Utilising a tactical periodization framework to simulate match demands during rugby sevens training

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ABSTRACT

Rugby sevens is a demanding sport that requires extensive physical preparation. Travel and logistical challenges in rugby sevens mean that coaches often have limited contact time with players, but must ensure adequate physical, technical and tactical preparation. Tactical periodisation (TP) presents a potential solution by simultaneously developing these aspects of performance, but this concept has not been empirically tested. To investigate the effectiveness of TP, microtechnology devices were used to measure total distance, high-speed distance, maximum velocity, mean acceleration, PlayerLoad and collisions in a group of international sevens rugby players (n=22) during four tournaments and two training camps. Differences in the mean and peak demands of matches and training session types (*volume, quality, speed, collision*) were determined using linear mixed

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models and effect sizes (ES) with 95% confidence intervals. *Volume* and *quality* training types simulated mean and peak match demands effectively with only PlayerLoad demonstrating a practically important reduction from match exertion (*match* vs. *quality* ES = -0.97, 95%CI -1.17 to -0.77). *Speed* training exceeded the peak high-speed running demands of matches over durations from 1 to 5 minutes (ES range 1.78 to 2.54). These results demonstrate that training guided by tactical periodization principles represents an effective method of preparation during the competition period.

INTRODUCTION

Rugby sevens is a physically demanding team sport that requires players to engage in large volumes of high-intensity running and frequent collisions (32). Sevens is most frequently played in a tournament format, with five to six matches played over a two to three day period (32). As a result, the total workload accumulated by players over the course of a tournament typically exceeds that of a full 15-a-side rugby match and objective markers of fatigue remain elevated for up to six days following tournament participation (46). As such, adequate physical preparation for rugby sevens is essential (36).

Preparing players for the physical demands of rugby sevens competition is a significant challenge for coaches and practitioners. Research has demonstrated that rugby union training sessions for both sevens (18) and 15's (5, 30, 40) typically fail to emulate the physical intensity of match play, and thus may not effectively prepare players for the demands of competition. It should however be noted that no rugby union (sevens or 15's) study has assessed the peak demands of training and therefore it is possible that training sessions meet or even exceed the peak demands of competition for brief periods, even if the aggregated session demands do not. This concept is yet to be empirically tested.

Preparing players for international sevens competition is subject to a number of logistical challenges. It is difficult to co-locate players who live in different locations across their respective countries (27). Players on the Sevens World Series (SWS) are generally full-time professionals (24), but cannot remain in camp continuously due to the relatively long periods between competition events (27). At sub-elite levels of the game, these challenges are exacerbated. Sub-elite players typically play both sevens and fifteen man rugby (32), representing their 15's clubs on a weekly basis, and attending infrequent sevens training camps in order to prepare for seven's tournaments which take place three to six times per year. Rugby 15's is played at a lower intensity than rugby sevens (32), and it follows that players who habitually play 15's require additional physical preparation for sevens competition. At both elite and sub-elite levels, restricted access to players places unique demands on coaches who must quickly and efficiently impart their 'game model' and operationalize team tactics within limited timeframes (31). As a result, training camps typically focus on developing player skill and team cohesion (27). This overt focus on tactical outcomes means that

strength and conditioning coaches have limited time with players and must work creatively to ensure adequate physical preparation.

An approach to training prescription that may provide solutions to the coach challenges described above is tactical periodization (37, 38). Tactical periodization is a coaching paradigm that discourages the separation of the physical, tactical, technical, and mental elements of preparation and suggests that instead coaches should plan creatively to ensure that all of these aspects are developed simultaneously through holistic training activities (13). In particular, it is essential that coaches and strength and conditioning coaches collaborate during planning to ensure that training activities are constructed to satisfy both technical/tactical and physical training outcomes (38). While this approach is theoretically promising, the application of tactical periodization has yet to be empirically explored in a rugby playing population (1). Therefore, the aims of this study are 1) to determine the whole and peak match demands of sevens match play at an international, sub-elite level of competition and 2) to determine whether the utilization of a tactical periodization approach to training prescription allows for the simulation of these physical demands. It is anticipated that this information will be useful to rugby coaches considering whether to adopt a tactical periodization approach in their own practice.

METHOD

Experimental approach to the problem

The experimental approach to this study was informed by the action research concept, a process through which an intervention or change program is implemented, and managed by, the participant(s) and situated in their practice (6). A major role of team sport coaches is to design practice sessions to best suit the development and performance needs of their teams and athletes (7). The principle investigators in this project were the coach and strength and conditioning coach of the team who were aiming to devise more effective methods of training within the constraints of their environment. Microtechnology device (GPS and accelerometer) data were collected during training camps and international tournaments to examine whether training prescribed using the tactical periodization approach was effective in attaining or exceeding physical match demands.

