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Human Kinetics
BRIEF REVIEW

Physical-Preparation Recommendations for Elite Rugby Sevens Performance

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Rugby sevens, a sport new to the Olympics, features high-intensity intermittent running and contact efforts over short match durations, normally 6 times across 2 to 3 d in a tournament format. Elite rugby sevens seasons often include over a dozen competitive tournaments over less than 9 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-speed running (>5 m/s from GPS measures) 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.

Q1 ***Keywords:*** Olympics, exercise performance

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 3 million registered athletes to 10 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 used by practitioners at the highest level of physical preparation in rugby sevens.

Competition Demands

Although played under essentially the same laws as 15-a-side rugby union, rugby sevens consists of 14-minute matches with 7 players per side. The sport is normally played in a tournament format consisting of 5 or 6 games over the course of 2 to 3 days rather than one 80-minute match on a weekly basis. As of 2016, the World Rugby Sevens Series, consisting of 10 tournaments for the men and 6 tournaments for the women played over the course of 8 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 4-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/s), with a mean peak velocity of over 8 m/s. 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 15-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, so 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. Data indicate that rugby sevens athletes should be trained for the same match demands, with adjustments for individual player plans based on physical capacities such as force–velocity profiles and rugby skill sets.

Given the importance of between-tournaments 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 2 to 3 hours between matches in a given day, where glycolytic energy use and acidosis have been observed in athletes postmatch.[5] Therefore, total-tournament loads may be equally or perhaps more useful than single-match reports when monitoring and adjusting training loads.

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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 skill sets required and expected durations and intensities presented by the sport.

Programming

With up 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 3- to 6-week periods of preparation and high training loads and competition periods is detailed and delineated in the sections that follow. 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. The primary responsibility of physical-preparation programs is to ensure that 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 that compliments the area of desired expertise: rugby sevens. The physical-preparation program should provide athletes 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 3 consecutive days; therefore, training-load management can follow a pattern of 2 days with higher loads followed by a day with a lower load. Equally, 2- to 3-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 (Tables 1A and 1B), both acute and chronic loads must be deliberately accounted for in order to prepare each athlete not only for individual matches or tournaments but also to be robust through an entire season. Finally, as rugby sevens is a running sport, proficiency in running skills is 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 healthy and robust with as few injuries as possible, capable of performing the basic physical demands of the sport, able to complete the physical tasks required for the coaches desired style of play, and 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 in 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 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 are priorities, whereas other

Table 1A Rugby Sevens Weekly Training Schedule—Preparation Block

Monday (medium)	Tuesday (hard)	Wednesday (low)	Thursday (very hard)	Friday (low–medium)	Saturday (low)	Sunday (rest)
Monitoring	Monitoring	Monitoring at home	Monitoring	Monitoring	Monitoring at home	Monitoring at home
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	Rest
Morning Training						
Speed (acceleration bias)	Rugby, hard		Speed (velocity bias)	Rugby, low/medium (additional conditioning as required)		
Gym (lower-body strength bias)		Rest	Gym (whole-body bias)			
Afternoon Training						
Rugby, medium	Gym (upper bias + posterior chain)		Rugby, medium	Gym (circuits/extras)		

Table 1B Rugby Sevens Weekly Training Schedule—Precompetition Block

Monday (medium)	Tuesday (hard)	Wednesday (low)	Thursday (very hard)	Friday (low–medium)	Saturday (competition)	Sunday (competition)
Monitoring	Monitoring	Remote monitoring	Monitoring	Monitoring	Monitoring	Monitoring
Physical prep (mobility/activations)	Physical prep (mobility/ activations)	Physical prep (mobility/activations)		Physical prep (mobility/ activations)		
Morning Training						
Gym (whole-body strength and power)	Rugby, medium (including speed/agility work)	Gym (whole-body power biased)	Rest day and soft-tissue work	Rugby, low volume, medium intensity	Activation session (3 h before 1st game)	Activation session (3 h before 1st game)
Afternoon Training						
Recovery session, optional/own time	Recovery session, optional/own time	Rugby, high intensity and low volume; *nonnegotiable recovery—hydrotherapy and cryotherapy*		*Nonnegotiable recovery—individual athlete choices*	Match routines and recovery	Match routines and recovery

