Manuscript title: Monitoring the physical demands of training in Rugby League: The practices and perceptions of practitioners.

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Abstract

The physical demands of elite sport are often monitored with the aim of making evidence-based decisions to enhance performance and reduce injury risk. However, there is limited evidence in rugby league of the monitoring practices and perspectives of practitioners. This study provides a cross-sectional view of practices and perspectives of rugby league practitioners engaged in monitoring the physical demands of training. Practitioners from the Super League, Championship and National Rugby League competitions completed an online survey. Questions related to the tools and measures used to monitor training, along with perceptions of monitoring effectiveness. 'Enhancing performance' was considered the most important factor for monitoring training demands with most practitioners using some form of time motion analysis (e.g. GPS) or accelerometers. Nearly all practitioners combined objective external measures of exercise intensity with subjective measures, of which RPE was most common. The monitoring parameters considered most useful were running metrics (high-speed running, total distance covered, and the number of accelerations). Findings suggest that current practices are mostly supported by evidence from research. There was a preference for internal load monitoring tools that are quick and simple, such as RPE. The extent to which training load was monitored was lesser in some Championship teams compared to those in the other competitions, which might be explained by discrepancies in funding and access to players.

Keywords: Rugby league, Demands, Load, Monitoring, Practitioner

Introduction

Rugby League is a high-intensity intermittent sport characterised by frequent physical contact and high impact forces. Physical conditioning of players for optimal performance and injury prevention is paramount and a range of training is prescribed to induce physiological adaptations, with an emphasis on the development of strength and power[1,2]. As per other professional sports, rugby league teams employ practitioners to inform decision-making on player evaluation, recovery strategy, and training prescription. Although a plethora of research has considered the physical demands of the sport, including physical fitness[1,3,8], anthropometric qualities[4], and injury risk[5-7], less research has focused on how training and match-play demands are monitored.

Monitoring training and competition is ubiquitous in modern sport science practice and is considered important for determining whether players are adapting to training, for assessing fatigue and the associated need for recovery, and for minimising the risk of non-functional overreaching, injury, and illness[9]. Frequently, in sport and exercise science nomenclature this is referred to as monitoring ‘load’. Relevant parameters often include internal biological stressors (internal load, e.g., heart rate, blood lactate, oxygen consumption, ratings of perceived exertion) and external objective measures (external load, e.g., global positioning system [GPS] and accelerometer derived parameters such as distance, speed, and accelerations)[9]. There is no consensus as to which measures are most useful, and there has been no research in rugby league, to date, regarding the current practices and perceptions of practitioners when monitoring these training parameters.

Monitoring training load has many potential applications, but researchers have cautioned against simply reducing load to one metric, particularly for the complexity associated with issues such as managing injury risk[14]. Indeed, common screening tests used in rugby league to assess the musculoskeletal response to training do not appear to be effected by changes in external load variables such as total and high-speed distances covered, limiting conclusions about player fatigue responses[13]. Furthermore, Weaving *et al*.[12] reported that a combination of internal and external measures are required during some training activities (e.g., skills, speed, wrestle, and resistance training) to avoid underestimating the training dose in professional rugby league players. Insight into practitioner perspectives could help develop a greater understanding of how monitoring training demands operates in ‘real-world’ environments, allowing researchers to better appreciate the complexities involved and to subsequently conduct research that is relevant and effective. For example, McGuigan *et al*.[15] highlighted that practitioners frequently prefer monitoring tools that are simple, inexpensive, and allow for efficient data collection and analyses over tools that may be more valid. Similar information would be valuable for rugby league practitioners and researchers to optimise ecologically valid training monitoring programmes and tools.

Relatively little is known about practitioner perspectives in rugby league, particularly compared to some other sports such as soccer[16,17]. For example, English soccer survey data shows coaches and practitioners perceive training load monitoring as worth-while, yet differences in practices and perceptions likely reflect club infrastructure[17]. This could be particularly relevant to rugby league in England because teams outside the top tier are mostly semi-professional and might not be able to dedicate the same amount of time to monitoring training and match-demands, recovery practices, or strength and conditioning compared to full-time professional teams. To date, two studies have examined practitioners' (coaches and strength & conditioning coaches) practices and perceptions in rugby league[18,38]. McCormack *et al.*[18] used semi-structured interviews to investigate the perceptions of fitness testing in academy players, while Bennett *et al.*[38] used an online survey to explore the applications and perceptions of high-speed running. Although Bennett *et al.*[38] showed that practitioners perceive high-speed running as an important training metric, particularly high-speed running distance, no research has examined the range of tools and practices that are used and favoured for measuring the training demands in high-performance rugby league. Therefore, the aim of this research is to provide a cross sectional view of the practices and perspectives of practitioners engaged in monitoring the physical demands of training, which can be used to facilitate applied research and practice.