Participants

Twenty-two players representing an international rugby sevens team that competed in the Rugby Europe Trophy competition between 2017 and 2019 were included in the study. The physical performance characteristics of these players are presented in Table 1. The Rugby Europe Trophy represents the third tier of international sevens competition (after the World Series and Rugby Europe Grand Prix) and teams competing at this level are ranked between 13 and 26 in Europe. Players were informed of the study procedures and provided written informed consent. Ethical approval was granted by the Local Research Ethics Committee of Leeds Beckett University and the recommendations of the Declaration of Helsinki were respected.

Procedures

Match and training exposures

Data were collected across four international sevens tournaments (23 total matches) and two international training camps (10 individual training sessions). Tournaments were played under World Rugby laws and as such the data collected were purely observational. Training camp activities were designed by the coaches according to the principles of tactical periodization. Each training camp consisted of five training sessions over two days with each individual session organized around particular tactical themes (Table 2). Individual training sessions consisted of a warm up, followed by a skill development activity, followed by game-form activities (25), and a cool down comprised of an individual skill development task. The game-form activities were structured to replicate the duration of a match half (7 mins), with 2-3 min recovery between each block. Activities within these blocks were organized around specific '*moments of the game*' (38) (e.g. attack from midfield rucks, kick off defence, etc.).

Table 1 – Physical performance characteristics of players representing an international rugby sevens team participating in the Rugby Europe trophy competition.

	All players (n = 22)	Forwards (n = 10)	Backs (n = 12)	p-value	Effect size, ±95%CI
Body mass (kg)	87.0 ± 7.2	91.6 ± 4.0*#	83.1 ± 7.1	0.002	1.07, ±0.65
1RM squat (kg)	141 ± 18	146 ± 20	137 ± 16	0.312	0.46, ±0.97
1RM bench press (kg)	108 ± 14	114 ± 16	104 ± 12	0.139	0.66, ±0.90
10m sprint (s)	1.82 ± 0.08	1.86 ± 0.09	1.80 ± 0.07	0.161	0.73, ±1.08
40m sprint (s)	5.45 ± 0.21	5.56 ± 0.16*	5.36 ± 0.20	0.046	0.87, ±0.86
Momentum (kg.m ⁻¹ .s ⁻¹)	472 ± 40	486 ± 26	462 ± 47	0.217	0.47, ±0.76
Counter movement jump (cm)	40.9 ± 4.8	38.8 ± 2.8	42.8 ± 5.5	0.121	0.66, ±0.87
Peak power (Watt)	4394 ± 359	44.9 ± 302	4373 ± 425	0.822	0.11, ±0.93
Relative peak power (Watt.kg ⁻¹)	50.3 ± 3.9	48.5 ± 1.8	52.2 ± 4.7	0.124	0.69, ±0.84
Bronco Run (s)	297 ± 11	300 ± 13	295 ± 9	0.406	0.41, ±1.03

Testing procedures for all variables are detailed in the supplementary document * indicates a significant difference between backs and forwards (p < 0.05) (independent samples t-test). # indicates that there is a greater than 75% likelihood that the differences observed were practically meaningful at an effect size threshold of 0.6 (moderate). Effect size represents the standardized difference between forwards and backs with 95% confidence intervals.

Within these game form activities, coaches attempted to manipulate the constraints of training to achieve particular physiological stimulus. Sessions were broadly categorized as either 'volume' or 'quality' type sessions. *Volume* sessions attempted to expose players to higher work rates than they would typically be exposed to during matches. The aim of *quality* sessions was to execute tactical movements successfully under physical demands similar to those experienced under match conditions. Quality sessions were utilized when new tactical approaches needed to be learned to allow time for brief periods of communication, feedback and reflection between playing bouts. Quality sessions were also used to recreate match conditions with no coach feedback, allowing players to problem solve on the field. In order to achieve these outcomes, work:rest ratios were manipulated to influence physical demands. *Volume sessions* were constructed with ball in play periods >45 seconds in duration and half as much rest provided (i.e work:rest ~ 2:1). *Quality* sessions were constructed with short ball in play periods <35 seconds in duration and longer rest periods up to 60 seconds in duration (work:rest ~ 1:2). This reflects the average ball in play time of 28-33 seconds during international competition (32). In cases where play broke down before the required playing time interval had elapsed, coaches would introduce another ball into the game and allow play to continue immediately from unstructured situations. Player numbers were occasionally manipulated to influence the physical load (where this was possible without affecting the tactical goals). In order to increase total and high speed running volume, or opportunities for players to reach maximal velocity, games were constructed with overloaded attack (e.g. 7 vs. 6 or 7 vs. 5). In contrast, when acceleration or collision demands were emphasized games took place with even numbers (6 vs. 6 or 7 vs. 7). Pitch dimensions were never altered and all sessions took place on a full size rugby pitch. Rugby sevens has one of the largest player to pitch area ratios of all team sports (at least 515 m²/player), and as such pitch area is unlikely to be a limiting constraint on player movement patterns. Sample sessions are provided in Table 3 for clarity.

