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Article Title: Physical Preparation Recommendations for Elite Rugby Sevens Performance

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PHYSICAL PREPARATION RECOMMENDATIONS FOR ELITE RUGBY SEVENS PERFORMANCE

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Abstract

Rugby Sevens, a new Olympic sport, features high intensity intermittent running and contact efforts over short match durations, normally six times across two to three days in a tournament format. Elite Rugby Sevens seasons often include over a dozen competitive tournaments across less than nine months, demanding deliberate and careful training-stress balance and workload management alongside development of the necessary physical qualities required for competition. Focus on running and repeated power skills, strength, and match-specific conditioning capacities is advised. Partial taper approaches in combination with high velocity running (>5m/s from GPS measures) exposures before and between tournaments in succession may reduce injury rates and enhance performance. In a sport with substantial long-haul intercontinental travel and repetitive chronic load demands, management of logistics including nutrition and recovery is inclusive of the formula for success in the physical preparation of elite Rugby Sevens athletes.

Introduction

As of the XXXI Games in Rio de Janeiro, Sevens is the Olympic code in the sport of Rugby. As a new Olympic sport it is expected that global participation will surge beyond the 2015 mark of just under three million registered athletes to ten million by the 2020 Tokyo Games[1]. With skill levels rising across all levels to create parity of competition, physical preparation comes into focus in a sport with unique match and competition demands. The aims of this paper are to provide a detailed outline of current practice methods utilized by practitioners at the highest level of physical preparation in Rugby Sevens.

Competition Demands

Although played under essentially the same laws as fifteen-a-side Rugby Union, Rugby Sevens play consists of fourteen minute matches with seven players per side. The sport is normally played in a tournament format consisting of five to six games over the course of two to three days rather than one eighty minute match on a weekly basis. As of 2016, The World Rugby Sevens Series, consisting of ten tournaments for the men and six tournaments for the women played over the course of eight months, often paired across consecutive weeks, is widely considered the highest standard of Rugby Sevens competition in the world. Further standalone pinnacle events such as the Rugby Sevens World Cup, Commonwealth Games, and Olympic Games operate in four-year cycles and take place outside of the World Series season, requiring additional preparation and careful load management across the annual calendar.

As reported by an observational study of the 2013 Men's World Rugby Sevens Series, competitors cover nearly 1500 m per match, of which over 250 m are at high speed (> 5 $m \cdot s^{-1}$), with a mean peak velocity of over 8 $m \cdot s^{-1}$. On average players take 3.5±2.5 ball carries, 2.4±2.3

tackles, and 2.3±3.9 total rucks per match in Pool play, with no meaningful differences between Pool match-play and Cup matches [2].

Over 90% of ball-in-play sequences during Rugby Sevens matches last less than 60 seconds, with an average sequence of 28 seconds in Pool play and 33 seconds in Cup play, while 65% of recovery sequences are under 45 seconds, with an average sequence of 38 seconds in Pool play and 45 seconds in Cup play [3].

Across a wide range of variables, only trivial to small differences in physical match-actions have been found between backs and forwards, with forwards engaging in more contact situations and backs performing more high-speed movements, ball handles and passes. Forwards are typically slightly larger and stronger, perhaps due to set-piece requirements, than Backs although the differences are not as significant as in fifteen-a-side Rugby [4]. In specific cases such as a forward spending more time on the training pitch than a back in order to work on set-pieces or basic scrummaging, load demands dictate morphology, therefore nutrition should reflect this including increased caloric intake.

Players are commonly required to play a variety of positions during a single match, with the common exceptions of a scrum-half and a hooker. This data indicates that Rugby Sevens athletes should be trained for the same match demands, with adjustments for individual player plans based upon physical capacities such as force-velocity profiles and rugby skillsets.

Given the importance of between-tournament recovery in a World Rugby Sevens Series campaign, it is of note that Rugby Sevens team starters cover approximately 51% greater total distance and approximately 40% more total contact efforts over the course of a tournament than backs in one 80 minute 15-a-side Rugby Union match despite similar total playing duration[2]. Unique acute recovery scenarios in Rugby Sevens (typically) include two to three hours between matches in a given day, where glycolytic energy usage and acidosis have been observed in athletes post-match[5]. Therefore, total-tournament loads may be equally or perhaps more useful than single-match reports when monitoring and adjusting training loads.

With such a large variability in activity between matches and lack of clear positional differences, it is suggested that physical preparation of Rugby Sevens athletes should focus on the skillsets required and expected durations and intensities presented by the sport.

Programming

With up to to 12 international tournaments in a calendar year and the current format of competition in which tournaments are often grouped in pairs, periods in which larger in-season training loads than in team sports with continuous weekly competitions for consecutive months are possible. A separation between three to six week periods of preparation and high training loads and competition periods are detailed and delineated in the sections below. Given competition load and schedule variability across years and genders, annual planning varies greatly.

The structure of any typical training week should allow for effective development and application of running skills and capacities, strength and power, injury prevention, aerobic and anaerobic conditioning, and tactical/technical components within the program. Primary responsibility of physical preparation programs are to ensure the players spend as much time as possible practicing their sport, equipped with the physical capacities to play their sport in the style desired by the head coach. Although Rugby Sevens players are exceptional athletes in many areas of physical ability, it is presumed that few could perform at an elite level in any single physical quality. This suggests a need for a highly specific yet well-rounded program which compliments the area of desired expertise: Rugby Sevens. The physical preparation program should provide the athlete with maximum opportunity to apply and express their abilities on the rugby pitch. Given squad size, travel and varying individual player plans, as well as specific requests of the rugby coach, creativity and an agile, solutions-based approach are necessary for collective success.

Anecdotally, athletes with habitually high running volume outputs may struggle to perform on three consecutive days; therefore training load management can follow a pattern of two days with higher loads followed by a day with a lower load. Equally, two-to-three-day competitions must be managed very deliberately to ensure adequate recovery for final matches. With varying effective preparation time between certain events and greater recovery demands intuitively occurring after tournaments in consecutive weeks (WT2, Figure 3), both acute and chronic loads must be deliberately accounted for in order to prepare each athlete not only for individual matches or tournaments but to be robust through an entire season. Finally, as Rugby Sevens is a running sport, proficiency in running skills are essential both for individual match-action successes and for economical energy expenditure, subsequent maximum performance late in matches and in latter matches of competitions [6–8].

Therefore the aims and priorities of a physical preparation coach in Rugby Sevens are to produce and maintain athletes who are:

1) Healthy and robust with as few injuries as possible
2) Capable of performing the basic physical demands of the sport
3) Able to complete the physical tasks required for the coaches desired style of play
4) Prepared to excel in worst-case scenarios presented during match-play

Planning an effective weekly program:

Program efficacy is largely dependent on synergy between the physical preparation coach and the head coach, working together to complement one another's desired programming. A physical preparation program will only be effective if there is cohesion with the rugby program[9].

