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

Anthea C. Clarke

A thesis submitted in fulfilment of the requirements of the University of Canberra for the degree of

Doctor of Philosophy

2016

Faculty of Health
University of Canberra
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.
commonly used threshold of 5 m\(\text{s}^{-1}\) 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\(\text{s}^{-1}\) 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\(\text{s}^{-1}\)) 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 (\(r = -0.29 \pm 0.59\)) 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 (\(r = 0.66 \pm -0.33\)) 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 $3.5 \text{ m.s}^{-1}$ 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:

<table>
<thead>
<tr>
<th>Nature of contribution</th>
<th>Extent of contribution (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Development of study design, data collection, analysis, manuscript preparation and submission to journals</td>
<td>80%</td>
</tr>
</tbody>
</table>

The following co-authors also contributed to the work:

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

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

<table>
<thead>
<tr>
<th>Signature 1</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>23/5/2016</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Signature 2</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>23/5/2016</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Signature 3</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>23/5/2016</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Signature 4</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>23/5/2016</td>
</tr>
</tbody>
</table>
Acknowledgements

“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)

Throughout my PhD I have been lucky enough to be surrounded by the excitement that builds around a new sport on its journey to the Olympic Games, and it has been a truly unique experience. I am grateful for being involved in such an amazing sport from the early stages of its development within Australia and to watch the public interest in it continue to grow.

To all the players, coaches, managers and parents whom I have met and worked closely with throughout my PhD – your enthusiasm for the sport is infectious, your willingness to participate commendable, and your friendship greatly appreciated. Rugby sevens holds a special place in my heart because of my interactions with you. Specifically, thank you to Tim Walsh, Craig Twentyman, Jarrod Presland and all players of the Australian Men’s and Women’s Rugby Sevens Squads.

To my supervisors, David Pyne and Judith Anson – Thank you for your guidance, gentle encouragement, and acceptance of my extracurricular activities. I have learnt so much from you both over these past few years, and it is thanks to you that this process has been such an enjoyable one. My thanks also go to Gordon Waddington, who took me in as a late request and enabled a smooth process during the academic procedures required of my PhD.

To my family and friends – The support and encouragement I have received from you all over the years has meant the world to me and I am so grateful for your presence in my life.

And finally, to Tom – For being there to share my excitement and frustrations; For being that voice of logic and reason; For giving me words of encouragement and believing in me when I did not myself; And for being you, for whom I share so much joy and happiness.
# Table of Contents

Thesis Abstract ........................................................................................................... iii
Certificate of Authorship ........................................................................................... vii
Statement of Contribution by Others ........................................................................ ix
Acknowledgements ................................................................................................... xi
List of Abbreviations .................................................................................................. xvii
List of Tables ............................................................................................................... xix
List of Figures ............................................................................................................. xxi
List of Articles Submitted for Publication ............................................................... xxv
List of Conference Presentations and Proceedings ..................................................... xxvii

CHAPTER ONE ............................................................................................................. 1
  Introduction ............................................................................................................... 1
  Background ............................................................................................................. 2
  Statement of the Problem ..................................................................................... 3
  Research Objectives ............................................................................................. 3
  Synopsis of the Thesis ........................................................................................... 4

CHAPTER TWO ............................................................................................................ 7
  Literature Review .................................................................................................. 7
  Introduction ........................................................................................................... 8
  Game demands in rugby sevens .......................................................................... 10
  Physical characteristics of a rugby sevens players ............................................. 18
  Effective management of players ...................................................................... 33
  Conclusion ............................................................................................................ 43

CHAPTER THREE ....................................................................................................... 45
  Game movement demands and physical profiles of junior, senior and elite male and
  female rugby sevens players .............................................................................. 45
Abstract ...................................................................................................................................... 46
Introduction .................................................................................................................................. 47
Methods ......................................................................................................................................... 48
Results .......................................................................................................................................... 50
Discussion ..................................................................................................................................... 56
Conclusion ...................................................................................................................................... 60

CHAPTER FOUR .............................................................................................................................. 61
Physiological-based GPS speed zones for evaluating running demands in women’s rugby sevens .................................................................................................................................................. 61
Abstract ...................................................................................................................................... 62
Introduction .................................................................................................................................. 63
Methods ......................................................................................................................................... 65
Results .......................................................................................................................................... 67
Discussion ..................................................................................................................................... 71
Conclusion ...................................................................................................................................... 75

CHAPTER FIVE ................................................................................................................................. 77
Proof of concept of automated collision detection technology in rugby sevens .................................. 77
Abstract ...................................................................................................................................... 78
Introduction .................................................................................................................................. 79
Methods ......................................................................................................................................... 81
Results .......................................................................................................................................... 83
Discussion ..................................................................................................................................... 84
Practical Applications ..................................................................................................................... 86