It was anticipated that even though session types could be manipulated to influence physical demands, it would not be possible to create game constraints that would consistently provide exposure to maximal velocity running or frequent high-intensity collisions, both of which are key determinants of performance (32). Therefore, specific drills designed to emphasise either maximal velocity running or collision exposure were developed and included in training sessions as skill development activities (Table 2). Due to the intensity of these activities these drills were not included in all training sessions, and each drill was typically only utilized once per training camp (Table 2).

Quantification of match and training demands

During training camps and international sevens tournaments players wore microtechnology devices (S5 Optimeye, Catapult Innovations, Melbourne, Australia) that sample global positioning system data at a frequency of 10Hz and contain a tri-axial accelerometer sampling at 100Hz. Players used the same microtechnology device for the duration of the data collection period. Devices were positioned between the shoulder blades, in a custom-designed undergarment provided by the manufacturer. The validity of these units for measuring team sports movements has been previously

established (23, 42). Following the completion of each match or training session, data were downloaded to the manufacturer's software (OpenField 1.14, Catapult Innovations, Melbourne, Australia) and trimmed to only include playing time. Playing time was considered to be the beginning to the end of each half or playing block (inclusive of ball out of periods) for matches and training respectively. For training sessions, only game form and specific skill development activities (collision or speed) were retained for analysis. Start and finish times of these activities were recorded by direct observation and then used to ensure that only relevant training periods were included in the data. Data were then exported as .csv files before being subjected to further analysis in RStudio (version 1.2.1335, Boston, MA, United States). GPS files were excluded from the data set if the mean number of satellites connected was <10, or the horizontal dilution of precision was >2.0. In total, 378 match halves and 379 training bouts (221 quality, 125 volume, 20 collision, 13 speed) were analysed.

The variables of interest were total distance, high speed distance (distance >5m.s⁻¹), mean acceleration, PlayerLoad, maximal velocity and collision count. These variables were selected because they are representative of the various physical demands of the game and have been previously reported, providing a basis for comparison (33, 35). Where appropriate, data were normalized to activity duration to account for differences in playing time (e.g. starters vs. substitute players) and thus total distance (m.min⁻¹), high speed distance (m.min⁻¹ >5m.s⁻¹), PlayerLoad (AU.min⁻¹) and collisions (n.min⁻¹) are all presented as per minute values, while acceleration (m.s⁻²) is presented as the mean value over the relevant time period and maximal velocity (m.s⁻¹) as the maximum value over the relevant time period.

PlayerLoad is measure derived from the accumulation of data from all axes of the triaxial accelerometer, and is considered to be a representation of the mechanical load that athletes are exposed to (3). Collision count was determined using the 'tackle' algorithm provided by the manufacturer, which derives collision events from the interaction between accelerometer and gyroscope data. Collision data were exported and all collisions less than 1 PlayerLoad (AU) and or lasting less than 1 second were excluded from the analysis in order to improve the accuracy of the detection (20). While it is acknowledged that this method has only been validated for use in rugby league, in the absence of a validated and commercially available application for determining collision counts in rugby sevens, this method was deemed to be representative of collision exposure.

Table 2 – Example training schedule from a two day international sevens training camp

