chapters are presented below.

- Chapter 1: To provide epidemiological data regarding injury incidence, location, type and mechanism for acute and chronic injuries in recreational and competitive surfers
• Chapter 2: To design a surf specific screen incorporating reliable and specific methods for a surfing population

• Chapter 3: To provide a comprehensive musculoskeletal and physiological profile of a recreational and competitive surfer