

The Seven Step Approach to the Application of Sports Science in English Professional Rugby League: Practical Considerations in Strength & Conditioning

C.E. Sanctuary¹, R.Meir² and I.Sadler³

¹ Wakefield Trinity Wildcats RL, Wakefield, England. Email:

colinsanctuary@wakefieldwildcats.co.uk; colin.sanctuary@hotmail.co.uk

² School of Health and Human Sciences, Southern Cross University, Lismore, Australia.

³ York St John University, York, England.

Abstract

This paper examines the training and competition loads performed with a full-time professional rugby league team during a Super League¹ season (pre- and in-season). While a logical and evidence-based approach was taken, involving initial planning, delivery, monitoring and evaluation, the idiosyncratic aspects of such a professional environment requires a high degree of tacit knowledge and adaptability. The current paper will therefore, describe the context, outline the broad process and approach, provide some detailed case examples of support work undertaken with associated data, and identify the methods for evaluation.

The use of four case studies (i.e.: i) injury audit; ii) hydration in a training week; iii) alternative training strategy; and iv) monitoring) helped review and inform strength and conditioning practice within a professional rugby league club environment. This

¹ Super League is the highest level of competition in professional English Rugby League with fourteen franchised teams.

applied/ecologically valid environment highlights the nexus between science and practice and how they combine to inform the performance approach.

Introduction

There is a growing body of sports science literature which focuses specifically upon the sport of rugby league. Within this body of literature there are a number of papers which fall into a number of categories or strands of research. Of particular interest has been research into injury incidence in different settings and at different levels of performance (e.g. Hodgson et al. [1]; Gabbett [2]; Gabbett [3]; King et al. [4]).

Another strand, which has a relatively high number of papers, focuses upon the physical and physiological demands of the game. This has included examining the demands on players as rule changes have been introduced to the way the game is played, for example, the introduction of the 10-metre rule requiring the defending team to retire 10 metres from the 'play-the-ball' (Meir et al. [5]) and research based upon notational analysis (King et al. [6] and Sirotic et al. [7]). In addition, further research has identified the characteristics of elite and sub-elite performers (Gabbett [8]; Gabbett et al. [9]; Meir et al. [10]). More recently this area of the literature has developed further to consider how variation in physiological capacity impacts upon rugby league playing performance (Gabbett [11]; Gabbett et al. [12]). A final strand of research is composed of studies which have assessed the efficacy of different training interventions upon a variety of rugby league specific attributes. These include agility (Davison [13]), speed (Dwyer [14]), strength (Seibold [15]), and a combination of these (Gabbett [16]).

Due to the highly applied nature of the sports science research into rugby league some consideration of the issues that emerge from putting this research into practice in a professional setting is likely to be useful for strength and conditioning and rugby coaches. The effectiveness by which appropriate research and sports science can be

integrated into an athlete's preparation and training is likely to be a key factor for successful performance. As argued by Meyers [17] it is the merging of 'science and sweat' that will allow athlete's to excel. The application of research in the practical sports training environment is now common place. It plays an important part in informing coaching practise that is aimed at improving athletic performance (Bishop [18]). Notwithstanding this, some have questioned its relevance (Bishop et al. [19]), and indeed there is evidence that suggests the transfer of 'useful' research to practical application is very low within the sciences (Crowley [20]). It seems likely that this may also hold true for the translation of sport-science research into the practical sports training environment [18]. However, there is evidence within the sport science literature that research can have a direct and real impact to the applied practitioner. For example, Gustafsson et al. [21] provided an overview of the work of a multi-disciplinary sports science support team in relation to overtraining syndrome in an endurance athlete. The application to rugby league of such an approach is limited due to it being a single case study of a young athlete and therefore far removed from the experience of working in a professional setting with multiple full-time athletes.

Of more potential relevance to the current paper is research by Gilborne and Richardson [22], which offers a personal view of sports science support in English professional soccer. However, this research was purely concerned with the provision of psychological support to athletes. Hills and Utley [23] do provide a more holistic account of sports science support as applied to elite athletes with learning difficulties. Within this research they discuss the provision of sport science support and the issues that emerged in working with athletes. From this, recommendations for adaptation and extension of support were made for athletes in that specific context. To add to this body of applied knowledge a series of four case studies, as presented in this paper, were utilised to help inform the development of a training programme in the sport of professional rugby league.