CHAPTER SIX ................................................................................................................................. 87
Neuromuscular fatigue and muscle damage following a women’s rugby sevens tournament .................. 87
Abstract ...................................................................................................................................... 88
Introduction .................................................................................................................................. 89
Practical Applications and Future Directions................................................................. 143
Practical Applications........................................................................................................144
Limitations and delimitations.......................................................................................... 145
Future Directions............................................................................................................. 147
REFERENCES ..................................................................................................................... 149
APPENDICES ...................................................................................................................... 169
Appendix A (abstract) – Physiologically-based GPS speed zones for evaluating running demands in women’s rugby sevens................................................................. 171
Appendix B (abstract) - Neuromuscular fatigue and muscle damage in women’s rugby sevens .................................................................................................................. 173
Appendix C (abstract) – Monitoring iron levels in male and female rugby sevens players over an international season .............................................................................. 175
# List of Abbreviations

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

Table 2.1. Comparison of match scores, activities and set piece play over three Men’s and Women’s World Sevens Series from 2012-2015. Results are presented as an average across all teams and tournaments within each season. Data published by World Rugby (105, 106). ................................................................. 9

Table 2.2. Game movements of elite male and female rugby sevens players. Data presented as a range of study means................................................................. 14

Table 2.3. Anthropometric profile of elite male rugby sevens players. Data are presented as mean ± SD................................................................................. 20

Table 2.4. Anthropometric profile of elite female rugby sevens players. Data are presented as mean ± SD. ................................................................. 23

Table 2.5. Power characteristics of male rugby sevens players. Data presented as mean ± SD. ................................................................................. 23

Table 3.1. Anthropometric characteristics and physical testing results of male and female rugby sevens players at different playing levels. Data presented as mean ± SD. .... 52

Table 3.2. Mean game movement patterns of male rugby sevens players across playing levels. Data presented as mean ± SD................................................................. 53

Table 3.3. Mean game movement patterns of female rugby sevens players across playing levels. Data presented as mean ± SD ................................................................. 54

Table 4.1. Team movement patterns per women’s rugby sevens game in an international tournament (n=12 players, *n=7 using individualised VT\textsuperscript{2} threshold). Data shown as mean ± SD ................................................................................. 68

Table 5.1. Observed GPS-detected collisions compared to manually-labelled collisions in an international World Series game of both men’s (n = 12 players) and women’s (n = 12 players) rugby sevens. ................................................................. 83

Table 6.1. Differences in game movement patterns of State and National players over a two-day women’s rugby sevens tournament (mean ± SD). ........................................ 95

Table 7.1. Biochemical and haematological response in State and National level female rugby sevens players following a two day tournament. Data presented as mean ± SD................................................................. 110

Table 7.2. Total game movement patterns in State and National players over a two-day women’s rugby sevens tournament. Data presented as mean ± SD. .................. 112
Table 8.1. Mean blood profile of male rugby sevens players throughout an international season. Mean ± SD. ........................................................................................................... 126

Table 8.2. Mean blood profile of female rugby sevens players throughout an international season. Mean ± SD. ........................................................................................................... 128

Table 9.1. Summary of thesis outcomes that can be applied to the management and monitoring of women’s rugby sevens players, before and throughout a competitive season. ........................................................................................................... 135

Table 9.2. Scoring system to identify the risk of developing iron deficiency during a rugby sevens season. ........................................................................................................... 137
List of Figures

Figure 1.1. Schematic diagram of the flow of experimental chapters (Chapter Three – Eight) within the thesis. .......................................................... 3

Figure 2.1. Sprint differences between male rugby sevens and rugby union players (57, 86, 94, 158, 163, 164, 170). Data presented as mean and SD. SD not available for rugby union 40 m sprint times. No undisclosed positional data available for male rugby union players’ 40 m sprint time. .......................................................... 26

Figure 2.2. Sprint differences between backs and forwards in women’s rugby sevens and rugby union players (5, 88). Data presented as mean and SD.......................... 27

Figure 2.3. Creatine kinase (CK) response following games or a tournament in rugby sevens (179, 203), rugby union (180) and rugby league (128). Data are presented as mean ± SD. Bloods were collected within 30 min of games finishing. End Day One includes three games of rugby sevens, End Day Two equates to three games of rugby sevens plus the cumulative effect of the previous day’s three games. End Day Two results for rugby union and rugby league game equates to CK measures obtained 24 hours post game. ........................................................................ 35