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 that occur during repeated efforts.[14] In a preseason or midseason preparation phase, blocks of strength-oriented work may be programmed as detailed following using intensity descriptors. Training should be individualized to meet individual player plans and contribute to required skill sets 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 program 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. Developing athletes may not require deload cycles as often due to natural caution taken when programming for such populations and therefore their having less chronic training stress than their more experienced counterparts. Typically for the primary training group, 1-week deload periods every 4 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 the full discretion of the physical-preparation coach and will not be covered in detail in this article. 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, 4 strength-oriented sessions are highly feasible, so programming 3 sessions within 4 weekly windows of opportunity to execute the sessions can ensure that necessary work is achieved at a high rate of compliance. With the following detailed biases, an athlete who only manages to complete 2 weight-lifting 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 it be 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 favor 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 compared with 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 that can provide the basis from which a player can express all of his 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 minimize 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 rates 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, while consistently matching and exceeding maximal loading scenarios that players may encounter during game play.

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. Repeated-sprint efforts and small-sided games are effective examples of running-based conditioning that can be tailored to mimic play sequences found in rugby sevens matches. Further off-feet conditioning options such as rowing, cycling, and swimming are 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 with 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 that could be elevated during travel and competition periods should also be a consideration for the physical-preparation coach.[21] Unpublished data from our group in a World Series male cohort suggest that athletes self-report increased muscle soreness on day 2 of competition if a tournament is preceded by 7 days or more without any exposure to heavy loaded resistance training. See Tables 2 and 3 and Figure 1 for sample weekly training schedule, exercise selection, and prescription schemes from a medal-winning team at the Rio Olympics.

Table 2 Typical Block Approach to Strength-Training Development

Week	Intensity	Sets × reps
1	Medium	4 × 5
2	Hard	4 × 4
3	Deload	2–3 × 2–3 (same intensity as wk 2)
4	Very hard	5 × 2

Speed and Power

Maximal-Effort Running

While field-sport athletes spend a dominant proportion of match time running at submaximal speeds, actions that determine match outcomes nearly always include sprints of maximum effort.[22,23] Therefore, training maximal effort and velocity sprinting skills is 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 first 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 in a training program can improve tolerance to running loads that 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 posttravel.[4]

International rugby sevens players have been observed to run an average of 1452 ± 243 m/match, with an average of 252 ± 103 m accumulated at or above 5 m/s,[2] and international-level women at an average of 1556 ± 189 m/match. With an average of 141 ± 53 m accumulated at or above 5 m/s at average maximal velocities of 7.9 ± 0.8 m/s (male forwards), 8.4 ± 0.7 m/s (male backs), and 6.8 ± 0.6 m/s (female forwards and backs), high-speed running is viewed as a prevalent action in the sport.[28,29] Elite international men complete an average of 7.5 ± 1.6 sprints above 5.5 m/s (forwards and backs) over an average of 19 ± 7 m,[28] with women completing an average of 5.3 ± 1.6 sprints above 5.5 m/s (forwards and backs) over an average of 17 ± 9 m.[30] Given further observations of

Table 3 Sample Weekly Exercise Selection for Elite Rugby Sevens Athletes

Session 1, lower-body bias		Session 2, upper-body bias		Session 3, whole-body bias	
A1 back squat	4 × 5	A1 bench press	4 × 5	A1 barbell step-ups	4 × 5 e/s
		A2 pull-ups	4 × 5		
B1 single-leg hip thruster	4 × 8 e/s	B1 Romanian deadlift	4 × 5	B1 barbell push press	4 × 5
B2 overhead push ancillary	3 × 10–12			B2 ancillary chest	3 × 10–12
C1 lateral slide board	4 × 8 e/s	C1 dumbbell seated shoulder press	4 × 5	C1 ancillary lower body	3 × 10
C2 dumbbell walking lunges	3 × 8 e/s	C2 ancillary row	3 × 10–12	C2 ancillary row	3 × 10–12

Key: A1, first super set, first exercise; A2, first super set, first exercise, etc.