Context: Background within professional rugby league

Case studies were undertaken with a professional rugby league team in the north of England. The team competes in the Super League competition with a full-time squad of 30 contracted professional players (aged 26.06 ± 6.75 years) who are supported by 5 coaching and support staff. These include a Director of Rugby (20yrs experience in professional coaching), 1st Team Coach (10yrs experience in professional coaching), Head of Sports Science Support (10yrs experience in professional sport), Club Doctor (20yrs experience in professional sport), Physiotherapist (7yrs experience in professional sport) and Masseuse (4yrs experience in professional sport).

A Super League match lasts 80mins, with a team playing approximately 26 matches per season plus a number of pre-season and secondary competition (Challenge Cup) matches. Within each game a team can typically expect to complete/contest 40 defensive 'sets'²(20 in each 40min of the match) and 40 attacking 'sets' (20 in each 40min of the match), meaning there are potentially 240 individual instances of attacking and 240 instances of defensive play within a match.

The importance of understanding the playing and training environment of rugby was highlighted by Dawson [24]. In this particular model Dawson argues that a systematic approach to the research process is necessary, if it is to ultimately achieve the goal of informing and guiding practice. Importantly, Haag (25) points out that this process is not a one-way street and that in fact practice can, and should, also guide research. In this context, the relevant research literature has been used to inform a seven-step model [26] developed and applied at the professional rugby league club which is the focus of this paper (see Figure 1)

Insert Figure 1 about here.

² A 'set' in Rugby League consists of a maximum of six tackles before the ball is 'turned over' to the opposition.

There are multiple theoretical frameworks which contribute towards the planning and delivery of conditioning and sports science support. The 'Seven Step Approach' was used, in this instance, within this RL club environment, to understand and assess individual player needs (stages 1 & 2), design, implementation and monitor various interventions (stages 3 & 4), evaluation and exiting (stages 5, 6 & 7). In addition, clearly there are many other elements of the players' preparation that can impact on competitive performance (e.g. illness, training age, social relationships, quality of rest, etc.). Not least of these is skill development as it relates specifically to rugby league. However, the skill development of players is not generally part of the strength and conditioning programme at the club. This is not to suggest that the strength and conditioning programme has no role to play in this regard. In fact, skill development strategies can be integrated into the strength and conditioning programme, if mandated by the head coach (Meir [27]). Typically, the skill acquisition aspect of player development at the club is primarily the role of the Head Coach who implements a strategy of individual and team skill development as considered appropriate across the entire training year.

Case Examples of Practical Considerations in Strength and Conditioning Throughout the Season

Case Study 1: Pre-season: Injury Audit

Injury studies in rugby league appear to present conflicting results with respect to the frequency and types of injuries reported. There also appears to be differences between northern and southern hemisphere data, which may be attributed to methodology and also the recency of reported studies (the majority of northern hemisphere injury studies in rugby league are pre-2000 and those in the southern hemisphere are post 2000).

During the 2009 season, data on all injuries from competitive games and training

sessions was collected for first team players at the club [28]. The aim of the case study was to attain an overview of the players at the club and the types and nature of their injuries. This information would then be used to develop, where appropriate, specific prehabilitation exercises in-conjunction with the strength and conditioning and medical staff. Data analysis was limited to injury incidence rates and relative sub-category frequencies for: (i) injury causation and acuity, (ii) contact versus non-contact, (iii) nature, (iv) location, and (v) severity. In addition, transient versus time-loss, as well as the influence that rugby session type and main playing position may have on these sub-categories (i.e, i-v) was also considered.

The calculated incidence rate for match injuries was 170.7/1000 player exposure hours with a training injury incidence of 9.4/1000 player hours. Tackling action generated the most common match injuries (71.8%), whereas overuse was the single most common cause of training injuries (40.7%) ($p < 0.0001$). Lower limb injuries seemed to be the most common (60-70%), followed by injuries to the upper limb (~15%) and head and neck region (8-10%). Finally, the findings showed forwards were more susceptible to injury than backs, during matches (203.1 vs. 142.9 per 1000 hours) and rugby training (16.4 vs. 3.8 per 1000 hours) ($p = 0.0431$).