Figure 3.1. Correlation between on-field running measures and A) Yo-Yo distance, B) 10 m sprint time, and C) Sum of seven skinfold thickness, in women (squares) and men (circles). ............................................................ 55

Figure 4.1. Correlations between treadmill VO$_2$ max variables, maximum game speed, and percent distance covered at high intensity using various speed thresholds for international-level women’s rugby sevens players. Represented as an r-value with 90% confidence interval shown, n=7. Shaded area is at ±0.1, lines that cross this threshold in both directions are deemed unclear. * large correlation; ** very large correlation........................................................................................................ 69

Figure 4.2. Schematic view of speed zone thresholds for low-, moderate- and high-intensity running using GPS, and the effect that a mean physiologically-defined (3.5 m.s$^{-1}$, represented by the dotted-lined arrows), relative to the industry used (5 m.s$^{-1}$, represented by the solid-lined arrows) threshold has on intensity determination. Solid circles represent the VT$_2$speed of the seven individual players who completed a VO$_2$ max test........................................................................................................ 70
Figure 4.3. Correlation between player fitness variables and percent time spent at Low speed (<2 m.s\(^{-1}\)), Moderate speed (2 m.s\(^{-1}\) to indVT\(_{2\text{speed}}\)), High speed (>indVT\(_{2\text{speed}}\)), and Sprint Distance (accelerating >2.5 m.s\(^{-2}\) for >1 s). Represented as an r value with 90% confidence interval shown, n=7. Shaded area is at ±0.1, lines that cross this threshold in both directions are deemed unclear. * large correlation; ** very large correlation..........................................................71

Figure 5.1. Graphical representation of how a collision event is classified when comparing video footage and microtechnology. ..............................................................82

Figure 5.2. Attempted and completed collision events reported as either true positive (correctly detected via GPS) or false negative (incorrectly missed by GPS) events in a women’s (A) and men’s (B) rugby sevens game. Completed collision (attacking and defending) were further categorised into area of contact on the ballplayer. .....84

Figure 6.1. Change in capillary creatine kinase concentration compared to Baseline over a two-day women’s rugby sevens tournament in State (n=10) and National (n=12) players. Small (*) and moderate (**) differences between playing levels are indicated. ..........................................................................................................................97

Figure 6.2. Correlation between on-field game metrics and the change from baseline to Day Two capillary kinase concentration following a two-day women’s rugby sevens tournament in State (■, n=10) and National (●, n=12) players. Data presented are r-value with 90% confidence intervals. Shaded area between ±0.1 shows the area of uncertainty. Dotted lines separate large (0.5-0.7), very large (0.7-0.9) and almost certain (>0.9) correlations.................................................................98

Figure 7.1. Percent change in haematological and biochemical values from baseline to one week post a two-day women’s rugby sevens tournament in National representative players. Data are presented as mean ± SD. Magnitude of change is represented as small (*), moderate (**), large (***) or very large (****)..........111

Figure 7.2: Correlation between neutrophil count post a two-day women’s rugby sevens tournament with on-field game performance metrics in State (●, n = 10) and National (■, n = 12) players. Dotted lines represent the threshold between moderate (0.3-0.5), large (0.5-0.7), very large (0.7-0.9) and almost certain (>0.9)..........112

Figure 8.1. Reference ranges frequently used to assess ferritin concentration in the general and athletic population. AIS Athlete range: Australian Institute of Sport reference range derived from healthy athlete samples (mean ± 95% confidence interval), F;
female, M; male, pop; population. When F and M are not specified, reference range refers to both sexes. ................................................................. 125

Figure 8.2. Ferritin values of male (circles) and female (triangles) rugby sevens players over a competitive season. Dark line represents mean changes for male and female players. Solid line at 12 µg.L\(^{-1}\) represents clinical deficiency cut-off, shaded area below the dashed line represents iron deficiency (30 µg.L\(^{-1}\)), below the dotted line (without shading) represents functional iron deficiency (99 µg.L\(^{-1}\)). .................... 127


List of Conference Presentations and Proceedings

Clarke, AC., Anson, JM., Pyne, DB., Physiologically-based GPS speed zones for evaluating running demands in women’s rugby sevens (abstract), *Be Active - Sports Medicine Australia*. Canberra, Australia, October 2014.


Clarke, AC., Anson JM., Pyne DB., Neuromuscular fatigue and muscle damage in women’s rugby sevens (abstract), *8th World Congress on Science and Football*. Copenhagen, Denmark, May 2015.

Pyne, DB., Clarke, AC., Anson, JM., Dziedzic, CE., McDonald, WA., Monitoring iron levels in male and female rugby sevens players over an international season (abstract), *American College of Sports Medicine 63rd Annual Meeting*. Massachusetts, USA, May 2016