TRAINING CAMP SCHEDULE			
Day 1		Day 2	
07:00 to 08:00	STRENGTH AND POWER TESTING	-	
08:00	BREAKFAST	BREAKFAST	
08:30 to 09:30	TEAM MEETING	TEAM MEETING	
09:30 to 10:30	PREPARATION: Physio, taping, foam rolling and mobility work	PREPARATION: Physio, taping, foam rolling and mobility work	
10:30 to 12:00	TRAINING SESSION #1 Tactical Theme: Defence Session type: Quality Session content <ul style="list-style-type: none"> Warm-up <u>Skill development</u> Collision – 2 vs 2 tackle drill <u>Tactical development</u> High D drill into game situation #1 High D drill into game situation #2 Game situation start from ruck#1 Game situation start from ruck #2 <u>Individual skills</u> Warm down Kick off skills Timing and detail 10 minutes 10 minutes Emphasis – repeat effort ~ 2-3 tackles/min 4 x 7 minutes Work: up to 30s Rest: up to 60s Ratio ~ 1:2 10 minutes	TRAINING SESSION #4 Tactical Theme: Attack from broken play Session type: Volume Session content <ul style="list-style-type: none"> Warm-up <u>Aerobic capacity test</u> Bronco <u>Tactical development</u> Red zone attack #1 Red zone attack #2 Mid-field ruck attack #1 Mid-field ruck attack #2 <u>Individual skills</u> Warm down Passing skills Timing and detail 10 minutes 10 minutes 4 x 7 minutes Work: more than 45s Rest: less than 30s Ratio ~ 2:1 10 minutes	
12:00 to 13:00	LUNCH	LUNCH	
13:00 to 14:00	PREPARATION: Physio, taping, foam rolling and mobility work	PREPARATION: Physio, taping, foam rolling and mobility work	
14:00 to 15:00	TRAINING SESSION #2 Tactical Theme: Kick off Session type: Quality Session content <ul style="list-style-type: none"> Warm up <u>Skill development</u> Speed - testing OR speed games <u>Tactical development</u> Game situation from kick off scenarios <u>Individual skills</u> Warm down Kick skill game Timing and detail 15 minutes 15 minutes Emphasis – maximum velocity 3 x 7 minutes Work: up to 30s Rest: up to 60s Ratio ~ 1:2 10 minutes	TRAINING SESSION #5 Tactical Theme: Match simulation Session type: Quality Session content <ul style="list-style-type: none"> Warm up (as per tournament) <u>Skill development</u> Wrestling and collision skills <u>Tactical development</u> Full match simulation <u>Individual skills</u> Warm down Penalty moves Timing and detail 10 minutes 15 minutes 3 x 7 minutes Work: up to 30s Rest: up to 60s Ratio ~ 1:2 10 minutes	
15:00 to 16:00	RECOVERY: Snack, mobility, foam roller	TEAM MEETING	
16:00 to 17:00	TRAINING SESSION #3 Tactical Theme: Attack from set piece Session type: Volume Session content <ul style="list-style-type: none"> Warm up <u>Skill development</u> Long passing <u>Tactical development</u> Attack from mid field scrums Attack from wide scrums Attack from lineouts Warm down Timing and detail 10 minutes 10 minutes 3 x 7 minutes Work: more than 45s Rest: less than 30s Ratio ~ 2:1 10 minutes	ONE ON ONE MEETINGS AND CLEAN UP	

Table 3 – Sample session plan focused on defensive organization, illustrating the incorporation of tactical periodization principles into session planning.

TRAINING SESSION #1			
Date: N/A		Phase: Pre-competition	Total time: 1 hour
Tactical Theme – Defence from rucks Game moments: Transition from first phase or turnover to ‘high-D’ structure Tactical scenario: Defending a ruck after slowing the ball down Sub-principle: Remove attack’s time and space as quickly as possible Sub-sub-principles: Line speed depends on prior organization – get position + width quickly			
Technical: Organisation from box and post defenders when arriving at rucks. NB roles and responsibilities		Physical: <ul style="list-style-type: none">- “Quality” emphasis – Work periods ~ 30 seconds/3-4 phases, with up to a minute between bouts. Work:rest 2:1- Adequate rest ensure that learning occurs at game speed.	Mental: Quickly switch roles – transitions are normally preceded by an error – adjust quickly to new scenario
Activity	Duration	Structure	Key coaching points
Warm up	10 minutes	Raise: Passing grid with submaximal running Activation and mobilization: Running technique drills Potentiate: Wrestle in prep for contact exposure	<ul style="list-style-type: none">- ‘Rifles’ – finish the pass- Control hips to dominate contact
Skill development 2 vs 2 tackle area drill	15 minutes	2 vs 2 tackle area drill	<p>Attackers - Agility before contact. Try to free arms for offload/long place. Support player 45 degrees on the inside and 2-3 m depth. Available for offload or clean.</p> <p>Defenders – Close space quickly! Settle prior to contact = feet ready to react to agility. Foot into contact zone. Wrap and leg drive after contact. Return to feet quickly.</p> <p>Catch up defender – Keep alignment. Awareness of offload. Identify opportunity for turnover or slow possession, or set defence quickly</p>
Player D pass to player C, Player C attempts to beat player B. Players D provide support and clean ruck. Player A make decision about whether to contest ruck or set defence.			

Tactical development High D – work together to reduce attack time and space	4 x 7-minute blocks	High D drill into game play – 2 x 7 minutes <p>Attacking and defending players start 10 – 15m ahead of the ruck. Ruck contains 2 attacking and 1 defending player. On the signal, both groups of players advance to the ruck and set to play – this simulates game situation following a ruck especially if we manage to slow down the ball. Defensive players KPI's –</p> <ol style="list-style-type: none">1. Set box, 2. Set post, 3. achieve width/alignment, 4. Work rate – achieve line speed, while maintaining connection. <p>- Second block – defence two players in ruck = one less player in the line.</p> <p>Game situations starting from ruck defence – 2 x 7 minutes Defence starts flat, but from various ruck positions (left, right, middle). Principles of High D to be demonstrated in dynamic game play.</p>	Tactical: <ol style="list-style-type: none">1. Box and post most NB – must set to avoid blindside attack2. Post must advance quickly to stop first attacker stepping back and attacking blind3. Retreating defenders work hard to achieve with/alignment and be ready4. Aggressive linespeed! Move fast when the ball is in the air, settle when ball is in hands.5. Maintain alignment. Technical: <ol style="list-style-type: none">1. Shoulders remain square even if sliding to avoid being beaten on the weak shoulder.2. Maintain connection with inside and outside defenders3. Positioning – inside, inside shoulder Mental: <ol style="list-style-type: none">1. Agitated/angry coaching behaviours to increase pressure2. Deliberately unfair refereeing during some bouts to develop resilience.
Warm down Kick off receipt skills	2 x 5 minute blocks	Catching in the air Players to pair off – one feeding, other catching. Feeder throws balls in the air requiring the catcher to move a few steps before jumping and catching overhead Supported catches As previous, but catchers now work as catching pods (1 lifter/1 catcher)	Technical: <ol style="list-style-type: none">1. Move early, watch ball to the peak of its arc before settling2. Hands above head and in the air to catch.

