Improving the Physical Preparation and Development of Women's Rugby Sevens Players

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Thesis Abstract

With the introduction of rugby sevens to the Olympic Games schedule from 2016, the exposure and increased professionalisation of the sport has grown rapidly worldwide in both the men's and women's game. Substantial investment is being directed into rugby sevens to better characterise the game demands and training requirements for enhancing the preparation and management of players. However, most research in rugby sevens has examined male players only, and unique differences between sexes, including aspects of physiology, health, and contextual factors, may limit the translational efficacy of this information to the women's game. The purpose of this thesis was to evaluate strategies for improving the management of women's rugby sevens players' health and physical development, assessment of game and training demands, and prescription of training and talent identification processes. In total, this thesis contains six independent studies that address aspects of these strategies. The first study was a cross-sectional comparison of the game demands and physical profiles of male and female rugby sevens players at three levels of competition. The second and third studies assessed microtechnology use for rugby sevens through a laboratory-based protocol to develop a physiologically-defined high-intensity speed threshold for women, and evaluated the efficacy of automated collision detection technology. Studies four and five were observational studies comparing the neuromuscular fatigue, muscle damage and inflammation between State and National level players following a two-day women's rugby sevens tournament. Finally, study six, a clinical investigation, explored sex differences in iron levels across a competitive season in male and female elite-level rugby sevens players.

Assessment of game movements and physical profiles of rugby sevens players showed small to large differences between playing levels (junior, senior, and elite) for most metrics in female players. In contrast, minimal differences were apparent between playing levels for men. Correlational analysis showed that superior physical fitness (aerobic, speed, power) was beneficial ($r = 0.39 – 0.65$) for game performance in female players. Training can now be prescribed for players based on the typical movement patterns of current or aspirational levels of competition, with assessment of general athletic ability recommended for all female rugby sevens players and talent identification. A sex-specific physiologically-defined threshold for high-speed running was established for female players. The

commonly used threshold of 5 $m.s^{-1}$ in men's rugby underestimated high-intensity running by up to 30% for female rugby sevens players, favouring those players who are typically sprinters. A mean physiologically-defined threshold of 3.5 $m.s^{-1}$ was determined to be more appropriate for assessing high-intensity running by female players. If adopted, this metric, or reference value, offers coaching staff a more accurate understanding of the running movements and demands of training and competition on female players. Automatic detection of collision events using microtechnology was deemed not of an acceptable standard given poor recall (0.45 – 0.69) and precision (0.71 – 0.73) in rugby sevens. It appears the nature of collision events in rugby sevens is different to other rugby codes (primarily related to differences in speed and number of players involved) from which algorithms were originally developed. Moreover, consideration of differences in size, strength, tackle technique, or patterns of play is needed to develop female-specific rugby sevens algorithm.

Substantial muscle damage, inflammation and impaired perceptions of fatigue and soreness occurred following a two-day women's rugby sevens tournament. National level players completed moderate to largely greater game movements during the tournament (standardised effect size (ES) = 0.65 – 1.32), however, State level players exhibited a higher (ES = 0.73) physiological disturbance in the muscle damage marker creatine kinase (CK). High-speed running (>5 $m.s^{-1}$) and impacts >10 g-force had large to very large positive correlations (r = 0.70 – 0.90) with the change in CK concentration for both State and National level players. Meanwhile, the post-tournament neutrophil count was large to very largely correlated (r = 0.57 – 0.89) with the total game movements of players regardless of playing level. Training should focus on high-speed running movements and collisions to adequately prepare players for competition and limit physiological disturbances induced by competition. Recovery practices should be implemented based on the total game time or running distance that players complete. Monitoring players over a competitive season for the presence of iron deficiency indicated that up to 30% of an elite women's rugby sevens squad had low iron stores at each time-point (pre-, mid-, and end-season). While the effect of an oral contraceptive on the serum ferritin level of female players (r = -0.29 ±0.59) was unclear, players who competed in four or more tournaments throughout the season had ~50% lower ferritin concentration that those who competed in less than four, while age was largely positively correlated (r = 0.66 ±~0.33) with ferritin concentration. Haematological

testing is recommended every six months for female players, corresponding to pre-season and mid-season time points.

In summary, women's rugby sevens programs should benefit from regular assessment of physical fitness within and between seasons, using a women's specific threshold of 3.5 $m.s^{-1}$ to assess high-intensity running, targeted recovery interventions during and after two-day tournaments, further refinement of automated technology to monitor impacts and collisions, and implementation of protocols to monitor and address iron status in female rugby sevens players.