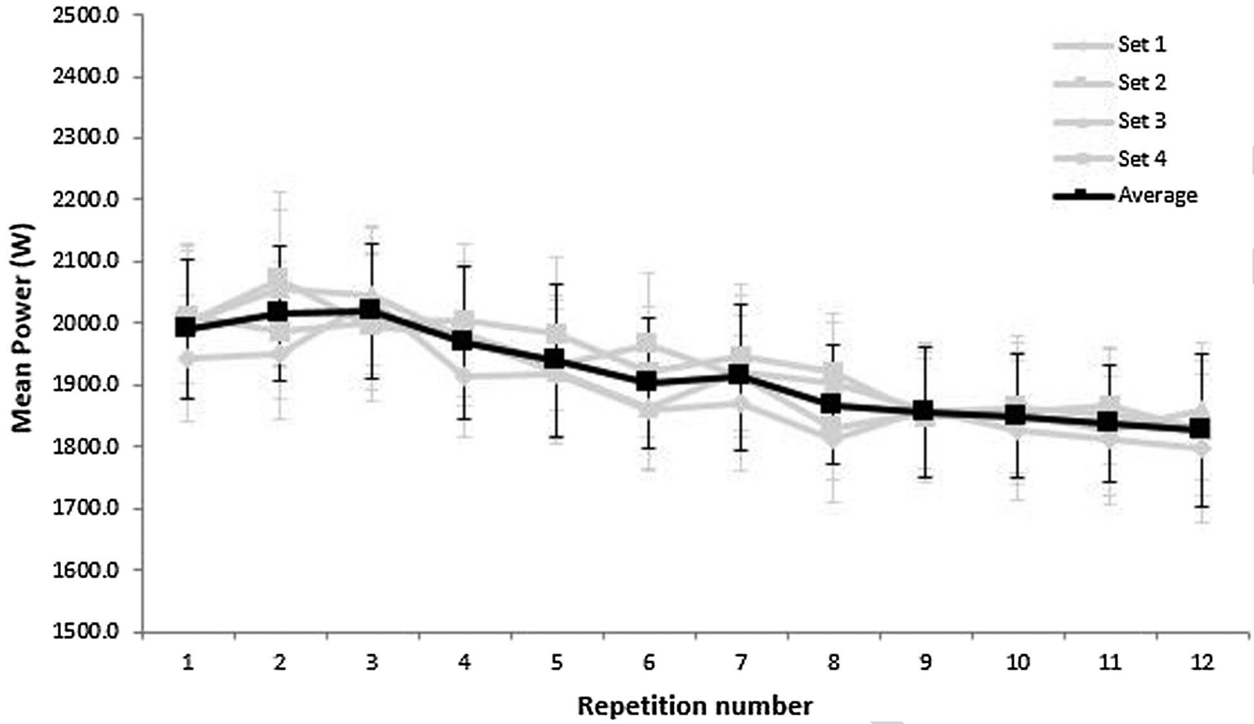

Figure 1 — Power decrement across a repeated countermovement-jump test in elite youth athletes. Repetition × repetition mean power output for 4 sets of 12 countermovement jumps with a 30% 1-repetition-maximum load (n = 12).

moderate to high correlations between 10-m-sprint time, 40-m-sprint time, 10-m momentum, and defenders beaten ($r = -.41$, $r = -.50$, and $r = .30$) and line breaks ($r = -.47$, $r = -.51$, and $r = .32$), 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 that have been shown to differentiate between amateur and national-level rugby sevens players.[29] While submaximal 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.[19,31]

Finally, in evaluating 196 rugby sevens matches, Higham et al stated the following in relation to the style of play most associated with winning[13(p363)]:

> 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 this has not been explicitly evaluated in a cohort of rugby sevens players, multiple studies have shown that reactive-agility (ie, changing direction in response to a stimulus) performance can differentiate between elite- and subelite-level rugby league players.[32,33] This provides further evidence that all elements of speed (ie, 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 in a training program can improve tolerance to running loads, which can benefit the athletes' overall physical preparation,[16] while we postulate that frequent exposure to velocities equal to or greater than those achieved during a match can greatly reduce the risk of running-related injuries such as hamstring tears. However, coaches are required to determine 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.[34] Furthermore, sprinting in the context of practice is not likely to support definitive changes in running efficiency, as sprinting in rugby is a means to and end rather than the end itself. Thus, if coaches seek to improve speed, time needs to be dedicated to linear-speed (ie, acceleration and maximal velocity) and/or multidirectional-speed (ie, planned and unplanned agility) development in the weekly structure. Specifically, to improve speed over 0 to 20 m, coaches are encouraged to have athletes perform 6 to 12 full-speed efforts over 15 to 20 m over the course of 1 or 2 training sessions lasting no longer than 45 minutes. Moreover, to improve speed over 20 m, coaches are encouraged to have athletes perform 3 to 6 full-speed efforts over 20 to 50 m over the course of 1 or 2 training sessions lasting no longer than 45 minutes. Note that drill work and submaximal sprint efforts would be included in the 45 minutes to bolster the development of coordinative capacity for both acceleration (0–20 m) and maximal-velocity sprinting (>20 m). Methodologically, both free and resisted sprinting have been shown to significantly improve speed from 0 to 20 m and >20 m to a far greater extent than resistance training and plyometric training alone.[35] Thus, when prioritizing 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,[26,36,37] while maximal-velocity sprinting has been associated with the capacity to generate higher vertical forces during the first half of ground contact.[38,39] 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 player's dominant cutting leg (ie, preferred kicking leg) and nondominant cutting leg could be correlated with relative lower-body strength ($r = -.52$ and $r = -.56$) and average maximal-velocity sprint speed ($r = -.63$ and $r = -.52$).[26] Furthermore, relative strength and power have been shown to correlate with 10-m-sprint times,[40] and they are also associated with sprint momentum, which has been shown to differentiate between elite and subelite rugby players.[41] 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, notably, the contact elements of game play. These actions can occur at multiple times in a 30-second period and up to 45 times in a game; of substantial importance is that these actions come at a high physiological cost.[28,42,43] A significant decrease in the number of these repeated high-intensity actions has been shown to occur in the second half of games,[28] reflective of the accumulation of fatigue and the inability to sustain high-intensity actions throughout a match.[7] Enhancing repeated-power ability (RPA) in sevens players may provide a performance advantage with regard to repeated high-intensity efforts (RHIE). This suggestion comes in light of poor indications in the literature of the relationships of both aerobic capacity and repeated-sprint ability with RHIE.[44] 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[45,46]). Exercises in such protocols are typically ballistic in nature, such as squat jumps and Olympic lifting derivatives, and moderate loads of 30% to 50% of 1-repetition maximum are commonly used. The total repetitions used per session have been found to range from as low as 50 to as much as 600 repetitions, with repetitions per set generally ranging from 10 to 16.[47,48] The use of cluster sets, where brief interset recovery is provided, can also be prescribed to assist in the maintenance of maximal power.[49,50] 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. 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.[50,51] There is some evidence that upper-body muscle endurance is a significant correlative factor for RHIE performance, in particular repeated tackling.[44] However, Gabbett and Wheeler[44] 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 programs.

Based on the current body of literature and the applied cases, 1 of 3 potential HVPT progressions we detail can be used to develop RPA and physically prepare sevens players for the repeated high-intensity efforts experienced in a game (Table 4). As seen in Table 5, we suggest that progressions B and C be used more during preseason or when longer preparatory phases between tournaments occur, while progression A is considered appropriate for use within 3 to 5 days of competition to maintain RPA with lower levels of fatigue. Elite team-sport athletes may need higher volumes of work than subelites, having been observed to achieve reattainment of maximal power between sets, less fatigue within sets, and no further accumulation of fatigue between sets (Figure 1, 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 for both maintaining team performance and limiting injuries at 4 time scales: the season, the stage, the tournament, and the day of competition.

To date, the relationship between training load, injury, and performance has not been investigated in rugby sevens. However, all practitioners involved in rugby sevens (eg, coaches, physiotherapists, and physical-preparation staff) are interested in identifying the optimal 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 to prepare athletes for the demands of competition but are also aware that excessive loading can result in increased injury risk.

Table 4 Duration, Frequency, and Training Load Before and Between 2 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[a] (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

Source: Ross et al.[2] Q5

Abbreviations: CL, confidence limits; ES, effect size; n, number of data files.

