Performance Science Domains: Contemporary Strategies for Teams preparing for the Rugby World Cup

Abstract

Purpose: As the start of the 10th Rugby Union World Cup approaches performance staff will be working on the final elements of their team's preparation. Much of this planning and preparation will be underpinned by the latest performance science research. In this invited commentary we discuss contemporary performance science research in rugby union centered around four key performance domains. First, we outline a systematic approach to developing an overall understanding of the game demands, and how performance staff can enhance the players preparedness for competition. We then move on to outline our understanding of the training science domain, followed by a brief overview of effective recovery strategies at major tournaments. Finally, we outline research in the area of competition day strategies, and how they can positively impact players readiness to compete. **Conclusions:** Evaluating a teams preparation for and during the Rugby Union World cup can be achieved by mapping their performance plan based on the four domains outlined above.

Introduction

In September 2023 the 10th Rugby Union World Cup (RWC) starts in France with 20 teams aiming to peak over this 7-week tournament. The teams will likely have used the latest performance science research to optimally prepare their athletes for this demanding competition with both the tournament structure and game intensity placing signifcant physiological and psychological demands on the players. This commentary explores contemporary performance science research related to rugby union, while the focus of this commentary is on physiological strategies to optimise physical preparation for and during the RWC, we fully acknowledge that other aspects of performance like technical and tactical preparation also play a pivotal role. We evaluate four key performance science domains: competition demands, recovery, training science, and competition day strategies. To best prepare for the physical demands of the RWC, we need to first understand what the demands of competition and tournament structure are. Thereafter, design training sessions and blocks to ensure we meet (and exceed) these demands. Additionally, recovery from training and matches is essential during a tournament with the RWC. Finally, optimal match day preparations play an essential role in ensuring players are best prepared for competition.

Understanding Competition Demands

A good understanding of the competition demands of international rugby union forms the foundation for the other 3 performance domains. Once competition demands have been established coaches and performance staff can develop, implement and evaluate appropriate training blocks, recovery strategies, and competition day strategies to maximize performance.

The journey of understanding the movement demands of rugby union accelerated with the emergence and adoption of Global Positioning Systems (GPS). This work has given performance staff a much greater understanding of the movement demands and positional differences over the last 10 years.[1,2] Early work by Jones et al [1] reported positional and temporal patterns within rugby union, and demonstrated that inside and outside backs had the greatest high-speed running demands. However, repeated high-intensity efforts and contact demands were greatest in loose forwards. Temporal analysis revealed marked differences in player load, cruising and striding between the 1st and 2nd half, and reductions in accelerations and decelerations throughout each half.

Although early studies offered initial insights into the movement demands of rugby union, they were limited by primarily reporting aggregated game averages. Even when examining the temporal patterns, researchers used fixed periods (of time) to describe game demands. While this information was useful to indicate the overall loads experienced, reporting players' responses across a whole match does not accurately reflect the heightened demands associated with discrete phases within a match. Understanding the movement demands experienced during the most intense periods of play (i.e., 'worst-case scenario' (WCS)) informs the design of specific training programmes that better prepare players for decisive moments of a game. Cunningham et al[3] showed that fixed periods underestimated worst case scenarios by up to ~21%, compared with when rolling averages were employed. Pollard et al[4] further enhanced our understanding of movement demands by reporting the distance covered relative to the ball in play time, noting that whole match metrics were substantially lower. In addition, to characterising the movement demands of rugby union, it's also important to have a clear understanding of the contact demands within the game, as tis beyond the scope of the current commentary to cover this the reader is referred to the recent systematic review of Paul et al.[5]

Another key aspect of characterizing the game demands of rugby union is to understand the most meaningful performance indicators (PIs) that differentiate successful and unsuccessful match outcomes. Understanding the relationship between PIs and outcomes is of pragmatic use to coaches and support staff in rugby union, providing valuable information that influences tactics and training.

A model that predicted performance in the group phase of the 2015 RWC identified important and relevant PIs associated with match outcomes.[6] For the group-phase matches, tackle ratio, clean breaks and average carry were accurate standalone predictors of match outcome and respectively predicted 75%, 70%, and 73% of the match outcomes. In addition, this model based on the group-phase games predicted correctly the outcome of 7 from 8 (87.5%) of the subsequent knockout-phase matches. In the knockout-phase clean breaks predicted 7 from 8 outcomes, while tackle ratio and average carry predicted 6 from 8 outcomes. Clearly a combination of physical and technical predictors associated with winning should be the focus of coaches and support staff.