In a sport with common "training camps" leading up to competitions, especially within decentralized programs, days with multiple rugby sessions must be monitored carefully to avoid contraindicative spikes in training load.

Management of players and coaches expectations with respect to the training process can be conducive to positive training culture. While stress is required in order to initiate adaptations to subsequently enhance performance, careful periodization and deliberate communication with rugby coaches around training approach decisions is essential for coherent team preparation. – Sometimes fatigue and therefore capacity building is priority, whereas other times, readiness to perform is desired. Furthermore, it is postulated that communication of such decisions and logic with the players themselves may enhance adherence. Rating of perceived exertion (the simple modified 1-10 RPE scale) can be used as a clear and simple way of planning session intensities and reflect retrospectively on the training process [10].

A successfully implemented physical preparation program features clear and deliberate delineations between the aims of the training phase, training stress balance, and readiness to play when the time comes. Furthermore, individual player plans are addressed while building capacities to be able to perform in the sport at the coaches demands in a robust manner with as few injuries as possible.

Strength and Conditioning

Given that stronger athletes have a lower risk of injury [11,12], a primary avenue of injury prevention and preparation for the physical demands of Rugby Sevens is well-developed strength qualities[13]. Lower body strength may also protect against the fatigue-induced reductions in tackling skill which occur during repeated efforts [14]. In a preseason or midseason preparation phase, blocks of strength oriented work may be programmed as detailed below using intensity descriptors.

Training should be individualized to meet individual player plans and contribute to required skillsets such as scrummaging and line-out work at the direction of the Rugby Sevens coaching staff.

Given other training demands both on and off the rugby pitch, it is essential to avoid excessive neuromuscular fatigue resulting from strength and power training. Achievement of desired stimuli for physical development must complement the rugby programme via careful structure of training. Weeks featuring a deliberately reduced load or "deload" can ensure an element of recovery in the training schedule, made even more effective if applied in combination with reduced running load, possibly leading to opportunity for higher outputs both on-field and in the gym the following week. These recommendations and dynamics may be more relevant in well-trained groups. Developmental athletes may not require deload cycles as often due to natural caution taken when programming for such populations and therefore less chronic training stress than their more experienced counterparts. Typically for the primary training group, one-week deload periods every four weeks of programming can allow for flexibility to account for injuries and other factors while retaining total and aggregate training load and gains within set training periods. In conjunction with any training schedule, desired adaptations are achieved when a significant and sufficiently high chronic training load is achieved[15,16].

Exercise selection and segmentation is at full discretion of the physical preparation coach and will not be covered in detail in this paper. It is advised that an effective stimulus, rather than exercise or body parts, be the focus of programming aims for any given training week. Given the growing body of literature on the minimum effective dose required for strength adaptations, spontaneous modifications to the physical preparation program can occur frequently[17,18]. In these instances it is important that exercise modifications retain the original desired stimulus.

In a preparation phase, four strength-oriented sessions are highly feasible, so programming three sessions within four weekly windows of opportunity to execute the sessions can ensure necessary work is achieved at a high rate of compliance. With the below-detailed biases an athlete who only manages to complete two weightlifting sessions per week still reaches substantial volume for both upper and lower body segments.

Desired stimulus must be a consideration behind all exercise selections, whether motor learning and skill acquisition, strength or power development, or strength-endurance in any given session or program block. As with any physical preparation program, Olympic lifting derivatives can be greatly beneficial provided that the teaching and learning cost does not outweigh the stimulus benefit, so return on investment must be considered. Where the motor learning of triple-extension is intended, in many cases an Olympic lift may not be ideal in favour of a jump squat. While the protective element of strength training is also highly conducive to power development, strength should be a focus of preparatory phases where running and rugby loads are relatively low as compared to competition phases when strength development opportunities diminish and power development and transfer of training to rugby skills become higher and more feasible priorities.

Rugby Sevens requires exceptional levels of fitness, including well-developed aerobic capacity which can provide the basis from which a player can express all of their other physical qualities. As speed, power, strength and anaerobic qualities all diminish in output as a result of repeated efforts without adequate recovery time, a well-developed aerobic base may minimise these required recovery times and can contribute to repeatability of such capacities[19]. A recent examination of Gaelic footballers demonstrated that athletes with a relatively high aerobic capacity display lower injury during speed activities and spikes in training load[16]. Given these findings, aerobic development should form a large basis of off season preparation phase work. A logical progression throughout a season is to progress from extensive aerobic work to intensive anaerobic work, whilst consistently matching and exceeding maximal loading scenarios which players may encounter during gameplay.

Beyond this early-stage basic aerobic work, a majority of conditioning of Rugby Sevens athletes should orient closely around the duration demands of the sport as detailed above. Repeated sprint-efforts and small-sided-games are two effective examples of running-based conditioning which can be tailored to mimic play sequences found in Rugby Sevens matches. Further off-feet conditioning options such as rowing, cycling and swimming exist as alternative options to condition athletes without a foot-strike exacerbation load.

There is a growing notion that athletes with greater levels of strength tolerate intense physical activity with lower decreases in strength and power [11,20]. Maintenance of muscle mass within the travel and competition demands of elite Rugby Sevens is a challenge commonly encountered by physical preparation coaches. Muscle loss has been observed in as little as 5 days disuse[5], so strategies to mitigate this should be implemented to avoid otherwise unnecessary hypertrophy blocks during preparatory phases. Additionally, inhibitory systems which could be elevated during travel and competition periods should also be a consideration for the physical preparation coach[21]. Unpublished data from the authors in a World Series male cohort suggest that athletes self-report increased muscle soreness on day two of competition if a tournament is preceded by 7 days or more without any exposure to heavy loaded resistance training.

Speed and Power

Maximal effort running

While field sports spend a dominant proportion of match-time running at submaximal speeds, actions which determine outcomes of matches nearly always include sprints of maximum effort[22,23]. Therefore, training maximal effort and velocity sprinting skills are highly conducive to success in Rugby Sevens. While a faster player would hypothetically cover ground more economically at proportionately lower running speeds and therefore conserve energy, the ultimate aspiration may be an athlete who possesses both outstanding absolute sprinting and repeated sprint abilities [24,25].