Subsequently, the case study helped identify the importance of prehabilitation exercises for the shoulder complex and lower limbs (for example, hamstring). During the season this led to the integration of specific prehabilitation sessions and exercises in the weight room and 'on the field' as part of the overall training regime (Meir et al. [29]). This case study further helped inform the 'mapping' of an exercise (combining weight room and field based training) matrix utilised for the sequential development of players.

Case Study 2: Alternatives to Traditional Training Strategies

Total training load and overall physiological stress are exacerbated in load bearing collision sports such as rugby league. In an effort to minimise these stressors an

ecologically valid approach was adopted to examine the effectiveness of aquatic versus land based repeated efforts. This case study compared the physiological responses from the players when undertaking pool-based (aquatic) activity against a track-based (land) activity. The rationale for the case study was to help provide an appropriate alternative, reduced lower limb impact, training stimulus. Within rugby football generally and rugby league specifically the use of pool based (aquatic) activities are sparsely reported and researched.

Examples of aquatic based research outside of rugby league can be seen through that of Thein and Brody [30] and King [31]. Thein and Brody [30] examined the use of aquatic based rehabilitation with elite athletes and King [31] researched aquatic based rehabilitation, with track athletes, based on the use of a running action within a swimming pool. In addition, Girolid et al. [32] previously examined dry land as opposed to assisted sprint efforts on swimming performance. It was suggested by Benelli et al. [33] that land as opposed to aquatic based activities yield a higher HR. However, no previous research has looked at elite rugby league players and examined the affect of aquatic and land based repeat efforts within the context of a professional team sport conditioning programme.

The nature of the repeat efforts in this research would best be described as interval training (i.e. repeated efforts of activity completed for predetermined lengths of time and at a designated intensity with prescribed periods of recovery between efforts and sets). When designing interval type training sessions a range of scientifically sound guidelines need to be applied in order to ensure its effectiveness. Billat [34] has identified different types of interval training session structures which can be used to improve aerobic and anaerobic capacity. Further, Billat [34] identified four key variables that can be used to manipulate the training effect of these types of sessions; these are: i) intensity, ii) the time-ratio for the high and low exercise

duration, iii) the amplitude, and iv) the duration and the distances run at high and low velocities.

In an applied setting issues such as, injuries and absences can impact on the number of complete days training by players and the amount of data gathered from subsequent track and pool sessions. During this case study heart-rate values and rating of perceived exertion (RPE; Impellizzeri et al. [35], Borg [36]) were recorded. These details provided both an objective and subjective indication of the intensity of training loads and the recovery abilities of SL players ($n=12$: mean \pm SD age, 24 \pm 7 years) participating in the sessions [37]. At the time of data collection players were completing their pre-season phase, which was based on a five/six day working week (Table 1).

Insert Table 1 about here

During the track ($n=8$) and pool ($n=8$) sessions HR data was collected through the use of the Team Polar System, (Polar Electro, Woodbury, NY). Prior to the identified track and pool sessions HR monitors were fitted to the players and checked for effectiveness of transmission. Each belt was numbered and matched for all sessions against a particular player. At the conclusion of all pool and track sessions HR belts were collected and individual RPE values for the completed session from each player were recorded. RPE was recorded approximately 15 minutes after the session and in isolation, ensuring that players could not see or hear their team mates response [38].

The RPE rating was used to 'cross-reference' the intensity of the session with the coaches and strength and conditioning staff's intended intensity. The reason for this is that training sessions may not always produce the planned external and anticipated internal load on players. As a result, coaching staff can use the individual and group average RPE rating as one technique for monitoring training response and possible overtraining. Higher than anticipated ratings might indicate that players are

either not coping with the planned session loads or that the coaching staff have incorrectly applied session intensities.

To standardise the track and pool sessions, the same distances were completed for each track session (2000M) and each pool session (600m). However, the breakdown of each session differed. In general the intensity of the track as opposed to the pool session/s were seen as 'more intense' by players than the coaches. This rating of the track and pool sessions is supported by the mean (swimming 172 ± 6 bpm; track 178 ± 8 bpm) and maximum (swimming 186bpm; track 192bpm) heart rate data summarised from all of the completed session/s. From the descriptive statistics and the RPE responses the pool based activities appeared less intense than the repeated efforts on the track, supporting the findings of Benelli, et al. [33]. However, as the difference between the average heart rates reported was negligible aquatic based activities were accommodated into a squad's training schedule, as an alternative to land based activities. As the 'intensity' of the aquatic against track training loads had been quantified, players and coaches embraced its inclusion within the schedule. Senior players, in-particular, appeared to benefit from the inclusion of the aquatic activities as the season progressed.