Materials and Methods

Participants and survey distribution:

Practitioners were convenience sampled from rugby league teams competing in the Super League (England/France), Championship (England/France), National Rugby League (NRL) (Australia/New Zealand), Women's Super League (England) and Women's NRL (Australia/New Zealand). Practitioners were contacted electronically using social media platforms (Twitter and LinkedIn) between February and October 2021. In total, practitioners from 46 Rugby League teams were contacted out of a possible 58 (12/12 Super League, 16/16 NRL, 13/14 Championship, 4/10 Women's Super League, 1/6 Women's NRL). Practitioners were identified through official team websites, known contacts of the research team, and LinkedIn. Where teams were not contacted, there was a lack of available contact information for coaches/practitioners from these sources. One practitioner was contacted per team to ensure that findings were not influenced by multiple responses from the same team. If contact couldn't be made with a practitioner, then a second practitioner from that team was contacted. We requested responses from the staff member with greatest responsibility for load monitoring, in line with previous methods investigating load monitoring practices[16,31]. Practitioners were invited to complete a survey that was created and accessed via an online resource (Qualtrics^{XM}, Utah, USA). All responses were anonymous, with practitioners only required to disclose their role, qualifications, experience, and the competition in which their team are involved. Participant information was provided at the beginning of the survey and all practitioners provided consent. The study received ethical approval from University of Huddersfield's Research Ethics Committee (approval number: SREIC/2020/115).

Survey design:

The cross-sectional survey contained 25 questions separated into 8 sections (Supplementary Material, Qualtrics Survey). The survey was modified from Akenhead and Nassis[16] and designed to capture: (1) demographic information (6 questions); (2) monitoring of exercise intensity and available tools (4 questions); (3) training intensity measures (3 questions); (4) interpretation of results (4 questions); (5) communication of results (2 questions); (6) influence of exercise intensity measures on training (3 questions); (7) perceived effectiveness (2 questions); (8) barriers to effectiveness (1 question). Questions were multiple choice, Likert scale, rank order or open-ended. All Likert scales were unipolar. Rank order questions asked participants to indicate the most and least important options from a list of available responses, or to rank the importance of their own practices/tools from most to least important.

For questions on perceived effectiveness, practitioners were asked how effective or ineffective they thought monitoring *could be* for achieving reduced injury rate, improved individual performance, and improved team performance, using a 1-10 to scale (1 = totally ineffective and 10 = very effective). Practitioners were asked the same question again, but this time reworded to ask how effective or ineffective they thought monitoring *actually is*, for the aforementioned issues. Practitioners were then asked what they thought were the limiting factors for the effectiveness of training load monitoring in their own practice using a scale of 1-5 (1 = does not limit effectiveness, 5 = severely limits effectiveness) for the following factors: empirical evidence (e.g., lack of scientific literature); lack of available facilities, equipment or expertise; lack of time/staff; coach understanding and 'buy-in'; player preferences (they like or dislike it); validity/reliability/sensitivity of field-based tests; other (asked to specify).

Open-ended questions provided an opportunity for participants to elaborate and provide context for responses. The survey design and question types were based on similar research investigating the practices and perceptions of practitioners monitoring load in soccer[16]. In line with similar survey based research[32,34], and the pre-testing recommendations in the Checklist for Reporting Results of Internet E-Surveys (CHERRIES) [33], the questions were piloted by two external practitioners, one from the Super League and one from the NRL, to check face validity. One new question was subsequently added prior to survey distribution.