To develop sprinting ability, outright maximal-effort sprints must firstly occur at a high velocity with sufficient horizontal power expression to withstand tackle efforts by opponents in the course of a carry or else to successfully tackle an attacking opponent arriving at the point of contact with great momentum. Therefore, it is essential to program the training of maximal effort sprints in isolation as separate stimuli from fatigue-based capacities. Horizontal force application is a determining factor of sprinting at both accelerative and maximal-velocity distances, and such qualities can be monitored simply and trained specifically [26,27]. Chronic accrued volume of sprinting within a training program can improve tolerance to running loads which can benefit the athletes overall physical preparation [16]. Furthermore, the separation of the various sprinting skills in the form of linear, multidirectional unplanned and planned agility as well as accelerative and maximum velocity actions can be beneficial for optimization of both learning pedagogies and physiological adaptations. With such dynamics of decision making, reactions and ball carrying, successful integration of sprinting skills with rugby training can enhance scope and volume opportunities for the physical preparation coach as well as ensure maximum possible transfer of training effects. High speed running abilities may be acutely inhibited by long-haul travel and such factors should be taken into consideration for activities immediately post-travel[4].

International Rugby Sevens players have been observed to run an average of 1452 +/- 243 meters per match, with an average of 252 +/- 103 meters accumulated at or above 5 $m \cdot s^{-1}$[28], and international level women at an average of 1556 +/- 189 meters per match. With an average of 141 +/- 53 meters accumulated at or above 5 $m \cdot s^{-1}$ at average maximal velocities of 7.9 +/- 0.8 $m \cdot s^{-1}$ (male forwards) and 8.4 +/- 0.7 $m \cdot s^{-1}$ (male backs), and 6.8 +/- 0.6 $m \cdot s^{-1}$ (female forwards and backs) respectively, high speed running is viewed as a prevalent action in the sport[29,30]. Elite international men complete an average of 7.5 +/- 1.6 sprints above 5.5 $m \cdot s^{-1}$ (Forwards and Backs) over an average of 19 +/- 7 meters[29], with women completing an average of 5.3 +/- 1.6 sprints above 5.5 $m \cdot s^{-1}$ (Forwards and Backs) over an average of 17 +/- 9 meters[31]. Given further observations of moderate to high correlations between 10-meter sprint time, 40-meter sprint time, 10-meter momentum, and defenders beaten (r=-0.41, r=-0.50, and r=0.30) and line breaks (r=-0.47, r=-0.51, and r=0.32), sprinting can be viewed as an essential and requisite skill for Rugby Sevens performance. Average velocity, number of sprints, and distance covered while sprinting are all variables which have been shown to differentiate between amateur and national level Rugby Sevens players [30]. While sub-maximal efforts make up a vast majority of running achieved in a Rugby Sevens match, there remains a distinct need for players to be able to complete rapid acceleration and repeated high velocity actions for impactful match outcomes [32,33].

Finally, in evaluating 196 Rugby Sevens matches, Higham et al (2014) stated the following in relation to the style of play most associated with winning (pg. 363)[13]:

"The associations of performance indicators with points scoring and probability of winning suggest higher-scoring and more-successful teams tend to control possession of the ball and play a patient, disciplined and evasive style of game. A less disciplined and more direct approach, characterized by conceding more penalties and free kicks and performing more rucks and mauls, gives the opposition greater opportunity to gain ball possession and is associated with lower scores."

Thus, it is not only acceleration and maximal velocity that are important to Rugby Sevens, but also the ability to evade defenders through the effective use of agility. While not explicitly evaluated within a cohort of Rugby Sevens players, multiple studies have shown that reactive agility (i.e., changing direction in response to a stimulus) performance can differentiate between elite and sub-elite level rugby league players [34,35]. This provides further evidence that all elements of speed (i.e., acceleration, maximal velocity sprinting, and reactive agility) contribute to success in the various codes of rugby.

From a training perspective, chronic accrued volume of sprinting within a training program can improve tolerance to running loads which can benefit the athletes overall physical preparation [16], while the authors postulate that frequent exposure to velocities equal or greater to those achieved during a match can greatly reduce risk of running-related injuries such as hamstring tears. However, coaches are required to identify if practice conditions are adequate to develop and maintain these qualities or if additional training time dedicated to the development of speed and agility is required. For example, while practice may provide a maximal velocity stimulus, the stimulus may be inconsistent and/or inadequate in intensity and volume to encourage significant increases in speed, especially over the course of a competitive phase [36]. Further, sprinting within the context of practice is not likely to support definitive changes in running efficiency, as sprinting within rugby is a means to and end rather than the end itself. Thus, if coaches seek to improve speed, then time needs to be dedicated to linear speed (i.e., acceleration and maximal velocity) and/or multidirectional speed (i.e., planned and unplanned agility) development within the weekly structure. Specifically, to improve speed over 0-20 meters, coaches are encouraged to have athletes perform 6-12 full speed efforts over 15-20 meters over the course of 1-2 training sessions lasting no longer than 45-minutes. Moreover, to improve speed over 20-meters, coaches are encouraged to have athletes perform 3-6 full speed efforts over 20-50 meters over the course of 1-2 training sessions lasting no longer than 45-minutes. Note that drill work and sub-maximal sprint efforts would be included within the 45-minutes to bolster the development of coordinative capacity for both acceleration (0-20 meters) and maximal velocity sprinting (>20 meters). Methodologically, both free sprinting and resisted sprinting have been shown to significantly improve speed from 0-20 meters and >20 meters to a far greater extent than resistance training and plyometric training alone [37]. Thus, when prioritising time for the weight room and time on the pitch, if speed development is the goal, the development of strength and power cannot be seen as a substitution for full speed sprint efforts.

Finally, research has shown that the primary mechanical determinant of acceleration is the ability to maximize horizontal force production [26,38,39], while maximal velocity sprinting has been associated with the capacity to generate higher vertical forces during the first half of ground contact[4041]. It has been demonstrated that acceleration and maximal velocity sprinting, while highly correlated with one another, are underpinned by different mechanical factors [26]. Specific to agility, evidence suggests that a players' dominant cutting leg (i.e., preferred kicking leg) and non-dominant cutting leg could be correlated with relative lower body strength (r=-0.52 and r=-0.56) and average maximal velocity sprint speed (r=-0.63 and r=-0.52)[26]. Furthermore, relative strength and power have been shown to correlate with 10-meter sprint times[42] and is also associated with sprint momentum, which has been shown to differentiate between elite and sub-elite rugby players

[43]. Thus, a comprehensive training program should seek to develop high levels of relative strength and power, while programming for multidirectional and linear speed based on the loads being achieved in the context of practice and the individual player's need to improve coordinative capacities and/or performance outcomes.