Case Study 3: Hydration during periodic training weeks

Within the playing season, this case study was conducted [39] to examine the fluid balance and body mass change of the players during a typical training week. Player hydration, in certain instances, was potentially identified as an area which warranted exploration. Although water and a carbohydrate/electrolyte drink were provided on a daily basis the amount of fluid consumed by some players was questioned.

Measurement of hydration levels is not new, but was used to inform and highlight best practice, pre, during and post sessions as well as after 'rest days'.

Hypohydration and hyperhydration has been associated with a decrease in performance [40] and negative health effects [41]. Research has shown that

professional rugby league players experience significant amounts of weight loss due to sweating during training and games [42]; [43]. Shirreffs et al. [44] also reported failure to adequately re-hydrate following an exercise session can negatively impact on an athlete's performance in the next training session or competition. This was another reason for this case study as the question was raised by the strength and conditioning staff that a lack of hydration might be impacting on the cognitive abilities of players early in a field session. Although there have been several studies regarding the fluid balance of various athletic groups (Shirreffs and Maughan [45], Burke and Hawley [46], Reher and Burke [47]), at present there is limited published data regarding the fluid balance of professional rugby league players in England. Hence, a sample of male full time professional rugby league players (n=17; aged 26.06 ± 3.75 years) competing in the 'Engage Super League' during the 2009 season volunteered and gave informed consent to participate in the project. All participants consented to three separate data collection weeks throughout the 2009 season. The data collection weeks were spread over the course of the season (February, May and August) to provide a greater representation of the different climatic conditions in England and phases of training that players undertook (see Table 2). The prevailing environmental conditions of temperature ($^{\circ}\text{C}$), humidity (%) and barometric pressure (mBar), were recorded using a digital weather forecaster model BAA913HG (Oregon Scientific, Oregon, USA).

Insert Table 2 about here

There were no significant changes in pre-training body mass between any of the testing sessions but there was a significant change in body mass from pre to post training. This is highlighted specifically by the changes (pre and post) seen in May (session 3) and August (session 2). As is seen through the literature, losses of 1-2% having a negative impact on performance with greater than 2% impairing cardiovascular function [48]; 49]. Group mean fluid intake for each training session

are shown in Table 3. Not surprisingly there was a tendency for fluid intake to be higher during the testing in August than in February, which is likely partly due to the warmer ambient conditions at this time of year.

Insert Table 3 about here

This increase in fluid intake from May to August, in particular, was potentially in view of the 1.6% change in body mass seen in May (session 3). Hence, additional bottled water was provided pre and post training at all sessions in August. It was, therefore, surprising to see such a high percentage body mass lost in August (Field session 2) at 1.9%. Subsequently, additional hydration education was provided in the 2010 season. Mean pre and post training urine osmolarity readings are also shown in table 3. Here, no statistically significant difference was seen between the pre and post training urine osmolarity. Although the reduction in body mass highlighted relatively high percentage body mass reduction in May (session 3) and August (session 2) it was reassuring that players were still hydrated, as indicated through the osmolarity readings. This potentially highlights that the initial rationale for increased provision of fluid for players and the supporting education did have an impact on the players hydration levels. As mentioned, the subsequent body mass losses in May (session 3) and Aug (session 2) ensured greater attention and education during these periods in the 2010 season.

Case Study 4: Monitoring and evaluating training and competition loads

Given the heavy training schedule typically prescribed for professional rugby league players it is important for the coaching staff to have a simple, quick, valid and reliable method of monitoring overall training load. Hence, the rationale for this case study was to examine the validity/significance of specific variables to help inform the 'well-being' of players. These included, body mass (Seca 877 scales, GMBH&Co.Kg.Germany), resting heart rate (radial pulse taken prior to exercise in the morning), counter movement jump height (Just Jump; Probotics Inc. 8602

Esslinger CT Huntsville AL 35802) and RPE [38] during 'field' based sessions. To assess the impact of daily training and weekly playing, first team players (n=30) were monitored throughout a full season. The monitoring of body mass, heart rate and vertical jump allowed thresholds for each individual to be identified, over a two month period, in conjunction with the physiotherapist, club doctor and strength and conditioning coach. The rationale for this case study was that where players were outside their personal thresholds this could be an indicator of fatigue, overtraining, predisposition to injury or health issues. These instances were then discussed by the coaching and medical staff and if it was deemed appropriate alternative sessions or rest could be prescribed for the individual player.