TRAINING SESSION #2

Date: N/A

Phase: Pre-competition

Total time: 50 minutes

Tactical Theme – Kick off recovery

Game moments: Kick off to recovery possession or kick off to exert pressure

Tactical scenarios: Leading/chasing game – One or two score differences

Sub-principle: Pressure on catcher – no time to look/assess options – create a contact point

Sub-sub-principles: Chase line – wide players ahead to cut off wider attack options.

Technical:

Kick quality – predictable height and positioning
Kick chase – contestable = 1 competing player, 1 past the ball + organized line

- Deep kick = 6 in a line, pressure into the corner

Physical:

- Maximum velocity and high speed running volume
- “Quality” emphasis – Work periods ~ 30 seconds/3-4 phases, with up to a minute between bouts. Work:rest 2:1
- Adequate rest ensure to ensure running intensity is maintained

Mental:

Decision making regarding score line scenarios, and reacting to opposition strength/weaknesses.

Activity	Duration	Structure	Key coaching points
Warm up	10 minutes	Max velocity preparation Raise: Long passing grid with submaximal running Activation and mobilization: Running technique and plyometric drills Potentiate: Gradual acceleration into 10 – 15 VMax	<ul style="list-style-type: none"> - Stay straight – don’t run sideways to deliver long pass - Postures and shapes – accel vs Max V.
Skill development Speed weapons	15 minutes	‘Finish in the corner’ drill ~ 5 attacks per player	<p>Attackers – Don’t allow defenders to close space before using your ‘weapons’. Vary speed and try to get defender to turn his shoulders.</p> <p>Defenders – Close space quickly! Shepard attacker, try to provide only one shoulder to attack and minimize the ability to use ‘weapons’.</p>

Player A kick/pass to player B. Player C is the last defender and may start moving as soon as player A passes. Player C must receive the ball and use speed and agility skills to beat player C and score anywhere over the try line.		
<u>Tactical development</u> Kick offs	3 x 7-minute blocks	Game play from kickoff starts <u>Block 1: Contestable kick</u> – 1 x 7 minutes <u>Block 2: Deep kick</u> – 1 x 7 minutes <u>Block 3: Variable (scenarios)</u> – 1 x 7 minutes
<i>Tactical:</i> <ol style="list-style-type: none"> 1. Contestable: Player in the air to compete with catcher – react to errors! 2. Deep kick: Pressure through high line speed and organized shape. Lock them in! 		
<i>Technical:</i> <ol style="list-style-type: none"> 1. Kick quality 2. Timing arrival into jump zone 		
<i>Mental:</i> <ol style="list-style-type: none"> 1. Decision making around kick type – when/why 		
<u>Warm down</u> Kick skills game	5 minutes	Cover the field Players kick to gain ground – if ball hits grass they receive another kick from where it landed. When close enough attempt drop goal.
<i>Technical:</i> <ol style="list-style-type: none"> 1. No pressure catch – set and execute 2. Kick skill – control fall of ball, head down. 		

Match and training exertions are described as both the mean (average exertion over the entire playing period) and peak (maximal mean exertion over specified time periods) values (47). Specifically, time-series files detailing players instantaneous speed every 0.1s were exported from the proprietary software to RStudio where the maximal mean of each player's instantaneous speed across different durations (30s, 1 min, 2 min, 3 min, 4 min, 5 min) were calculated using a shifting time window according to the methods of Delaney et al. (2015) (10). The same time series files were used to derive mean acceleration by calculating the absolute value of all acceleration/deceleration data, before being averaged over the duration of the defined period. Mean acceleration provides a reliable assessment of the total acceleration and deceleration demands of an activity (8, 12).