Repeat power ability

In addition to high and moderate speed running demands, Rugby Sevens involves repeated high intensity actions including accelerations, decelerations, changes of direction and importantly the contact elements of game play. These actions can occur at multiple times within a 30 second period and can occur up to 45 times in a game; of substantial importance is that these actions come at a high physiological cost [29,44,45]. A significant decrease in the number of these repeated high intensity actions have been shown to occur in the second half of games[29], reflective of the accumulation of fatigue and the inability to sustain high intensity actions throughout a match[7]. Enhancing repeated power ability (RPA) in seven's players may provide a performance advantage with regards to repeated high intensity efforts (RHIE). This suggestion comes in light of poor indications within the literature of the relationships between both aerobic capacity and repeated sprint ability with RHIE [46]. A need for emphasized specificity exists when training capacities for repeatability of high intensity sporting actions.

To avoid excessive running loads in the physical preparation for rugby sevens, high volume power training (HVPT) may be used to build capacity for repeated bouts of high intensity work. HVPT consists of volumes of work much greater than those used in the traditional training of maximal power (≤ 5 sets of 1-6 repetitions [47,48]). Exercises in such protocols are typically ballistic in nature, such as squat jumps and Olympic lifting derivatives and moderate loads of between 30-50% 1RM are commonly used. The total repetitions used per session have been found to range from as low as 50 up to 600 repetitions with repetitions per set generally ranging from 10 to 16 [49,50]. The use of cluster sets, where brief inter-set recovery is provided, can also be prescribed to assist in the maintenance of maximal power [51,52]. These methods have been shown to improve measures of RPA and other sporting tasks involving repeated high intensity performance such as repeated jump performance, repeated change of direction and repeated sprint ability. Importantly, HVPT has also been shown to enhance maximal power output and therefore offer a training modality whereby maximal power and RPA can be enhanced simultaneously [53,54]. There is some evidence that upper-body muscular endurance is a significant correlative factor for RHIE performance, in particular repeated tackling[46]. However, Gabbett & Wheeler [55] found estimated aerobic power to be a poor indicator of RHIE performance; this is important when considering training specificity for the development of RPA and the inclusion of HVPT in preparatory programmes.

Based on the current body of literature and the applied cases, one of three below-detailed potential HVPT progressions can be used to develop RPA and physically prepare Seven's players for the repeated high intensity efforts experienced in a game (Table 1.). As seen in Figure 5, it is suggested that progressions B and C are used more during pre-season or when longer preparatory phases between tournaments occur, while Progression A is considered appropriate for use within 3-5 days of competition in order to maintain RPA with lower levels of fatigue. Elite team sport athletes may need higher volumes of work than sub-elites, having been observed achieving the re-attainment of maximal power between sets, less fatigue within sets and no further accumulation of fatigue between sets (Figure 4. unpublished data).

Athlete Load Monitoring and Injury Prevention

Given the unique duration and frequency of international Rugby Sevens competitions, management of player fatigue is crucial both for maintaining team performance and limiting injuries at four time scales: the season, the stage, the tournament, the competition day.

To date, the relationship between training load, injury, and performance has not been investigated in Rugby Sevens. However, all practitioners involved in Rugby Sevens (e.g. coaches, physiotherapists, and physical preparation staff) are interested in identifying the optimum amount of training to elicit specific performance levels. This training “dose-response” relationship is analogous to pharmacological studies where chemists wish to understand the positive and negative effects of a particular drug. Sport scientists understand that physically hard training is required in order to prepare athletes for the demands of competition, but are also aware that excessive loading can result in increased injury risk.

Early research reported a positive relationship between training load and injury, suggesting that the harder athletes train the more injuries they are likely to sustain [56,57]. Furthermore, greater amounts of high-speed running have been associated with greater lower-body, soft-tissue injury risk [58,59], while reductions in training load resulted in fewer injuries and greater improvements in aerobic fitness[60]. However, in more recent times, a significant body of evidence has emerged to demonstrate that high chronic training loads may protect athletes against injury [57,61–63]. Collectively, these results suggest that training load might best be described as the “vehicle” which drives athletes towards *or away from* injury[64].

Several studies have demonstrated the protective effect of high training loads [16,61,65]; athletes from a wide range of sports experience a lower risk of injury when their chronic training loads are high. Importantly, the best predictor of injury was the size of the current week’s training load (termed *acute training load*) in relation to the chronic training load. This has been termed the "*acute:chronic workload ratio*" (also previously referred to as "training-stress balance") [57]. When the acute:chronic workload ratio was within the range of 0.8 to 1.3 (i.e. the acute training load was approximately equal to the chronic training load), the risk of injury was relatively low. However, when the acute:chronic workload ratio ≥1.5 (i.e. the acute training load was much greater than chronic training load), the risk of injury increased exponentially [66]. The protective effect of training appears to arise from two sources: (1) exposure to "load" allows the body to tolerate "load", and (2) training develops the physical qualities (e.g. strength, prolonged high-intensity running ability, and aerobic fitness) that are associated with a reduced injury risk [16,62,63].

Although "spikes" in training load may contribute to injuries, undertraining and "troughs" in training load may elicit similar negative consequences. For example, a "U"-shaped relationship between the number of maximal velocity exposures and injury risk has been shown in team sport athletes; both over-*and under-training* increased injury likelihood [16,67]. The risk sometimes associated with exposure to maximal velocity running is mitigated through exposure to high chronic training loads [16,68,69].

These results have three important practical implications; (1) high chronic training loads may protect against injury, (2) athletes are better able to tolerate the high-intensity components of training and competition if they have been exposed to higher chronic training loads, and (3) the acute:chronic workload ratio is a more closely associated with injury than either acute or chronic load in isolation. As such, to adequately prepare Rugby Sevens players for match-play, physical preparation coaches should aim to safely develop high chronic training loads, using the acute:chronic workload ratio to guide increases and decreases in load.

Physical preparation coaches will likely benefit from a combination of both objective and subjective data encompassing physiological wellness, neuromuscular status, fluctuations in body mass and athlete ratings of their recovery and readiness to train. Unpublished data in a male World Sevens Series cohort shows that indices of exercise heart rate recover at a different rate to peak velocity on a vertical jump and at different rates depending on the length and direction of travel demonstrating the need for multifaceted monitoring systems to encompass these different biological systems. The value of subjective data has been strongly demonstrated; therefore it is recommended that this is also a central component of monitoring an athlete's readiness to train [10]. Due to the nature of long haul travel, the physical preparation coach may also benefit from utilising measures of mobility such as a sit and reach or knee to wall tests on a daily basis. With all monitoring practices, in order to give them context it is important to compare an athlete to their individual normative data. It is recommended that these tests be scheduled into the weekly training out-of-competition periods to establish baseline data and meaningful changes.