External training load is readily measured by recording the training stimulus prescribed by the strength and conditioning/coaching staff (e.g. resistance training session reps, sets and actual load lifted; 10 x 80 metre sprints at or under 13 seconds, etc.). However, what coaching staff are unable to readily measure is the internal training response (i.e. the relative physiological stress) such external training loads impose on a player (Impellizzeri et al. [35]). Heart rate monitoring has been used to quantify relative training load. However, at a practical level it is not always feasible to do this with large groups due to the cost of heart rate monitors, the need for a degree of technical expertise, technical problems resulting in a loss of data, the inadequacy of using heart rate to monitor high intensity activity, and the time needed to set up and record responses for each individual (Foster, et al. [50]; Impellizzeri et al. [35]). Foster et al. [50] therefore, proposed and validated (Foster et al. [51]) a highly practical and useful alternative to more objective methods of monitoring internal training load. They propose the use of a modified rating of perceived exertion utilising a 10 point session-RPE scale (CR10-scale; Borg et al. [52]) which could be multiplied by the session's duration (time) to record an individual's perceived level of exertion at the conclusion of a training session. This approach has been used with

some success by a number of researchers in rugby league (Kelly and Coutts, [38]; Gabbett, [53], [54]) and has also been reported to relate to heart rate and blood lactate markers of exercise intensity (Foster et al. [50]). Importantly, this tool might also have significant benefits in the prevention of overtraining (Impellizzeri et al. 55)]. As a result, it was considered appropriate to use this index (CR-10 score x by session duration) to monitor players' internal response to the prescribed 'field training load'. This approach was used after all field sessions and after each game using the methodology described by Kelly and Coutts [38] in their research with Australian professional rugby league players.

Analysis of the body mass, resting heart rate, counter movement jump height and RPE during field sessions was conducted using SPSS for Windows version 14. Here, a multiple linear regression, which incorporated a backward step method, was used to identify the predictor variables that accounted for the greatest variance in game rating. The game rating was provided by the same first team coach after all first team matches (ordinal rating scale 1-10; 1=Poor Performance, 5=Average Performance, 10=Exceptional Performance), based on, real time view of game, video review of game, match statistics and individualised team play criteria.

When all of the predictor variables were considered together they accounted for 17% of the variance in game rating. However, the relationship between the predictor variables in combination and game rating was found to be non significant ($P=0.053$). The only significant predictor of game rating to emerge from the analysis was training RPE ($P=0.007$). This variable accounted for 12% of the variation in game rating (Table 4). The correlation between training RPE and game rating indicated a moderate, negative relationship (R^2 Linear = 0.103).

Insert Table 4 about here

The main finding was that for every 1 point increase in training RPE in the days before a game there was a 0.57 decrease in game rating. This could indicate that

any field and/or 'team prep' sessions towards the end of a weeks preparation (prior to the next game) needed to be perceived by players as 'easier', potentially an RPE rating of 4 (noted on the RPE scale as moderate) or lower. Subsequently, this approach was taken by coaching staff with training sessions later in the week. This finding regarding the RPE for field sessions later in a training week is hardly surprising. However, from the data examined it was the non-significant impact of factors such as, body mass, heart rate and vertical jump, on subsequent performance, that was surprising.

Conclusion

The aim of this paper was to capture the complexities, issues and approach to the application of sports science, from a strength and conditioning perspective, within an English professional rugby league environment. As the seven step approach proposes, a methodical and structured approach is important in such a challenging environment. The use of the case studies ('injury audit', 'hydration in a training week', 'alternative training strategy' and 'monitoring') helped review and inform practice within a professional rugby league team environment. While much research in the sport and exercise sciences is undertaken in highly controlled laboratory settings, with relatively small numbers of participants using costly and labour intensive techniques of assessment, the applied strength and conditioning practitioner does not typically have the luxury of such resources. It is in this (applied/ecologically valid) environment that the nexus between science and practice combine to inform and develop the performance environment. In this context this paper has attempted to demonstrate how within one particular sport setting, professional English rugby league, through exemplar case studies decisions were made and strategies adopted regarding the 'day-to-day' management and development of a squad of professional rugby league players. The application of this knowledge and understanding was