[a] ≥5 m/s.

Table 5 Sample Repeated-Power-Training Progressions for Elite Rugby Sevens Athletes

Progression	No. of series	No. of sets	No. of repetitions	Within-set rest/clusters (s rest/no. repetitions)	Interset 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

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.[52,53] Furthermore, greater amounts of high-speed running have been associated with greater risk of lower-body soft-tissue injury,[20,54] while reductions in training load resulted in fewer injuries and greater improvements in aerobic fitness.[55] However, in more recent times, a significant body of evidence has emerged to demonstrate that high chronic training loads may protect athletes against injury.[53,56–58] Collectively, these results suggest that training load might best be described as the "vehicle" that drives athletes toward or away from injury.[59]

Several studies have demonstrated the protective effect of high training loads[16,56,60]; athletes from a wide range of sports experience a lower risk of injury when their chronic training loads are high. Note that 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).[53] When the acute:chronic workload ratio was within the range of 0.8 to 1.3 (ie, 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 was greater than or equal to 1.5 (ie, the acute training load was much greater than chronic training load), the risk of injury increased exponentially.[61] The protective effect of training appears to arise from 2 sources: Exposure to load allows the body to tolerate load, and training develops the physical qualities (eg, strength, prolonged high-intensity-running ability, and aerobic fitness) associated with reduced injury risk.[16,57,58]

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 overtraining and undertraining increased injury likelihood.[16,62] The risk sometimes associated with exposure to maximal-velocity running is mitigated through exposure to high chronic training loads.[16,63,64]

These results have 3 important practical implications: High chronic training loads may protect against injury, 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 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 show that indices of exercise heart-rate recover at a different rate from 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 we recommend that this also be 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 using measures of mobility such as 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 athletes with their individual normative data. We recommend that these tests be scheduled into the weekly training out-of-competition periods to establish baseline data and meaningful changes.

Tournament Preparation

In the current format of competition, a balance must be struck between the high loads required to develop physical capacity[53] and instigation of peak performances on the day of competition.[65,66] The challenge of consecutive competition days separated by a 6-day week featuring international travel across multiple times zones is relatively unique in sport and must be deliberately addressed 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.[67] 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 are maintained. A taper (a period of reduced training volume to enhance performance)[68,69] is one such method that can be used in the build-up to tournaments. Based on the data presented by Mujika and Bosquet, the following practical implications for optimal tapering strategies can be drawn[65,66]: maintenance of training intensity to avoid detraining, reductions in training volume as high as 30% to 60%, and use of a period lasting 4 to 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 in field-sport athletes.[70] Figure 2 details load variations before and between 2 successive IRB World Series tournaments in an elite, Olympic-qualified team during the 2015–16 season. Data were collected from 9 players (age 27.2 ± 5.2 y, body mass 90.0 ± 11.5, height 182.8 ± 8.5 cm) who participated in all 10 (7 rugby, 3 power) training sessions during the observed period. The first week, termed the week of preparation (WP), preceded the week just prior to and between the 2 tournaments (WT1 and WT2, respectively). Table 6 details sample programming across 3 such weeks, while Tables 1 and 7 show training loads observed during the 3 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 WP and