Tournament Preparation

Within the current format of competition, a balance must be struck between the high loads required to develop physical capacity [57] and instigation of peak performances on the day of competition [70,71]. The challenge of consecutive competition days separated by a six-day week featuring international travel across multiple times zones is relatively unique in sport and must be deliberately addressed in order to maximize results of a physical preparation program. It can be expected that athletes will suffer from disrupted sleep (length and quality), other jet lag symptoms, hormonal disruptions, alterations in markers of muscle damage and a short term decrease in performance [72]. Physical preparation coaches should consider their travel schedules and attempt to begin the travel process with adjustments in sleep prior to departure along with ensuring that travel hygiene and nutritional quality is maintained. A taper (a period of reduced training volume to enhance performance) [75,73], is *one* such method which can be utilized in the buildup to tournaments. Based on the data presented by Mujika and Bosquet, the following practical implications for optimum tapering strategies can be drawn[70,71]:

1. Maintenance of training intensity to avoid detraining
2. Reductions in training volume as high as 30-60%
3. Use of a period lasting 4-28 days

Decreasing training load by ~30% during taper weeks via a reduction in the duration and frequency of training while maintaining intensity can increase performance in high-intensity activities among field sport athletes [74]. Figure 7 details load variations before and between two successive IRB World Series tournaments among an elite, Olympic-qualified team during the 2015/2016 season.

Data were collected from 9 players (age: 27.2±5.2 years; body mass: 90.0±11.5; height: 182.8±8.5 cm) who participated in all ten (seven rugby, three power) training sessions during the observed period. The first week, termed "week of preparation" WP preceded that just prior to and between the two tournaments (WT1 and WT2, respectively). Figure 6 details sample programming across three such weeks, while Table 1 and 2 shows training loads observed during the three weeks, as calculated by the sum of the Session Rating of Perceived Exertion (sRPE, session duration multiplied by RPE) for all training sessions performed per week [10]. The data demonstrate effective reduction of the training load between the last week of preparation (WP) and the week before the first tournament (WT1) alongside a total duration of training (min) and sRPE decrease of 34±0% and 36±9%, respectively (table 1). The total distance and consequently the distance covered at low and high intensities were also significantly reduced in WT1 (table 2). Because of reduced movement on the field during the training sessions in WT1, the observations of fewer sprints during this week were predictable. However, with the ratio between the number of sprints and the rugby duration of the week, players actually performed more sprints per minute in WT1 than WP. High intensity distance (HID) in WT1 were slightly reduced (-2.6±8.9 %), perhaps due to lower duration of match-simulation sequences undertaken during tactical rugby sessions. In order to retain a high number of explosive moments, physical preparation coaches can add short, high-intensity running drills to the end of warm ups during sessions occurring in these tournament preparation weeks. In summary, the week before the first tournament (WT1) in a pair can be distinguished by a significant reduction of volume (duration, sRPE and distance) with intensity maintained via repeated high-intensity running drills.

A second consecutive weekly instance of international travel shapes the training load between paired tournaments (WT2). Recent research [75] indicated that a single Sevens tournament reduces the neuromuscular function such that players are not fully recovered to baselines by the start of the second competition stage. During this period, emphasis should be placed on enhancing recovery strategies. Total training loads are reduced in WT2 as compared to both WP and WT1 in part due to a reduction in number of sessions completed, with only one additional sequence of maximal power (Table 1 and 2). A progressive reduction within the week for the total and high intensity distance covered is common (Figure 2, Table 3).

Common among team sports are a “captains run” or ritual session in the day before (or last hours before) the start of a competition. These sessions are often termed as “preloading” consisting of small-sided games and repeated sprints, though it has been observed [76] that no significant benefits were observed on a soccer-specific endurance test performed 4 hours after such a session. Therefore, further work on this topic is warranted in order to determine the effect and role of different types of sessions immediately prior to competitions in order to optimize match-play preparation. Alternative to the above-described taper is a "high-low-high" approach, which may also be successful. Unpublished data from the authors indicates reduced intra-tournament muscle soreness resulting from such an approach in a male World Series cohort, compared to a traditional taper. Often included in both approaches is a scrimmage or "scratch match" early in tournament weeks, featuring light-contact simulated play typically against a team not in the same tournament pool. Such sessions should be included as any other in external and internal load monitoring and management processes. While an overall reduction in load during the lead-up to competition in some form is almost certainly beneficial, mitigation of the acute impact of live matches on the body via small exposures of specific stimuli (i.e. high velocity sprints) in the day or days prior to competition is advisable. Physical preparation coaches must also use trial and error to determine the most appropriate approach to prepare their athletes for tournaments.

Preparation for travel with respect to maintaining training adaptations is emphasized in WP, recovery from travel with reduction in training volume alongside maintenance (or slight increase) of intensity features in WT1, while focus turns largely to neuromuscular recovery of the athletes in WT2. "Captains runs", or sessions programmed in the immediate 4 to 24 hours prior to commencement of competition, may impact positively (or potentially negatively) on performance, however are case-specific, with the potential benefits unclear at this time. Research on these commonly performed "captain's runs" and "blow out" sessions in the hours before competition is needed to inform practitioners.

Match-day Nutrition and Recovery

Careful and deliberate athlete management across two or three days must be achieved if a full roster of athletes is to be fit and available for a sixth and final tournament match where honors are at stake. A significant fatigue-induced decrease in physical performance and increase in physiological load occurs in the second half of games compared to the first half, potentially explaining the higher incidence of injury both late in individual games and over the course of tournaments [77,78]. On the World Sevens Series, intervals from one game to the next are typically between two and three hours. Coaches and medical staff must implement efficient strategies throughout and between the competition days in order to minimize injuries and maximize game to game performance.

Post-match priorities include parasympathetic system activation, rehydration and nutrient replenishment, and soft tissue care via a variety of methods. A typical example of recovery and game preparation protocols between two Rugby Sevens games, although highly dependent on resources, feasibility and athlete individualization is described below:

- **Step 0 - Postgame Debriefing**: A very short game debriefing (2-min) is given by the head coach directly on the pitch.
- **Step 1 - Rehydration and Refueling**: Replenishment of muscle glycogen and repairing of muscle tissue damage incurred from the physical demands of Rugby Sevens (repeated high-intensity running, sprinting, accelerations/decelerations, collisions) can be initiated by consuming 1-1.5g carbohydrate.kg^{-1} in addition to 20-25g of protein within 30 min of the game. The consumption of 150% of sweat losses in fluid during the recovery phase can effectively rehydrate an athlete, especially in hot conditions [79]. In all cases, within these broad guidelines, it is recommended that personal preferences be recognized and palatability and osmolality of food and beverages consumed be prioritized to avoid gastric distress.