presented and discussed through a proposed 'seven step approach' [26], which demonstrated how a systematic approach to player preparation and support can be readily employed with limited resources. There is a phrase in sport/life that '...if it ain't broke don't fix it', however, the approach in this paper highlights that it is important to understand why and how aspects of performance training work. Once the performance environment is better understood, and in the event that some aspect of the implemented training system does 'break', a solution to 'repair' should be easier to identify and implement. Subsequently, improved understanding was achieved through: i) the injury audit, which helped in the development of a matrix of prehabilitation exercises; ii) a study of hydration in a training week resulting in an amended hydration and education strategy being implemented; iii) an investigation of aquatic and land based repeat efforts training was undertaken, reinforcing the rationale for the use of aquatic based activities for rugby league players in their training schedule; and iv) monitoring and identifying potential thresholds for players regarding readiness to play and train in addition to the RPE responses to sessions during a training and playing week in an effort to control total training load over time.

The importance of further longitudinal research in such an applied environment, in rugby league and other sports, should not be underestimated and should be encouraged as it will only enhance our awareness and understanding of the performance training and playing environment.

Acknowledgements:

The authors would like to recognise the contributions of Dr Patrick Dissmann, Alistair Black and Wakefield Trinity Wildcats RL in relation to the construction of this research paper.

References:

1. Hodgson, P.L., Standen, P.J. and Batt, M.E., Effects of Seasonal Change in Rugby League on the Incidence of Injury, *British Journal of Sports Medicine*, 1998, 32(2), 144-148.
2. Gabbett, T.J., Severity and Cost of Injuries in Amateur Rugby League: A Case Study, *Journal of Sports Sciences*, 2001, 19(5), 341-347.
3. Gabbett, T.J., Incidence of Injury in Junior and Senior Rugby League Players, *Sports Medicine*, 2004, 34(12), 849-859.
4. King, D.A., Hume, P.A., Milburn, P.D. and Guttenbeil, D., Match and Training Injuries in Rugby League, *Sports Medicine*, 2010, 40(2), 163-178.
5. Meir, R., Colla, P. and Milligan, C., Impact of the 10-metre Rule Change on Professional Rugby League: Implications for Training, *Strength and Conditioning Journal*, 2001, 23(6), 42-46.
6. King, T., Jenkins, D. and Gabbett, T. A., Time-Motion Analysis of Professional Rugby League Match-Play, *Journal of Sports Sciences*, 2009, 27(3), 213-217.
7. Sirotic, A.C., Coutts, A.J., Knowles, H. and Catterick, C. A., Comparison of Match Demands Between Elite and Semi-Elite Rugby League Competition, *Journal of Sports Sciences*, 2009, 27(3), 203-209.
8. Gabbett, T.J. A., Comparison of Physiological and Anthropometric Characteristics Among Playing Positions in Junior Rugby League Players, *British Journal of Sports Medicine*, 2005, 39(9), 675-680.
9. Gabbett, T., Kelly, J. and Pezet, T. A., Comparison of Fitness and Skill Among Playing Positions in Sub-Elite Rugby League Players, *Journal of Science and Medicine in Sport*, 2008, 11(6), 585-592.

10. Meir, R., Newton, R., Curtis, E., Fardell, M. and Butler, B. Physical Fitness Qualities of Professional Rugby League Players: Determination of Positional Differences. *Journal of Strength and Conditioning Research*, 2011 5(4):450-458.
11. Gabbett, T.J., Physiological And Anthropometric Correlates of Tackling Ability In Rugby League Players, *Journal of Strength and Conditioning Research*, 2009, 23(2), 540-549.
12. Gabbett, T., Kelly, J. and Pezet, T., Relationship Between Physical Fitness and Playing Ability in Rugby League Players, *Journal of Strength and Conditioning Research*, 2007, 21(4), 1126-1133.
13. Davison, S., Using Small Sided Games to Improve Agility in Rugby League Players: A Pre-Season Program. *Journal of Australian Strength and Conditioning*, 2010, 18(1), 58-64.
14. Dwyer, M., Speed Training in Rugby League, *Journal of Australian Strength and Conditioning*, 2009, 17(3), 45-50.
15. Seibold, A., Sport Specific Strength and Conditioning for Rugby League: A Case Study from the UK, *Journal of Australian Strength and Conditioning*, 2008, 16(4), 33-38.
16. Gabbett, T.J., Performance Changes Following a Field Conditioning Program in Junior and Senior Rugby League Players, *Journal of Strength and Conditioning Research*, 2006, 20(1), 215-222.
17. Meyers, M.C., Enhancing Sport Performance: Merging Sports Science with Coaching, *International Journal of Sports Science and Coaching*, 2006, 1(1), 89-100.
18. Bishop D., An Applied Research Model for the Sport Sciences, *Sports Medicine*, 2008, 38(3), 253-263.