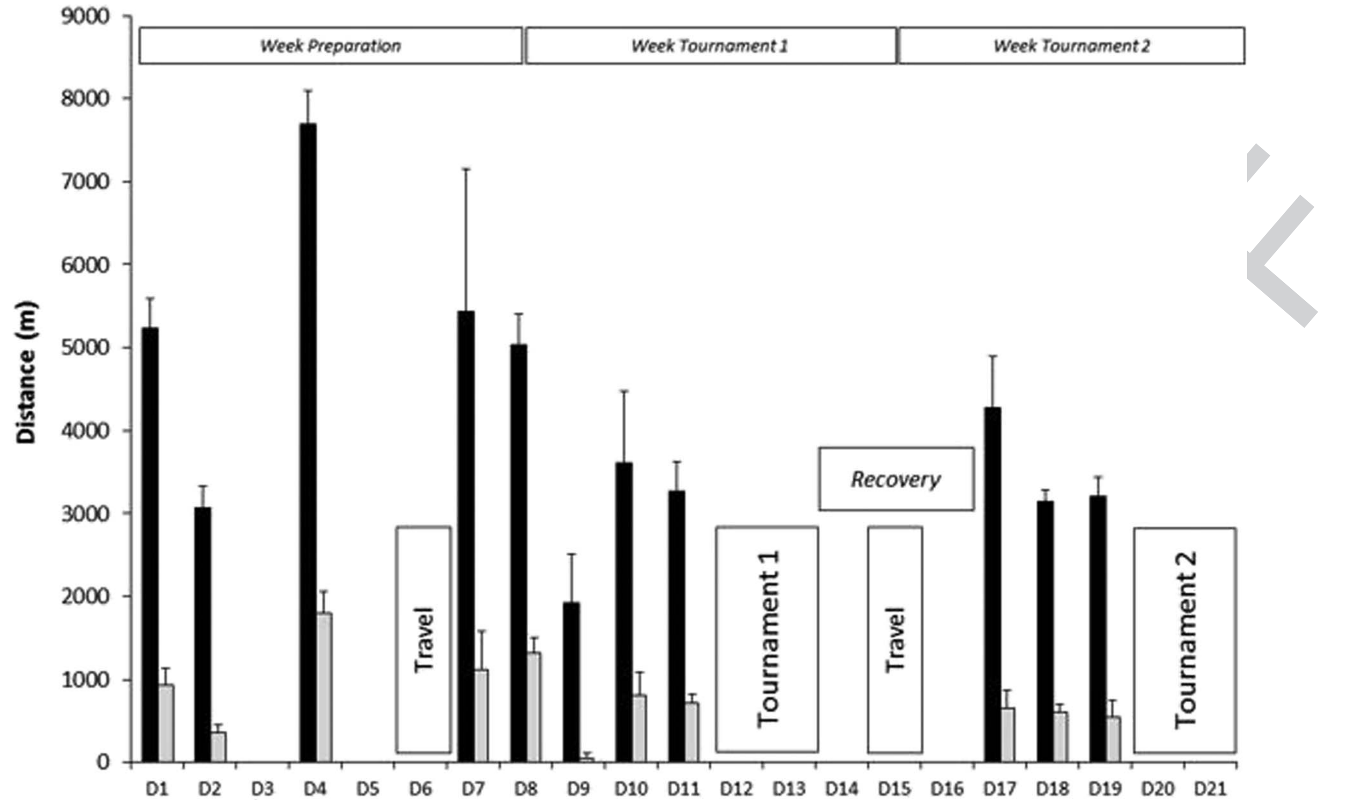

Figure 2 — Variation of daily distance covered before and between 2 rugby sevens tournaments. Black bars indicate distance total; gray bars, high-speed distance (>5 m/s).

Table 6 Weekly Programming of the International Rugby Sevens Team Before and Between 2 Tournaments

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
WP						
Resistance, strength and power	Resistance, strength and power		Resistance, strength and power		Travel	
Rugby tact	Rugby tech and tact		Rugby tact and lactic (aer game)			Rugby tech and tact
HIT cycle					Active recovery, swimming pool	
Recovery	Recovery		Recovery			Recovery
WT1						
Resistance, strength and power	Rugby tech	Rugby tact	Rugby tact	Tournament	Tournament	Recovery
Rugby tact and lactic	Recovery	Resistance, explosive/power	Recovery			
Recovery		Recovery				Recovery
WT2						
Travel		Rugby tact	Rugby tact	Rugby	Tournament	Tournament
Active recovery, swimming pool	Active recovery, cycle/elliptic	Recovery	Resistance, explosive/power	Recovery		
Recovery			Recovery			

Abbreviations: aer, aerobic; HIT, high-intensity training; tac, tactical; tech, technique; WP, 1 wk before the first tournament; WT1, 1 wk before the first tournament; WT2, 1 wk before the second 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 7). 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 in WP. High-intensity distance in WT1 was slightly reduced (−2.6% ± 8.9%), perhaps due to lower duration of match-simulation sequences undertaken during tactical rugby sessions. 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, 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[68] indicated that a single sevens tournament reduces 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 compared with both WP and WT1, in part due to a reduction in number of sessions completed, with only 1 additional sequence of maximal power (Tables 1 and 7). A progressive reduction in the week for total and high-intensity distance covered is common (Tables 2 and 8).