Once the performance indicators that differentiate successful and unsuccessful outcomes are established both technical and performance staff can develop ways of improving these elements. From a performance science perspective, one of the best ways of improving these performance indicators is to examine the physical attributes that underpin them. While the relationship between performance on physical tests and movement capabilities has been reasonably well established [7] , the link between physical qualities and game behaviours has had limited attention. A deeper insight into this critical aspect will inform coaching staff whose game plans and playing styles are influenced by prerequisites of physical and technical performance. Cunningham et al[8] investigated the relationship between various physical performance tests (including a comprehensive strength and power testing battery) and key PIs during elite international rugby union match-play. In the backs, the sled-drive test correlated with the number of carries (r = -0.751), effective attacking rucks (r = -0.584), number of dominant collisions (r = -0.792), and offloads (r = -0.814). Coaches can use this physical performance-focused information to improve key performance indicators, and thus match performance, of rugby union players.

The above process will be significantly enhanced through the integration of all key coaching personal, which will ensure a clear and effective plan between the performance and coaching staff.

Training Science

Once the WCS movement demands and key PIs of competition have been characterized the next key performance domain, training science, comes into play. There are several key areas within training science pertinent to preparing for and training at a RWC, namely responses to key training sessions, training session order, and ensuring training meets (and at times exceeds) the demands of competition. Understanding the team and individual physiological responses to key sessions drives our understanding of the adaptations to these sessions, the placement of these sessions within a training week, and subsequent recovery from these sessions.

Speed and acceleration are key game metrics. Johnston et al[9] examined the acute neuromuscular, biochemical, and endocrine responses to a maximal speed training session (6 maximal effort repetitions of 50 m running sprints with 5 minutes of recovery between each sprint). Neuromuscular performance displayed a bimodal recovery pattern in response to maximal speed training, with an initial impairment in performance after training. Performance recovered 2 hours post session, before undergoing a second decrease at 24 hours. It appears that periods longer than 24 hours are required to allow full neuromuscular recovery from maximal speed training.

Rugby players typically undertake training programs involving a combination of single multiple daily training sessions every week. For the player to adapt effectively to such a program, the loads must be sequenced in an order or spacing that facilitates recovery to a point where they can meet or exceed the requirements of the next training session. Two factors that potentially influence this requirement are the addition of a second training session on the same day, and the order in which the sessions are performed. [10,11]

The physiological basis of training adaptation in response to combination training (resistance and speed training) informs training prescription. The addition of a weight training session (4 sets of 5 back squats and Romanian deadlift at 85% 1RM) 2 hours after a speed session can enhance the neuromuscular, biochemical, and endocrine responses compared to a speed session alone performed in the morning.[10] Although there was an increase in the perception of fatigue the following day, the addition of a second session does not result in a marked difference in endocrine response or neuromuscular capability. More research and capturing of existing elite rugby knowledge in this area would be useful.

In terms of session order, Johnston et al[11] had rugby union players perform a weight training session followed 2 hours later by a speed training session and on a separate day reversed the order. The sequencing of strength and speed training does not appear to affect the neuromuscular, endocrine, and physiological recovery over 24 hours. In preparatory phases, it's common to program combination training (within a day), however, within competition phases coaches typically prescribe a single physical capacity (e.g. strength or power) and then a second session focused on the technical – tactical side of the game. Both research and practical experience have demonstrated the utility of small-sided games to mimic the competition demands.

A key requirement is detailing the responses to a rugby-specific training session, and how this session replicates (or exceeds) game movement demands. Greater total distance, low-intensity activity, maximal speed and meters per min were apparent in competitive matches compared to training for all playing positions.[12] Similarly, match heart rate, and session RPE responses were higher during competition compared to training. Substantial disparities were evident between the perceptual, physiological, and key skill demands of competitive matches versus training sessions in rugby union players. However, the WCS from the competition were not used, and consequently the actual disparity between training practice and games is likely much higher. More research is needed to assess the responses to technical and tactical sessions in Rugby Union, and the overall intensity of these sessions compared to the WCS in movement demands of games need to be determined.