19. Bishop, D., Burnett, A., Farrow, D., Gabbett, T. and Newton, R., Sports-Science Roundtable: Does Sports-Science Research Influence Practice? *International Journal of Sports Physiology and Performance*, 2006, 1(2), 161-168.
20. Crowley, W.F., Translation of Basic Research into Useful Treatments: How Often Does it Occur? *American Journal of Medicine*, 2003, 114(6), 503-505.
21. Gustafsson, H., Holmberg, H-C. and Hassmen, P., An Elite Endurance Athlete's Recovery from Underperformance Aided by a Multidisciplinary Sport Science Support Team. *European Journal of Sport Science*, 2008, 8(5), 267-276.
22. Gilbourne, D. and Richardson, D., Tales from the Field: Personal Reflections on the Provision of Psychological Support in Professional Soccer, *Psychology of Sport and Exercise*, 2006, 7(3), 325-337.
23. Hills, L. and Utley, A., Reflections on Providing Sport Science Support for Athletes with Learning Difficulties, *Disability and Rehabilitation*, 2010, 32(18), 1488-1499.
24. Dawson, C, Practical Research Methods: A User-Friendly Guide to Mastering Research Techniques and Projects, *How To Books Ltd*, 2005
25. Haag, H. Sate-of-the-art Review of Sport Pedagogy, *Sport Science Review*, 1994, 3(1), 1-10.
26. Sanctuary, C.E. and Smith, R.A., A Seven Step Approach to Analysis of Performance, *BASES Interdisciplinary Workshop*, York St. John University, 2000.
27. Meir, R., Conditioning the Visual System: A Practical Perspective on Visual Conditioning in Rugby Football, *Strength and Conditioning Journal*, 2005, 27(4), 86-92.

28. Dissmann, P.D. and Sanctuary, C.E. A Current Survey of Injuries Sustained by Professional UK Rugby League Players, Unpublished MSc Thesis, School for Health, University of Bath, 2010.
29. Meir, R., Diesel, W. and Archer, E., Developing a Prehabilitation Programme in a Collision Sport: A Model Developed within English Premiership Rugby Union Football, *Strength and Conditioning Journal*, 2007, 29(3), 50-62.
30. Thein, J.M. and Brody, L.T., Aquatic-Based Rehabilitation and Training for the Elite Athlete, *The Journal of Orthopaedic and Sports Physical Therapy*, 1998, 27(1), 32-41.
31. King, D., Aquatic Training for Track Athletes, *National Strength and Conditioning Association Journal*, 1993, 15(6), 67-69.
32. Giroid, S.B., Maurin, D., Dugue', B., Chatard, J-C. and Millet, G., Effects of Dry-Land Vs. Resisted- and Assisted-Sprint Exercises on Swimming Sprint Performances, *Journal of Strength and Conditioning Research*, 2007, 21(2), 599–605.
33. Benelli, P., Ditroilo, M. and De Vito, G., Physiological Responses to Fitness Activities: A Comparison Between Land-Based and Water Aerobics Exercise, *Journal of Strength and Conditioning Research*, 2004, 18(4), 719–722.
34. Billat, V.L., Interval Training for Performance: A Scientific and Empirical Practice (Part1), *Sports Medicine*, 2001, 31(1), 13-31.
35. Impellizzeri, F.M., Rampinini, E., Coutts, A.J., Sassi, A. and Marcora, S.M., Use of RPE-Based Training Load in Soccer, *Medicine and Science in Sports and Exercise*, 2004, 36(6), 1042-1047.
36. Borg, G.A.V., Borg's Rating of Perceived Exertion and Pain Scales. Champaign, IL: Human Kinetics, 1998.