Common in team sports are "captain's runs," or ritual sessions on the day before (or last hours before) the start of a competition. These sessions are often termed preloading and consist of small-sided games and repeated sprints, although it has been observed[71] 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 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 previously described taper is a "high-low-high" approach, which may also be successful. Unpublished data from our group indicate reduced intratournament muscle soreness resulting from such an approach in a male World Series cohort compared with 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 to specific stimuli (ie, 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, and focus turns largely to neuromuscular recovery of the athletes in WT2. Captain's runs, or sessions programmed in the immediate 4 to 24 hours prior to commencement of competition, may positively (or potentially negatively) affect performance but are case-specific, with the

Table 7 Duration, Frequency, and Training Load Before and Between 2 Rugby Sevens Tournaments

	WP	WT1	WT2	Change WP to WT1	Change WT1 to WT2	Change WP to WT2
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 (a.u.)	2935 ± 496	1865 ± 287	1269 ± 284	−36% ± 9%	−33% ± 7%	−57% ± 6%

Abbreviations: a.u., arbitrary units; sRPE, rating of perceived exertion × duration (min); WP, week of preparation; WT1, week of tournament 1; WT2, week of tournament 2.

Table 8 Physical Training Activity the Weeks Before and Between 2 Rugby Sevens Tournaments, Mean ± SD

	WP	WT1	WT2	Change WP to WT1	Change WT1 to WT2	Change WP to WT2
Total distance (m)	23,885 ± 952	13,620 ± 1462	10,634 ± 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)	18,655 ± 457	10,718 ± 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

Abbreviations: WP, week of preparation; WT1, week of tournament 1; WT2, week of tournament 2; LID, low-intensity distance; HID, high-intensity distance.

potential benefits unclear at this time. Research on these commonly performed captains 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 2 or 3 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 with the first half, potentially explaining the higher incidence of injury both late in individual games and over the course of tournaments.[72,28] In the World Sevens Series, intervals from one game to the next are typically 2 to 3 hours. Coaches and medical staff must implement efficient strategies throughout and between competition days to minimize injuries and maximize game-to-game performance.

Postmatch 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 2 rugby sevens games, although highly dependent on resources, feasibility, and athlete individualization, is presented in Figure 3 and described as follows:

- 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 to 1.5 g carbohydrate/kg body weight in addition to 20 to 25 g of protein within 30 minutes 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.[73] 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 conflicting 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.[74] While cold-water immersion is a highly individual preference and may offer primarily a placebo effect, where available and desired by the athlete[75] a protocol of whole-body immersion lasting at least 10 minutes (maximum 20 min) at a temperature of 12°C to 15°C immediately after the game may be effective.[76]
- Step 3—Soft-Tissue Care: Given that many athletes present postmatch 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