Statistical analysis

All data were log transformed prior to analysis to reduce non-uniformity of error. Differences in physical characteristics between backs and forwards were assessed using independent samples t-tests. Linear mixed models were constructed in RStudio to assess the difference between match exertions and different training session types. Separate models were built for each measured variable and duration. Match or training session type were designated as fixed effects, while player identity, match or training session identity, player position (back or forward), period (half 1 or 2 for matches and interval 1 to 5 for training sessions) and season were all included as random effects. These random effects were included to account for differences in exertions that may occur as results of pacing and fatigue (17, 39, 41). Random effects that did not demonstrate significant effects on the overall model were later removed to ensure parsimony. Pairwise comparisons were made between training session types and match exertions using the least-squares mean test. Cohen's *d* effect sizes (ES) and 95% confidence intervals were calculated. ES magnitudes were interpreted as 0.00-0.19, *trivial*; 0.20-0.59, *small*; 0.60-1.19, *moderate*; 1.20-1.99, *large*; and >2.0 *very large* (19).

Due to the applied nature of this study, it was important to assess whether differences were practically meaningful, rather than just significantly different. As such, percentage likelihood that observed effects exceeded a minimum threshold for practical importance were derived from the p-values of the least-squares mean tests (19). It has been previously demonstrated that mean running speed and acceleration are highly variable in team sports, and that as a result of this variability small effects may lie within the typical error of measurement of these metrics (14). On this basis, an effect size of 0.6 was designated as the threshold for practical importance. Accordingly, differences were considered practically meaningful if there was a >75% likelihood of the effect being moderate (ES > 0.6).

Results

The mean movement demands of sevens match play and the various tactical periodization training structures are presented in Table 4. Figure 1 shows the magnitude of difference (effect size $\pm$ 95%CI) from match-play of the various training structures for all of the movement variables.

Table 4 – Mean movement demands of international rugby sevens matches and tactical periodisation training structures.

	Training type				
	Match	Quality	Volume	Speed	Collision
Total distance (m.min ⁻¹)	107 ± 37	93 ± 17	102 ± 14	76 ± 7*	41 ± 5*,§,#,%
High speed distance (m.min ⁻¹)	16 ± 11	10 ± 5	10 ± 4	22 ± 3 [§]	0.6 ± 0.4*,§,#,%
Maximum velocity (m.s ⁻¹)	7.2 ± 1.0	6.9 ± 0.9	7.2 ± 0.8	7.8 ± 0.9	4.1 ± 0.4*,§,#,%
Mean acceleration (m.s ⁻²)	0.35 ± 0.10	0.40 ± 0.07	0.41 ± 0.05	0.27 ± 0.09 ^{§,#}	0.32 ± 0.06
PlayerLoad (AU.min ⁻¹)	10.7 ± 1.3	9.0 ± 1.8*	10.2 ± 1.2	6.7 ± 0.8*,§,#	4.5 ± 0.5*,§,#,%
Collisions (N.min ⁻¹)	1.5 ± 2.4	1.0 ± 0.9	1.1 ± 0.9	-	1.4 ± 0.3

*, §, # and % designate practically meaningful differences (> 75% likelihood of a moderate or greater effect) from match, quality, volume and speed type training respectively.

Figure 1 - Comparison of standardized effect sizes with 95% confidence intervals of movement characteristics between international rugby sevens match-play and tactical periodization training activities. * designates a practically meaningful difference (> 75% likelihood of a moderate or greater effect) from matches.

Overall, despite the intention to create overload, none of the training structures implemented lead to physical exertions that were meaningfully greater than match play. For mean acceleration, the *volume* and *quality* type training structures displayed *moderate* (ES 0.60, 95%CI 0.35 to 0.86; $p = 0.054$; 63% likelihood of a +ve effect) and *small* (ES 0.57, 0.37 to 0.76; $p = 0.081$; 50% likelihood) positive differences from match demands respectively, but these effects did not exceed the threshold for practical importance. Similarly, the *speed* training structure neared practically meaningful differences from match play for high speed distance (ES 0.61, -0.02 to 1.24; $p = 0.506$; 52% likelihood) and maximum velocity (ES 0.61, -0.01 to 1.25; $p = 0.191$; 50% likelihood), but did not exceed the threshold for practical importance.

In contrast, both the *volume* and *intensity* type training structures simulated the demands of match play fairly well. There were no practically important differences between match play and *volume* type training for any of the performance parameters measured. The only meaningful difference between match play and *quality* type training was a *moderate* difference in PlayerLoad (ES -0.97, -1.17 to -0.77; $p < 0.001$; 85% likelihood).

The skill development activities designed to emphasise either speed or collision exposure displayed some large differences from match activity. *Speed* type sessions resulted in less total distance being covered (ES -0.85, -1.48 to -0.21; $p = 0.001$; 91% likelihood) and less PlayerLoad (ES -2.32, -2.97 to -1.66; $p < 0.001$; 100% likelihood) than matches. *Collision* training was the training type that was most similar to match play for collisions (ES -0.04, -0.60 to 0.52; $p = 0.263$; 100% likelihood of trivial effect), but was meaningfully lower for total distance, high speed distance, maximum velocity and PlayerLoad measures (*large* to *very large* effects, $p < 0.001$, 100% likelihood).