Data analysis:

The CHERRIES guidance was followed for survey analysis and reporting the results. Data were analysed descriptively due to the observational, cross-sectional nature of the research. Raw data were exported from Qualtrics to Microsoft Excel (Microsoft Corp, Redmond, WA). For questions involving a Likert scale, frequency analysis was used to determine the percentage of practitioners that provided each response option. For ranked responses where practitioners were asked about importance of load monitoring practices/tools, points were awarded based on the number variables included in the question. For example, for questions with 10 variables, 10 points was awarded to the variable ranked first (most important), 9 points for the variable ranked second and so on[16,34,37]. Points for each variable were then summed and ranked in order of highest to lowest accumulated points of importance. Where participants were asked to list the parameters they used to monitor load in order of importance, variables only mentioned once (across all practitioners) were omitted from the analysis of accumulated importance.

Open-ended questions were analysed using inductive content analysis[19,35]. Participant responses were read diligently by one of the authors (LDH) to get a deep sense of the data. Themes and sub-themes were established using an inductive content analysis approach, which involves no pre-existing framework or misconceptions[36]. Emergent themes were assigned a descriptive label. Second order themes were then established, and this analysis continued until data saturation had occurred[19].

Results

Demographic Information:

Thirty participants gave informed consent and started the survey, with twenty fully completing all questions. The responses of the ten participants who did not complete the survey were removed prior to analysis, resulting in a 44% response rate from the 46 teams contacted. Due to only one response from practitioners working in women's rugby league, their responses were also removed. Six practitioners were from the Super League (three with seniors only, three with both senior and academy), seven from the National Rugby League (five with seniors only, two with both senior and academy), and six from the Championship (three with seniors only, two with academy only and one with both senior and academy). Practitioners had worked in rugby league for 6 ± 3 (2-25) years and had 9 ± 4 (2-16) staff working in their department. Ten practitioners had a Master's degree, three had a Doctorate, four had a Bachelor's degree, one had a PGDip and one had a Certificate of Education. The position/role of the practitioners within their organisation are provided in Table 1.

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Training Load Monitoring Methods:

Fifteen practitioners measured external and internal load, with one measuring internal only, one measuring external only, and two measuring neither. The two practitioners who measured neither worked for Championship clubs (one academy, one senior), with the reasons provided relating to a lack of funds and buy-in at the senior level ("Don't have the budget for external means, part-time players did not buy into internal means"), and a lack of contact with players ("We only see them once per week, the amount of training load that occurs outside of the club far exceeds inside, but it is quite hard to track accurately"). Therefore, seventeen practitioners answered the remaining questions in the survey.

Enhancing Performance was considered the most important reason for measuring training load, followed by *Reduce Injury*, *Enhance Fitness*, *Evaluate Training Plans*, *Showcase Expertise* and *Showcase Technology*, with the latter two considered least important by all practitioners (Figure 3). To measure training load, fifteen practitioners used Time-motion analysis (e.g., GPS), ten used accelerometers (including those integrated with GPS units), nine used heart rate monitors, nine used RPE scales (including Session RPE), and three used differential RPE (dRPE). Figure 2 provides the individual parameters that practitioners use to monitor training load. The parameters considered most useful (e.g., highest accumulated points of importance) were Total Distance (listed by 11 practitioners, with 7 ranking this parameter as the most important), High-Speed Running (> 5 or 5 m/s) (n = 10 practitioners, with 2 ranking as most important), Number of Accelerations (n = 12 practitioners, with 2 ranking as most important), session RPE (n = 8, with 4 ranking this as most important), and Sprint Metres Per Minute (n = 8, with none ranking this parameter as the most important). Thirteen practitioners collected data on individual players for each training session, two collected data on individual players but not at each training session, and two collected data on a subgroup of players at each training session due to a lack of GPS units. More detail on the analysis/thresholds used to interpret and monitor internal and external load is provided in Supplementary Material (Question 19 Responses).

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Reasons for Monitoring Load:

The second order themes identified for why practitioners measured training load were *Reduce Injury Risk* ("decrease injury risk"; "to mitigate risk of soft tissue injury"), *Session Planning and Adjustment* ("to plan and prescribe drills relative to competition"; "adjust individuals training load according to pre-determined parameters"; "drill selection"), *Rehabilitation* ("tailor return to play protocols for rehab athletes"; "workload monitoring for individuals returning to play") and *Assess Performance* ("ensure players are hitting targets"; "give feedback to coaches about who is working hard").