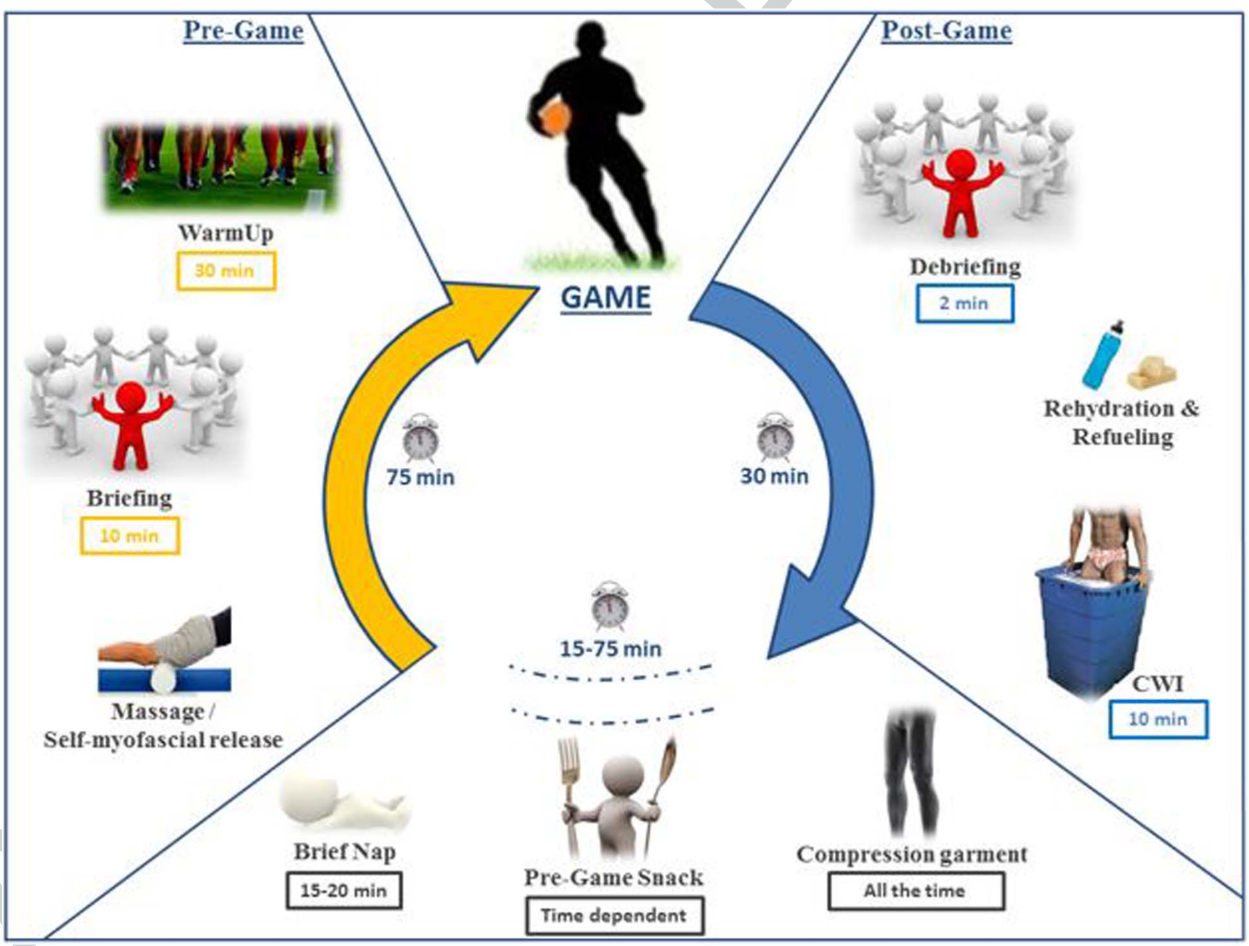

Figure 3 — Between-games recovery strategies during a rugby sevens tournament.

the legs vertically up a wall or on a chair can be a cheap and effective way of redirecting fluid from the lower extremities.[77] 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 previous 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,[78,79] so these materials could be used by athletes between games.

- Step 4—Pregame Snack: While feeding remains a highly individual preference and response, in an effort to continue (re) fueling it is recommended that athletes consume a carbohydrate-rich meal no later than 1 hour before each game. Carbohydrate-rich foods and drink may help ensure that fuel targets are met before subsequent exercise bouts ($1–1.2\ g \cdot kg^{-1} \cdot h^{-1}$),[80] while food density and fiber and fat portions must be considered with gastric comfort as a priority. Caffeine ingestion (1–3 mg/kg, equivalent to about 2 or 3 espressos for a rugby sevens player 1 h prior to games) can be used as an ergogenic aid,[81] although caution must be taken over a 2- to 3-day tournament regarding the deleterious effects of repeated dosing of caffeine, with quality sleep between competition days prioritized.[82,83]
- Step 5—Brief Nap (optional): Time permitting, brief (15- to 20-min) naps between games may improve both cognitive and motor performance.[84] Caffeine consumption immediately prior to the nap may lessen the phenomenon of sleep inertia after waking.[85]
- Step 6—Repeat Soft-Tissue Care.
- Step 7—Pregame 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 15 minutes from the first whistle of a match to the last, normally 6 times across 2 or 3 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 best-practice examples described herein in their own programs, prioritizing basic modalities while recognizing the highly individual nature of responses to physical-performance methodologies.

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