Statement of Contribution by Others

Declaration by candidate

In the case of Chapters 3-8, the nature and extent of my contribution to the work was the following:

Nature of contribution	Extent of contribution (%)
Development of study design, data collection, analysis, manuscript preparation and submission to journals	80%

The following co-authors also contributed to the work:

Name	Nature of contribution	Chapter	Contribution (%)	Are they a UC student?
Judith Anson	Assistance with study design and manuscript preparation	3-8	10%	N
David Pyne	Assistance with study design, statistical analysis and manuscript preparation	3-8	10%	N
Christine Dziedzic	Proof reading/editing of final draft	8	<5%	N
Warren McDonald	Proof reading/editing of final draft	8	<5%	N

Candidate's Signature: **Date:** 23/5/2016

Declaration by co-authors

The undersigned hereby certify that:

(1) the above declaration correctly reflects the nature and extent of the candidate's contribution to this work, and the nature of the contribution of each of the co-authors.
(2) they meet the criteria for authorship in that they have participated in the conception, execution, or interpretation, of at least that part of the publication in their field of expertise;
(3) they take public responsibility for their part of the publication, except for the responsible author who accepts overall responsibility for the publication;
(4) there are no other authors of the publication according to these criteria;
(5) potential conflicts of interest have been disclosed to (a) granting bodies, (b) the editor or publisher of journals or other publications, and (c) the head of the responsible academic unit; and
(6) the original data are stored at the following location(s) and will be held for at least five years from the date indicated below:

Location(s) Research Institute for Sport and Exercise, University of Canberra
Physiology Department, Australian Institute of Sport

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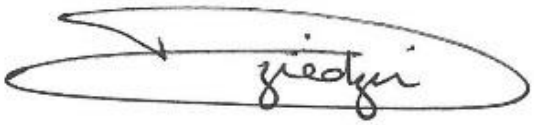
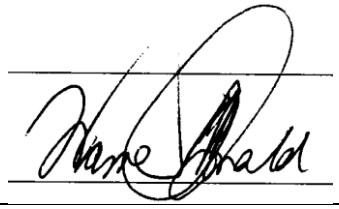
Signature 3		**Date** 23/5/2016
Signature 4		**Date** 23/5/2016

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"You are loved, you are strong, you are powerful and you are worthy of all those who will help you along the way."

Kurt Fearnley, Pushing the Limits (2014)

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List of Abbreviations

Δ	Change
°C	Degrees Celsius
% time	Percent of time
%TfrSat	Percent transferrin saturation
µL	Microlitres
$\mu g.L^{-1}$	Micrograms per litre
$ave.game^{-1}$	Average per game
AFL	Australian Football League
C	Cortisol
CI	Confidence interval
CK	Creatine kinase
CL	Confidence limits
CMJ	Countermovement jump
CV	Coefficient of variation
CWI	Cold water immersion
DXA	Duel-energy X-ray absorptiometry
EAR	Estimated average requirement
ES	Effect size
Fer	Ferritin
g	Force of gravity
$g.dL^{-1}$	Grams per decilitre
GPS	Global positioning system
Hb	Haemoglobin
Hct	Haematocrit
HR	Heart rate
hrs	Hours
$impacts.min^{-1}$	Impacts per minute
kg	Kilograms
$kg\ m.s^{-1}$	Kilograms per metre per second
$km.h^{-1}$	Kilometres per hour
LMI	Lean mass index
m	Metres
MCV	Mean cell volume
min	Minutes
mg	Milligrams
$mg.day^{-1}$	Milligrams per day
mL	Millilitres
$mL.kg^{-1}.min^{-1}$	Millilitres per kilogram per minute
mm	Millimetres

mM	Millimoles
$mmol.L^{-1}$	Millimoles per litre
$m.min^{-1}$	Metres per minute
$m.s^{-1}$	Metres per second
$m.s^{-2}$	Metres per second squared
NSAIDs	Non-steroidal anti-inflammatory drugs
O_2	Oxygen
PV	Plasma volume
r	Pearson's correlation coefficient
RBC	Red blood cells
RDI	Recommended dietary intake
RPE	Rating of perceived exertion
RSA	Repeat sprint ability
s	Seconds
SD	Standard deviation
T	Testosterone
T/C	Testosterone to cortisol ratio
Tfr	Transferrin
$U.L^{-1}$	Units per litre
VO_2 max	Maximal oxygen uptake
vVO_2 max	Velocity at maximal oxygen uptake
VT_2	Second ventilatory threshold
$VT_{2\ speed}$	Speed at second ventilatory threshold
W	Watts
$W.kg^{-1}$	Watts per kilogram
WBC	White blood cell
y	Years
Yo-Yo IR1	Yo-Yo intermittent recovery test level 1

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List of Articles Submitted for Publication

Clarke, AC., Anson, J., Pyne, D., Physiologically based GPS speed zones for evaluating running demands in women's rugby sevens, *Journal of Sport Sciences.* 33: 1101-1108, 2015.

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