- **Step 2 – Cold and Contrast Water Immersion**: Despite conflicted literature, contrast water immersion has been shown to be an effective strategy to enhance recovery after high intensity exercise by controlling hyperthermia, reducing muscle inflammation and damage and decreasing muscle soreness [80]. While cold water immersion is a highly individual preference and may offer primarily a placebo effect, where available and desired by the athlete [81] a protocol of whole-body immersion lasting at least 10 minutes (max.: 20 min) at a temperature of 12 to 15°C immediately after the game may be effective [82].
- **Step 3- Soft Tissue Care:** Given that many athletes present post-match with minor injuries, soft tissue care protocols are an important part of preparation for subsequent games in a tournament. Massage is resource-dependent, while simple inversion of legs vertically up a wall or on a chair can be a cheap and effective way of redirecting fluid from the lower extremities [83]. Foam rollers and self-massage balls are commonly used as well and are recommended for potential range of motion and blood flow benefits once the above time-sensitive priorities have been addressed. Recent literature has detailed potentially beneficial effects of compression garments for recovery of muscle function, muscle soreness and blood markers of muscle damage [84,85], so the use of these materials could be utilized by athletes between games.
- **Step 4 – Pre-Game Snack:** While feeding remains a highly individual preference and response, in an effort to continue (re)fueling it is recommended to consume a carbohydrate-rich meal no later than 1 hour before each game. Carbohydrate-rich foods and drink may help to ensure that fuel targets are met before subsequent exercise bouts (1-1.2 g/kg/hour) [86], while food density and fiber and fat portions must be considered with gastric comfort as a priority. Caffeine ingestion (1-3 mg.kg^{-1}, equivalent to about 2-3 espressos for a Rugby

Sevens player one hour prior games) can be utilized as an ergogenic aid [87], although caution must be taken over a 2-3-day tournament concerning the deleterious effects of repeated dosing of caffeine, with quality sleep between competition days prioritized [88,89].

- **Step 5 – Brief Nap (optional):** Time permitting, brief (15-20 min) naps between games may improve both cognitive and motor performance [90]. Caffeine consumption immediately prior to the nap may lessen the phenomenon of sleep inertia after waking [91].
- **Step 6 – Repeat Soft Tissue Care**
- **Step 7 – Pre Game Briefing**
- **Step 8 – Warm-up**

Summary

Elite Rugby Sevens performance requires skilled high velocity running, repeated power application, and exceptional levels of conditioning expressed over fifteen minutes from the first whistle of a match to the last, normally six times across two or three days, often in consecutive weeks. Careful and deliberate management of load and athlete health across periods of high load and acute competition preparation can mitigate injuries and maximize performance. Safe achievement of high chronic training loads can create robust athletes able to withstand the high acute loads achieved during competition periods. Where feasible, physical preparation coaches in elite Rugby Sevens are advised to apply the above best-practice examples within their own programs, prioritizing basic modalities while recognizing the highly individual nature of responses to physical performance methodologies.

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Figure 1: A sample Rugby Sevens weekly training schedule

Monday (medium)	**Tuesday (hard)**	**Wednesday (low)**	**Thursday (very hard)**	**Friday (low-medium)**	**Saturday (low)**	**Sunday (rest)**
Monitoring	Monitoring	Remote Monitoring	Monitoring	Monitoring	Remote Monitoring	Remote Monitoring
Physical Prep (mobility/activations)	Physical Prep (mobility/activations)	Soft Tissue Active Recovery Pool Sessions Low Level Aerobic Work	Physical Prep (mobility/activations)	Physical Prep (mobility/activations)	Active recovery Top Ups or additional training components	
Speed (acceleration bias)	Rugby – Hard		Speed (max velocity biased)	Rugby – low/medium		
Gym (Lower Bias)		Rest	Gym (Whole Body Bias)			
Rugby - Medium	Gym (Upper Bias + Posterior Chain)		Rugby - Hard	Gym (circuits/extras)		

Figure 2: A sample monthly strength training scheme for elite rugby sevens athletes

Week	Intensity	Sets x Reps
Week1	Medium	4x5
Week2	Hard	4x4
Week3	De-load	2-3x 3-4
Week4	Very Hard	5x2

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Figure 3: Sample weekly exercise selection for elite rugby sevens athletes

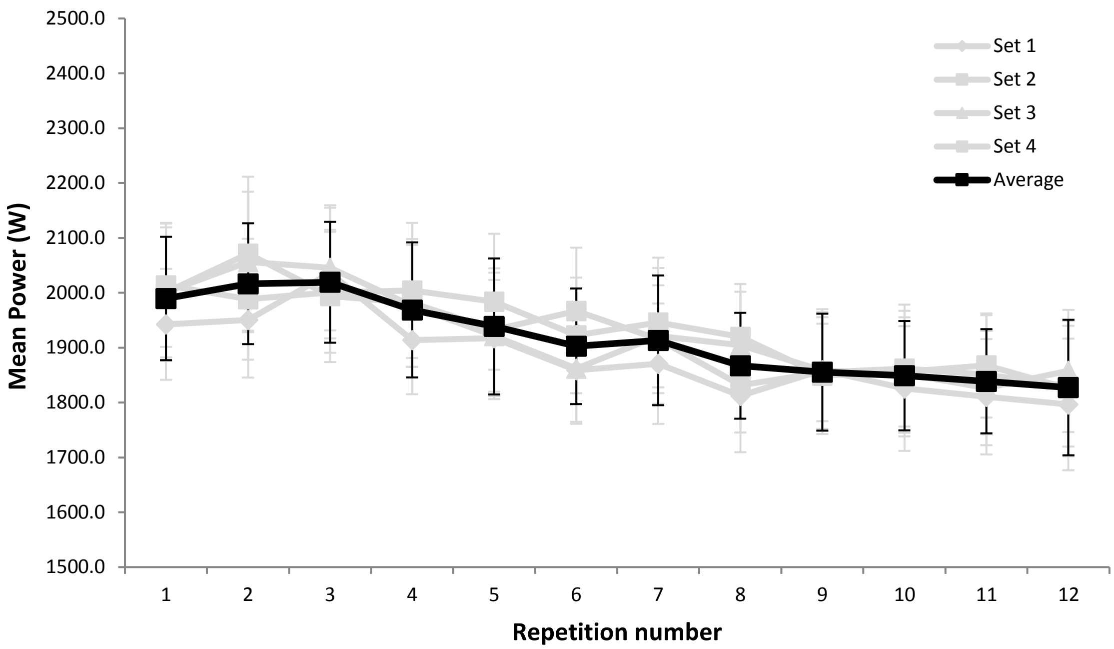
Session 1		**Session 2**		**Session 3**	
Lower Body Bias		**Upper Body Bias**		**Whole body Bias**	
A1 Back Squat	4x5	A1 Bench Press A2 Wtd Pull Ups	4x5 4x5	A1 BB Step Ups	4x5e/s
B1 SL Hip Thruster **B2 OH Push Ancillary**	4x8e/s 3x10-12	B1 RDL	4x5	B1 BB Push Press B2 Ancillary Chest	4x5 3x10-12
C1 Lateral Slideboard **C2 DB walking Lunges**	4x8e/s 3x8e/s	C1 DB Seated Shoulder Press C2 Ancillary Row	4x5 3x10-12	C1 Ancillary LB (goblet) C2 Ancillary Row	3x10 3x10-12