When comparing between different training types, it is clear that *collision* type training is atypical, displaying practically important differences from all other training types for all measures except mean acceleration and collisions. *Speed* type training had meaningfully lower mean acceleration demands than both *volume* (ES -2.54, -3.34 to -1.73; $p = 0.062$; 89% likelihood) and *quality* (ES -2.18, -2.89 to -1.46; $p = 0.079$; 86% likelihood) type training. *Speed* training lead to more high speed running than *intensity* (ES 0.95, 0.31 to 1.59; $p = 0.040$; 87% likelihood) and *volume* (ES 1.18, 0.51 to 1.83; $p = 0.381$; 69% likelihood) type training, but only *intensity* presented a clear difference. No collisions occurred during *speed* training.

Figure 2 - Peak (maximal mean) demands of international sevens matches and tactical periodisation training types for A) total distance, B) high speed distance and C) mean acceleration over 30, 60, 120, 180, 240 and 300 second time periods. Data are presented as mean $\pm$ SD. * and [§] designate practically meaningful differences (> 75% likelihood of a moderate or greater effect) from matches from matches and *intensity* type training sessions. Absolute values are provided in the supplementary file.

Based on the evidence of the previous analysis, *collision* training data was not carried forward to peak demands analysis due to being so clearly different. The averaged peak values for total distance, high speed distance and acceleration over time periods ranging from 30 seconds to 5 minutes are presented in figure 2. There were no practically meaningful differences between matches and *quality* or *volume* training types over any duration. *Speed* sessions exceeded the average peak high speed running demands of matches over durations ranging from 1 to 5 minutes (*large* to *very large* effects, $p < 0.05$, $> 89\%$ likelihood). *Speed* training was not practically different to matches for total distance or mean acceleration any time period. *Speed* training also exceeded the high speed running demands of *quality* training over durations of 1 and 2 minutes (*very large* effects, $p = 0.013$, $> 87\%$ likelihood). *Speed* training was also not practically different to *volume* training for any variable.

Discussion

The main finding of this study is that it was possible to meet, but not exceed, the physical demands of international rugby sevens match play in training through the use of game form activities that manipulate ball in play time, work:rest ratios and player numbers. This result contrasts directly with previous examination of rugby sevens training where training drills failed to reproduce the movement demands of matches (18). Research in rugby 15's has highlighted a similar problem where training generally fails to reproduce the demands of match play (5, 30, 40). This study therefore presents novel findings that may be useful to coaches and practitioners aiming to improve training prescription for the rugby codes.

An interesting finding of this study was that despite the differing constraints applied, the movement demands of the two game form structures examined here – *volume* and *quality* – were still relatively similar to each other in terms of both mean and peak demands. Research in rugby 15's and field hockey also documented similar running demands for different small sided training game structures (14, 43). Previous research demonstrates that team sports players reduce their levels physical exertion in the periods immediately following the highest intensity periods of play (4, 29), suggesting that players regulate their levels of exertion to ensure adequate reserves for future periods of play (44). On this basis, the lack of differentiation between training structures may indicate that both training structures are sufficiently physically demanding that players are forced to regulate their efforts.

In contrast, the manipulations applied within the skill development activities – *speed* and *collision* training – allowed for particular movement challenges to be emphasised, but equally resulted in these activities becoming quite different from the generalised demands of match play. On this basis, it seems pragmatic to prescribe a combination of game-form and skill development activities to ensure that players are generally conditioned for match play, but are also regularly exposed to more intense

sessions focused on developing particular physiological qualities. In this sense, the *speed* session was highly effective as a stimulus for maximal velocity and high speed running.

The match data provided here is the first to examine the physical demands in the third tier of international sevens competition. In general, the total and high speed distance outputs of the players examined here were similar to those that have been previously reported for tier 1 (sevens world series) players (2, 18, 28, 33, 35), with the exception of mean maximal velocity which may be greater in tier 1 players (range 7.5 to 8.4 m.s⁻¹) (18, 33) than tier 3 players (7.2 ± 1.0 m.s⁻¹). There were also notable similarities between peak running demands reported here and those previously reported for sevens world series match play (15, 28). Collectively these results suggest that there is very little difference in the movement demands between these distinct levels of competition. Previous researchers have also highlighted a similar lack of distinction between movement demands of provincial and international levels of competition (35), highlighting that success at higher levels of competition is likely to be due to technical and tactical attributes. This understanding is a strong argument in favour of the use of the tactical periodisation approach. Applying tactical periodisation methods maximises opportunities to develop technical skills and tactical understanding under game conditions, while providing an adequate physiological stimulus for game preparation.