Interpretation of Results:

Three practitioners did not use specific thresholds when interpreting and monitoring load, five used arbitrary (i.e., manufacturer) thresholds, and nine used individualised thresholds. The reasons for using arbitrary thresholds related to a lack of previous data on academy players and a lack of staff time. Individualised thresholds were based on players' maximum velocity, fitness testing (including Maximal Aerobic Speed) and "a personalized acute:chronic ratio".

Communication of Results:

The method and frequency of communication of load data with key stakeholders is provided in Table 3. Face-to-face meetings were more common when communicating data to team managers/head coaches, whereas mobile apps/email/shared servers were more commonly used to communicate data to players. Whilst Team Managers/Head Coaches received this data predominately daily, players tended to receive it when deemed appropriate; however, there was variation among practitioners/clubs.

Influence of Load on Training:

There was a mixed response to how frequently training sessions are adjusted due to prior training/match load information. One of seventeen practitioners adjusted sessions every time. Five occasionally (~30% of sessions), four frequently (~70% of sessions), four sometimes (~50%), two usually (~90%), and one rarely (< 10%) adjusted sessions. Most practitioners (71%) adapted training sessions for each individual player based on their data, with the rest (29%) adapting sessions based on team data.

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Perceived Effectiveness & Barriers to Effectiveness:

Regarding how effective training monitoring can be, on average practitioners thought monitoring was somewhat effective at improving team (7 ± 1, range: 5-10) and individual (8 ± 2, range: 5-10) performance, and reducing injury rate (7 ± 2, range: 4-10). For perceptions of how effective training monitoring actually is, practitioners thought monitoring was less effective at improving team (5 ± 1, range: 4-7) and individual (5 ± 1, range: 3-7) performance, and reducing injury rate (5 ± 2, range: 2-7). No factor was seen as a big limiting factor to the effectiveness of load monitoring, although experience (3 ± 1, range: 1-5), lack of available facilities/equipment/expertise (3 ± 1, range: 1-5), lack of time/staff (3 ± 1, range: 2-5), coach understanding/buy-in (3 ± 1, range: 1-5) and the validity/reliability/sensitivity of field-based tests (3 ± 1, range: 1-4) were all viewed as somewhat limiting. Player preferences (2 ± 1, range: 1-3) and empirical evidence (2 ± 1, range: 1-3) were not viewed as limiting effectiveness.

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Discussion

The aim of this study was to assess the practices and perspectives of rugby league practitioners engaged in monitoring the physical demands of training. To our knowledge this is the first study to investigate the monitoring tools used and favoured by practitioners in high-performance rugby league. The main findings are: 1) most practitioners combine internal and external load measures to monitor training, but predominantly focus on running metrics; 2) monitoring is only deemed somewhat effective at enhancing performance and reducing injury rates; 3) training load was monitored less in some Championship teams compared to those in other competitions, which might be explained by discrepancies in resources (financial and staffing) and player availability.

Nearly all practitioners combined measures of external and internal load. This appears to be good practice, with combined measures reported to be more effective for predicting perception of effort in training[20] and estimating the training dose[14] compared to individual measures alone. Training loads were primarily monitored to enhance performance and fitness, reduce the risk of injury, and to plan and adjust training sessions. However, monitoring was only deemed somewhat effective at improving team performance (5 ± 1 on a scale of 1 to 10), individual performance (5 ± 1 on a scale of 1 to 10) and reducing injury rates (5 ± 2 on a scale of 1 to 10). This is unsurprising given the complex multifaceted nature performance and injury. Whilst no single factor was viewed as a large barrier to the effectiveness of monitoring load (Figure 3), there appears to be a discrepancy in the use of external load monitoring tools between practitioners working in the first and second tiers of the European rugby league system. All Super League practitioners used measures of external load, but only half of the practitioners responding from Championship teams used such measures. Two second-tier practitioners did not monitor internal or external load, citing a lack of funds and a lack of player contact. Both factors are likely, in part, due to the semi-professional structure of some Championship teams. In terms of monitoring injury risk, there is evidence of a relationship between injury rates and training load across several sports[21], however, a review by Impellizzeri *et al.*[22] concluded that changes in measured training load cannot predict injury risk. They highlighted flaws in common measurements of load, such as GPS measures, which do not indicate the amount of time spent in the gym and does not account for activity on days off, both of which would contribute to the overall training load. This conclusion is reflected in the response of a Championship team practitioner that did not measure load "We only see them once per week, the amount of training load that occurs outside of the club far exceeds inside, but it is quite hard to track accurately".