LB=Lower Body, UB=Upper Body, BB=Barbell, DB=Dumbbell

RDL=Romanian Deadlift, OH=Overhead, SL=Single Leg, Wtd = Weighted

A1=First super set, first exercise, A2=First super set, first exercise etc

Figure 4: Power decrement across a repeated Countermovement Jump test in elite youth athletes



Repetition x repetition mean power output for 4 sets of 12 Countermovement Jumps with a 30% 1RM load (*n* = 12)

Figure 5: Sample repeated-power-training progressions for elite Rugby Sevens athletes.

Progression	Number of series (no.)	Number of sets (no.)	Number of repetitions (no.)	Within-Set Rest/Clusters (s rest/no. repetitions)	Inter-set Rest (s)
A	1	4	15	5 s rest/5 rep Cluster	120
B	2	4	12	n/a	60
C	3	4	10	n/a	30

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Figure 6. Weekly programming of the international Rugby Sevens team before and between two tournaments.

WP

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Resistance Strength & power	**Resistance** Strength & power		**Resistance** Strength & power		**Travel**	
Rugby tact	**Rugby tech & tact**		**Rugby tact & Lactic** (aer. game)			**Rugby tech and tact**
HIT cycle					**Active recovery** Swimming pool	
Recovery	*Recovery*		*Recovery*			*Recovery*

W T1

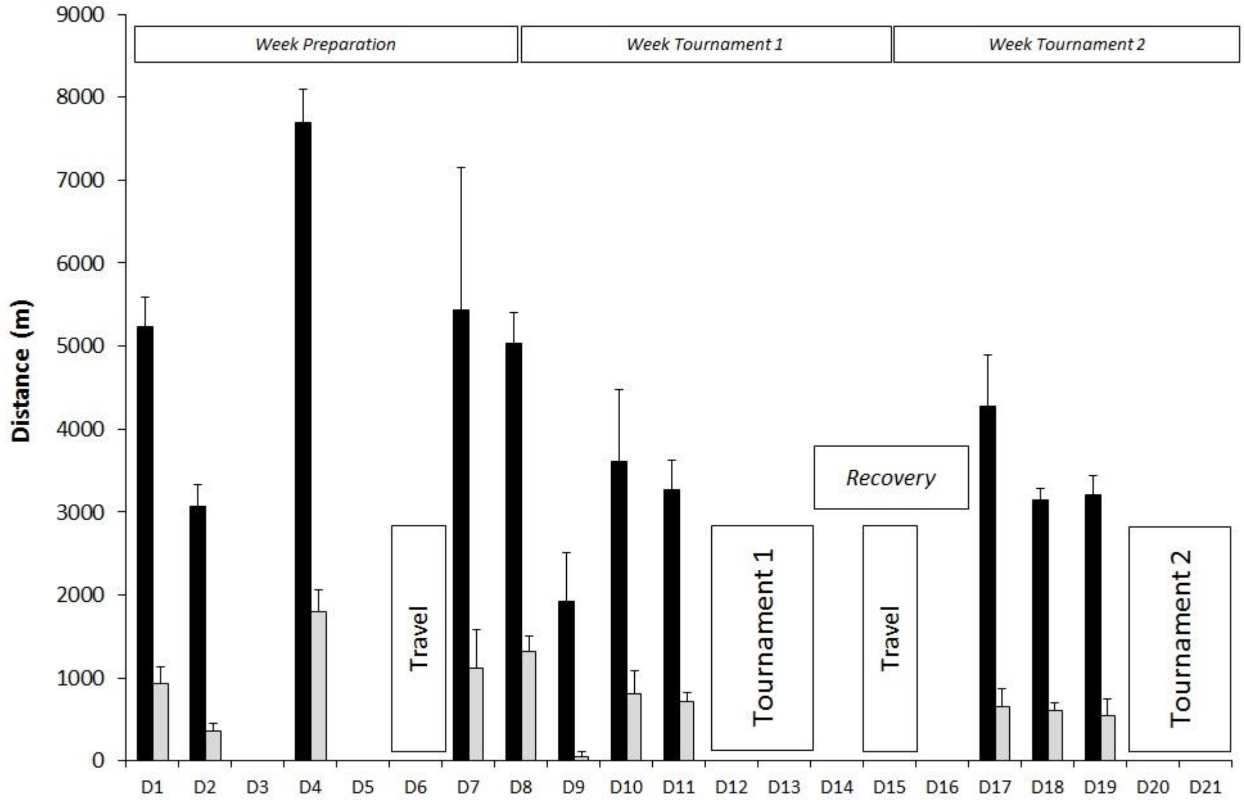
Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Resistance Strength & power	**Rugby tech**	**Rugby tact**	**Rugby tact**	**Match 1**	**Match 1**	*Recovery*
	Recovery		*Recovery*			
Rugby tact & lact		**Resistance** Explosivity/Power		**Match 2**	**Match 2**	
Recovery		*Recovery*		**Match 3**	**Match 3**	

W T2

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Travel		**Rugby**	**Rugby**	**Rugby**	**Match 1**	**Match 1**
		Recovery	*Recovery*	*Recovery*		
Active recovery Swimming pool	**Active recovery** Cycle and elliptic		**Resistance** Explosivity/Power		**Match 2**	**Match 2**
					Match 3	**Match 3**

WP: one week before the first tournament, W T1: one week before the first tournament, W T2: one week before the second tournament. Tech=technique, Tac=tactical, Aer=aerobic, HIT=high intensity training

Figure 7. Variation of daily distance covered before and between two Rugby Sevens tournaments.



Black bars: distance total, grey bars: high speed distance (>5 m·s^{-1}).