On this basis, tactical periodisation provides a useful solution to the programming puzzle for in-season training where the focus must necessarily be on metabolic conditioning, technical and tactical skills and sport specific endurance (21). However, it should also be considered that the physical performance characteristics of the players in this study were notably poorer than those previously reported for a highly successful sevens world series team (34). In particular, the elite team displayed greater body mass, strength, speed and power characteristics, highlighting the need for continued physical development for players this level of competition. In this sense, tactical periodisation approaches do not offer a panacea for all training problems, and trainers must invest in developing the underpinning physiology – particularly strength and speed – required for success in the sport. These aspects of performance required sustained effort over a number of years to develop, and may be best addressed during off-season and pre-season training periods (21).

This paper presents a number of analyses that are novel in sevens rugby. Previous analysis of the peak demands of sevens match play have provided data on the peak total distance and high speed running distances over periods of 1 to 2 minutes (15, 16, 28). The data provided here extend this analysis, considering both shorter (30 s) and longer periods of play (5 min). This is important because the mean ball in play time for international sevens is approximately 30 seconds (32), thus the data provided here give an accurate reflection of the ball in play demands. In addition, understanding the average peak intensities of longer game periods is essential for evaluating the effectiveness of training prescription (11). When comparing the peak running intensities across all durations, there appears to be very little difference between rugby sevens, international rugby union (11) and professional rugby league (22, 45).

Previous sevens research has quantified the acceleration demands of the game using frequencies of entries into different acceleration thresholds (2). This method has been called into question because the discretization of time series data reduces the reliability of the measurement (8). A more appropriate method is to report the absolute mean acceleration for the period in question (8). To the authors knowledge this study is the first to apply this approach in rugby sevens. The peak mean acceleration of match play and training determined here are lower than those that have been previously reported for field hockey (14), rugby union (11) and rugby league (9). This is likely a result of the high player to pitch area ratio in rugby sevens which may not require players to accelerate, decelerate and change direction as often as in other team sports. Despite the low mean acceleration values observed, the ability to accelerate effectively remains an important performance characteristic for sevens players (1). This suggests that to accurately describe the acceleration demands of sevens it is necessary to record both the intensity and frequency of acceleration efforts.

A challenge for researchers working in the rugby codes is that although most microtechnology devices estimate collision exposure in some form, these estimations often don't correspond to actual collisions (26). This study is the first to use the Hulin et al (2017) method to estimate collision exposure (20). This measure has not been validated in rugby sevens, but unlike the majority of collision estimation metrics applied in rugby sevens, the measure was validated against observable video criterion and displayed high levels of sensitivity (97.6%) and specificity (92.7%). Results showed that during matches players are exposed to 3 collisions every two minutes, which is similar to the peak collision frequency observed in professional rugby league players (22).

An apparent limitation of this study is the aggregation of training sessions into different training type categories. While the grouped sessions certainly shared similarities in their structure, each training session was unique and would have resulted slightly different load profiles. In practice, it is possible to create many more categories of activity to satisfy the various technical, tactical, psychological and physical outcomes desired. The examples here provide heuristic type guidelines for session design, but coaches looking to adopt this approach should continuously review and adjust the training structure to ensure that the desired outcomes are achieved. Further, while it is desirable to achieve game like physical outcomes during training, the most important factor is whether players are improving the technical and tactical aspects of their game. Anecdotally, the team in question performed well in the seasons where the tactical periodisation approach, and achieved their highest ever ranking in the European trophy competition in one of the seasons. However, no direct measures of technical or tactical skill were made in this study and it is thus impossible to objectively state that tactical periodisation lead to improvements in these areas.

Practical applications

This study has demonstrated that through use of appropriate constraints, game form activities can simulate the physical demands of match play in rugby sevens. This is useful because it confirms that adequate physical preparation for competition can be achieved while focusing on the development of technical, tactical and mental skills for competition. Game constraints can be manipulated to emphasise particular aspects of conditioning (e.g. high speed running or collision exposure).

Conclusion

In conclusion, the data presented here demonstrate that applying the principles of tactical periodisation in training design, resulted in training exposures that matched the demands of international sevens competition match play. This is a novel finding because previous research has shown that rugby training activities are unable to simulate match demands. Therefore, tactical periodisation is presented as a useful tool for coaches, particularly those who have limited contact time with their players, for ensuring the rapid acquisition of technical and tactical skills along with physical match readiness.

Contributions

Contributed to conception and design: JCT, BSD

Contributed to acquisition of data: JCT

Contributed to analysis and interpretation of data: JCT, CO

Drafted and/or revised the article: JCT, BSD, AV, CO

Approved the submitted version for publication: : JCT, BSD, AV, CO

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Data and Supplementary Material Accessibility

No supplementary material available. Sharing of interview transcripts risks compromising the anonymity of the study participants.

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