Recovery

In international Rugby union, the physical demands of training, and the tournament schedule will place significant physiological and psychological stress on players. West et al.[13] demonstrated that both neuromuscular function and hormonal levels are disrupted until 60 hours post-match. During the RWC, teams will play 4 pool games followed by between 1-3 knockout games, with 4-6 days of recovery separating each game. Although currently there is no research examining the impact of a RWC schedule on recovery profiles, Johnston et al[13] reported neuromuscular function, perceptual well-being and blood CK increased in magnitude as a rugby league competition progressed. Large reductions in relative distance covered in high-speed running and maximal accelerations were reported during the final game. Moreover, psychosocial, sleep, and other elements of recovery also need addressing over longer campaigns as reported by Serpell et al. [15]

Out of the 4 performance domains covered in this Commentary, there are more research studies[16] devoted to recovery strategies in team sports compared with the other 3 domains. It is beyond the scope of this Commentary to cover the various recovery modalities in detail. Cold-water immersion and massage can promote recovery up to 72 hours post-match at a perceptive level.[17] However, there is a need for more high-quality research that identifies effective recovery strategies and effects on physiological and psychological readiness. Cook & Beavan[18] also showed the importance of individual perception and belief in the recovery strategies that also need to be researched in more depth.

Competition Day Strategies

Work focusing on the competition day strategies emerged first within other sports[19] but its relevance to Rugby Union became clear early on. Rugby Union has several windows of opportunity for performance staff to positively impact performance (e.g. time between completion of warm-up and the start of the competition, half-time) on competition day. Strategies can be employed on the day of competition to optimize performance, most notably passive heat maintenance and morning exercise.

During international rugby union, two primary heat loss windows are available on competition day: the time between the end of the pre-game warm-up and the start of the game (usually 15-20 min) and secondly, the half-time break (normally 15-20 min). During both heat loss windows, physical performance may decline, and players may also be at a heightened risk of injury due to a decrease in muscle temperature. Performance staff can optimize performance through the incorporation of passive heat management strategies that offset these declines in muscle temperature.

Some early work by Kilduff and colleagues[20] demonstrated that repeated sprint performance and lower body peak power output (PPO) were greater when wearing a passive heat maintenance garment during a 15-minute post-warm-up recovery period. Russell et al[21] reported that incorporating passive heat maintenance strategies attenuated the decline in core temperature, and improved subsequent peak power output and repeated sprint ability in professional Rugby Union players. Finally, Russell et al[22] evaluated a combined passive and active warm-up strategy during a half-time period. This combined approach to attenuating heat losses was most beneficial for core temperature and subsequent PPO and sprint performance in professional Rugby Union players. Two additional heat loss windows available during a game of rugby union involving substitutes and players who are sin-binned. It is possible that passive and active strategies would be effective in ensuring players are optimally prepared for entering the playing field.

Many rugby games are played in the late evening, and although sporting performance can be influenced by several intrinsic and extrinsic factors, the involvement of circadian rhythmicity in influences changes in performance occurring at different times of the day.[22] Testosterone (along with several other hormones) exhibits circadian rhythmicity and correlates positively with indices of athletic performance in elite athletic cohorts.[24] Moreover, pre-game testosterone concentrations have been implicated in match outcomes in professional rugby players. [25] However, testosterone typically displays an early morning peak before slowly declining across the waking day.

Offsetting the circadian decline could benefit sporting activities performed at times when testosterone concentrations have experienced a circadian decline, such as in the afternoon. One method proposed for offsetting this circadian decline in testosterone has been the use of a morning exercise "priming" session.[26,27] Cook et al.[26] reported that morning strength training improved countermovement jump peak power output, 40 m sprint times, 3RM bench and squat performance performed 6 h later, in rugby union players. Morning strength training could offset the circadian decline in testosterone, however it is unclear whether these hormonal changes are causal in the improvements in performance shown, or are simply a reflective marker. Russell et al[27] demonstrated that three different sessions (weights, repeated sprint cycling and an on-feet repeated sprint protocol) performed in the morning improved markers of afternoon performance, but running appeared the most beneficial to professional rugby union players. A rationale, therefore, exists for preceding afternoon competition with morning exercise. Collectively, these strategies offer performance staff an additional opportunity to ensure their teams are optimally prepared for competition.

Practical Application

Ensuring teams incorporate the lastest performance science research (both in the preparation and competition phase) is vital to overall success, therefore using the 4 domains outlined in this invited commentary will provide a suitable framework for this.

Conclusions

Success at the 10th RWC will be determined by a multitude of factors. Both research and hard-earned practical experience of coaches and support staff across the four performance domains in rugby union will form part of this success. A combination of observation, modelling and experimental studies will inform future developments in the physical preparation of players for international competitions.

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