Most practitioners monitored external training load using time-motion analysis (e.g., GPS) and accelerometery. These are common tools in team sports[23] and have been frequently used in research to assess the physical demands of rugby league[8]. Practitioners considered running metrics (total distance, high speed running [≥ 5 m/s], , number of accelerations, and sprint distance and speed) to be the most useful load monitoring parameters. This partially aligns with research suggesting that rugby league is characterised by elements of high intensity running and collisions[24]. However, only two practitioners used data on collisions (in the form of tackles and carries made) and it's been suggested that external load measures based on running metrics alone could be inaccurate, as they do not account for tackle, kicking and jumping elements[25].

We found that most practitioners collect individual player data for each training session (n = 13) and that 71% of the practitioners adapt training sessions for individuals based on their load data, with the rest (29%) adapting sessions based on team data. Individualised load monitoring strategies appear to be an important consideration for coaches as a large magnitude of variability has been reported for total distance and high-speed running distance during competition between position groups[8], as well as within and between players[26]. When monitoring high speed running, considered the most useful metric by practitioners here, Lovell and Abt[27] recommended individualised speed thresholds should be used rather than an arbitrary approach. Our data shows that three practitioners did not use specific thresholds when interpreting and monitoring load, five used arbitrary (i.e., manufacturer) thresholds, and nine used individualised thresholds, suggesting that most practitioner activity is supported by research in this area. Practitioners that did not monitor individual data for each session cited a lack of GPS units for all players. This could explain why a lack of available facilities/equipment/expertise was viewed as a somewhat limiting factor to monitoring the effectiveness of training load. Rugby league teams with less financial resources might benefit from partnerships with local Universities to gain access to load monitoring technology, such as GPS systems and accelerometers, along with support from students and staff.

RPE the most frequently reported internal load measures in this study, perhaps due to its simple implementation. Heart-rate-derived training impulse (TRIMP) is also regularly cited alongside RPE as a valid measure of internal load (e.g.,[12, 28]), yet it was not reported as a monitoring tool by our respondents, despite several practitioners measuring heart rate for internal load. This suggests a preference for quick and simple measures of internal load, such as RPE, over more complex metrics, such as TRIMP.

Whilst these findings improve our understanding of the monitoring methods preferred and used by practitioners, several limitations should be acknowledged. Practitioners were aware of the survey topic beforehand, which could potentially bias the responses towards individuals that use research-based evidence in their practice. Further, due to difficulties in accessing practitioners, individuals working at academy and senior level were included and, although not considered here, differences in training requirements for academy and first-team players could have influenced some of the reported practices. We requested responses from practitioners with the greatest responsibility for load monitoring to better reflect the practices of each team, however, it is possible that some responses might not represent the systems wide approach of the club. Although most responses where from practitioners in roles related to strength and conditioning (S&C) and sport science, we also included responses from a physiotherapist and sports therapist. While this provides a broader sample of the load monitoring practices across rugby league, it could have introduced variation between responses based on role specific priorities. For example, physiotherapists might prioritise metrics related to reducing injury risk over improving performance, which might be prioritised by those in S&C and sport science roles.

Conclusions

Many of the training load monitoring practices reported here are supported by evidence from research. Objective and subjective measurement tools are predominantly combined to assess training, with running metrics most frequently reported as the preferred measure of exercise intensity. However, few practitioners considered collision elements when asked about the most useful load monitoring parameters, despite these elements being frequently reported in research on the demands of the sport[8]. When considering internal load, most practitioners appear to use tools that are quick and simple, such as RPE, over more complex metrics, such as TRIMP. There were some differences in load monitoring practises between competitions, with some teams in the Championship not monitoring load, or only monitoring internal load. This might be explained by discrepancies in financial resources and access to players. It is hoped that these findings will prompt researchers to work with practitioners when developing training load monitoring tools and practices, to maximise their application.

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