37. Perry, S.R., Housh, T.J., Johnson, G.O., Ebersole, K.T. and Bull, A.J., Heart Rate and Ratings of Perceived Exertion at the Physical Working Capacity at the Heart Rate Threshold, *Journal of Strength and Conditioning Research*, 2001, 15(2), 225–229.
38. Kelly, V. and Coutts, A., Planning and Monitoring Training Loads During the Competition Phase in Team Sports, *Strength and Conditioning Journal*, 2007, 29(4), 32-37.
39. Black, A., King, R. and Sanctuary, C.E., Fluid balance and body mass change of full time professional rugby league players during a typical training week, Unpublished MSc Thesis, Leeds Metropolitan University, 2010.
40. Coyle, E.F., Substrate Utilisation During Exercise in Active People, *American Journal of Clinical Nutrition*, 1995, 61(suppl.), 968S-979S.
41. Sawka, M.N. and Montain, S.J., Fluid and Electrolyte Supplementation for Exercise Heat Stress, *American Journal of Clinical Nutrition*, 2000, 72: 564S–572S.
42. Meir R., Brooks L. and Shield T., Body Weight and Tympanic Temperature Change in Professional Rugby League Players during Day and Night Games: A Study in the Field, *Journal of Strength and Conditioning Research*, 2003, 17(3), 566-572.
43. Meir R. and Murphy A., Fluid Loss and Rehydration during Training and Competition in Professional Rugby League, *Coaching and Sport Science Journal*, 1998, 3(1), 9-13.
44. Shirreffs, S.M., Armstrong, L.E. and Cheuvront, S.N., Fluid and Electrolyte Needs for Preparation and Recovery from Training and Competition, *Journal of Sports Sciences*, 2004, 22(1), 57-63.

45. Shirreffs, S.M. and Maughan, R.J., Urine Osmolarity and Conductivity as Indices of Hydration Status in Athletes in the Heat, *Medicine and Science in Sport and Exercise*, 1998, 30(11), 1598–1602.
46. Burke, L.M. and Hawley, J.A., Fluid Balance in Team Sports: Guidelines for Optimal Practices, *Sports Medicine*, 1997, 24(1), 38–54.
47. Rehrer, N.J. and Burke, L.M., Sweat Losses during Various Sports, *Australian Journal of Nutrition and Dietetics*, 1996, 53(4), S13–17.
48. Harvey, G., Meir, R., Brooks, L. and Holloway, K., The Use of Body Mass Changes as a Practical Measure of Dehydration in Team Sports. *The Journal of Science and Medicine in Sport*, 11(6), 600-603.
49. Meir, R.A. and Halliday, A.J., Pre- and Post-Game Body Mass Changes during an International Rugby Tournament: A Practical Perspective, *Journal of Strength and Conditioning Research*, 2005, 19(3), 713 – 716.
50. Foster, C., Florhaug, J.A., Franklin, J., Gottschall, L., Hrovatin, L.A., Parker, S., Doleshal, P. and Dodge, C., A New Approach to Monitoring Exercise Training, *Journal of Strength and Conditioning Research*, 2001, 15(1), 109-115.
51. Foster, C., Hector, L.L., Welsh, R., Schragar, M., Green, M.A. and Snyder, A.C., Effects of Specific versus cross-training on running performance, *European Journal of Applied Physiology*, 1995, 70(4), 367-372.
52. Borg, G., Hassmén, P. and Lagerström, M., Perceived Exertion Related to Heart Rate and Blood Lactate During Arm and Leg Exercise, *European Journal of Applied Physiology*, 1987, 56(6), 679-685.
53. Gabbett, T., Physiological and Anthropometric Characteristics of Junior Rugby League Players Over a Competitive Season, *Journal of Strength and Conditioning Research*, 2005, 19(4), 764-771.

54. Gabbett, T., The Development and Application of an Injury Prediction Model for Noncontact, Soft-Tissue Injuries in Elite Collision Sport Athletes, *Journal of Strength and Conditioning Research*, 2010, 24(10), 2593-2603.

55. Impellizzeri, F.M., Rampinini, E. and Marcora, S.M., Physiological Assessment of Aerobic Training in Soccer, *Journal of Sports Sciences*, 2005, 23(6), 583-592.