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Figure 8: Between-game recovery strategies during Rugby Sevens tournament

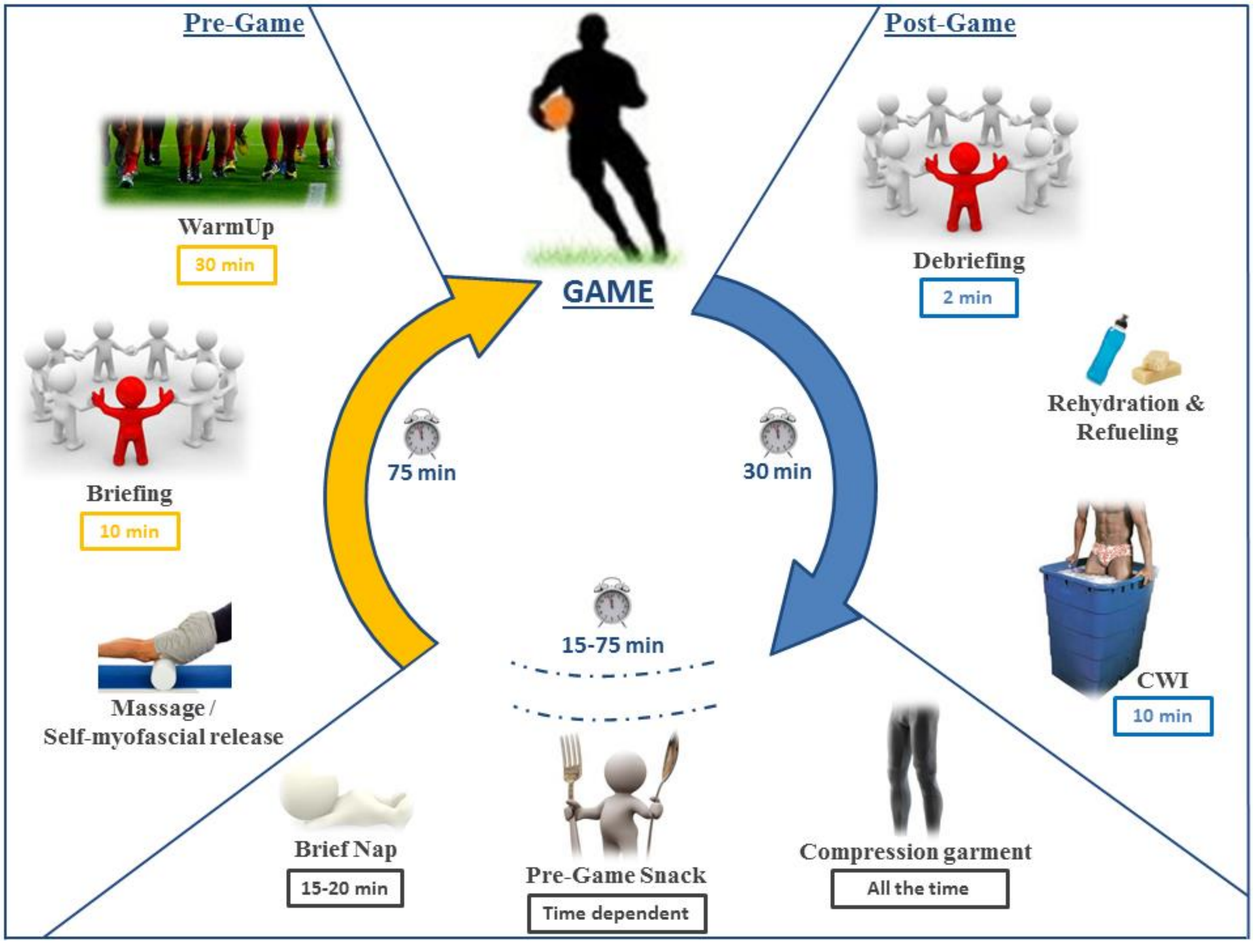

Table 1: Duration, frequency and training load before and between two Rugby Sevens tournaments

	Pool Mean ± SD	Cup Mean ± SD	ES ± 90% CL
Locomotor Demands	*N=78*	*N=58*	
Total Distance (m)	1446±299	1423±285	-0.012±0.25
High-Speed Running (m)	254±123	246±117	-0.094±0.96
Maximal Velocity (m/s)	8.1±0.7	8.2±0.8	0.067±0.27
Match Activities	*N=199*	*N=207*	
Ball Carries	3.5±2.5	3.8±2.6	0.047±0.15
Total Rucks Attended	2.3±3.9	3.2±3.5	0.07±0.12
Tackles	2.4±2.3	2.7±2.5	0.12±0.14
Notes: N=number of data files. High-Speed Running = >5m/s; ES= effect size, CL= confidence limits			

From Ross et al [28]

Table 2: Duration, frequency and training load before and between two Rugby Sevens tournaments

	WP	W T1	W T2	% Change WP to W T1	% Change W T1 to W T2	% Change WP to WT 2
Total training (min)	530	350	260	-34%	-26%	-51%
Rugby (min)	350	250	160	-29%	-36%	-54%
HIT (min)	60			-100%		-100%
Strength/power (min)	120	100	40	-17%	-60%	-67%
Active recovery (min)			60		100%	100%
Frequency training (n)	8	6	5	-25%	-16.7%	-27.5%
sRPE (u.a.)	2935±496	1865±287	1269±284	-36±9%	-33±7%	-57±6%

RPE: rate of perceived exertion. sRPE (u.a.)=RPE×duration (min), WP=Week of Preparation, WT1=Week of Tournament 1, WT2=Week of Tournament 2

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Table 3: Mean values (±SD) of the physical training activity the weeks before and between two Rugby Sevens tournaments

	WP	W T1	W T2	Change WP to W T1	Change W T1 to W T2	Change WP to WT 2
Total distance (m)	23885 ± 952	13620 ± 1462	10634 ± 865	-43,0 ± 5,2	-21,5 ± 7,1	-55,5 ± 3,0
Sprints (n)	200 ± 35	171 ± 28	111 ± 28	-13,8 ± 8,2	-35,3 ± 13,3	-44,8 ± 7,9
Sprints (n/min)	0,57 ± 0,10	0,68 ± 0,11	0,70 ± 0,18	20,8 ± 11,4	1,1 ± 20,8	20,7 ± 17,4
LID (m)	18655 ± 457	10718 ± 1027	8809 ± 650	-42,6 ± 5,2	-17,2 ± 9,6	-52,8 ± 3,6
% LID	78,2 ± 2,1	78,8 ± 2,0	82,9 ± 3,0	0,8 ± 2,5	5,2 ± 3,2	6,1 ± 2,4
HID (m)	5230 ± 698	2901 ± 505	1825 ± 418	-44,4 ± 7,5	-37,2 ± 7,3	-65,4 ± 4,6
% HID	21,8 ± 2,1	21,2 ± 2,0	17,1 ± 3,0	-2,6 ± 8,9	-19,5 ± 11,5	-22,1 ± 9,5

WP: one week before the first tournament, W T1: one week before the first tournament, W T2: one week before the second tournament. LID: low intensity distance, HID: high intensity distance.