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Internal and external loads in professional women's Rugby Sevens: analysis of a block-based training session with small games

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ABSTRACT

Purpose. This study aimed to compare internal load (IL) and external load (EL) variables between blocks of a game-based Rugby Sevens training session.

Methods. A descriptive cross-sectional study design was employed. Twenty-eight professional athletes from the first division of the Brazilian national championship were monitored during a game-based training session, which consisted of varying durations of ball-in-play blocks. The training session comprised 4 blocks of 1 min, 2 blocks of 2 min, and 1 block of 3 min of ball-in-play, with 1-min intervals between blocks of the same duration and 2-min intervals between blocks of different durations.

Results. A reduction in EL was reported during longer bouts of ball-in-play. Specifically, a reduction was observed when comparing block 5 to block 1 (p = 0.021) and when comparing block 7 with blocks 1, 2, 3, 4, and 6 for distance per min. For accelerations and decelerations, blocks 5, 6, and 7 showed lower values than block 1 (p = 0.001 and p = 0.005, respectively). Block 4 showed an increase in rate of perceived exertion (RPE) values compared to blocks 1 (p = 0.010) and 2 (p = 0.004). Increased RPE values were also found in block 5 compared to block 1 (p = 0.001), as well as compared to blocks 2 (p = 0.001) and 3 (p = 0.002). RPE in block 7 was higher than in blocks 1, 2, 3, and 4 (p = 0.001).

Conclusions. In summary, higher RPE values were reported across blocks, and IL appeared to be more volume-dependent.

Key words: small-sided games, external load, internal load, female Rugby Sevens, performance monitoring

Introduction

Female Rugby Sevens is a high-intensity sport, comprising a series of sprints and collisions throughout the match [1], with players covering up to 126 m per min, performing an average of 20 accelerations, and enduring about 12 impacts (above 8.0 G) per match during competitive tournaments [2]. Due to the rise in competitive levels and the increased number of matches per season, prioritizing high-intensity training sessions becomes crucial for fostering favourable physiological adaptations [3, 4]. However, it is equally important to manage workload effectively to mitigate the risk of injuries and overtraining [5].

Several methods are commonly employed for workload control in rugby. Global positioning systems (GPS) are typically used to monitor external load (EL) [6]. EL is described by Impellizzeri et al. [7] as the organization, quality, and quantity of the exercise, which encompasses the overall training plan. In team sports, EL can be measured by metrics such as distance covered, accelerations, and other performance indicators. These systems record various player actions to determine the EL experienced, including distance covered, sprint dis-

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tance, accelerations, and decelerations, among other variables [8]. Previous research focusing on women's Rugby Sevens indicates that international-level players typically cover greater total and high-speed running distances during matches compared to players at the developmental level [9]. Metrics registered by this equipment are generally compared with metrics obtained during matches to assess whether the prescribed workloads during training sessions, particularly in drills and skill-based games, are being applied as planned [10]. However, this method requires equipment that may be less accessible for clubs and strength and conditioning coaches.

The concept of internal load (IL) incorporates all the psychophysiological responses that occur during the execution of the exercise prescribed by the coach. These responses correspond to the internal training load [7]. Acute and chronic changes in training outcomes are ultimately the result of an athlete's cumulative IL. Therefore, understanding the measurement of this variable and the factors that influence it is crucial [11]. To monitor IL, the self-reported rate of perceived exertion (RPE) is commonly used [12]. The Borg CR-10 scale [13] is the predominant tool for assessing athletes' RPE following training sessions or matches. According to Quarrie et al. [14], professional rugby workload management should include RPE monitoring due to its simplicity, efficiency, and non-invasiveness, offering valuable insights about IL [15]. From RPE, various variables can be derived, such as training load (calculated by multiplying the session RPE by the session duration), weekly load (the sum of all session training load scores for that week), and training monotony (day-to-day training variability during a training week) [16, 17].

The monitoring and quantification of training load are crucial aspects of athlete management and provide an objective framework for evidence-based decisions [14, 15, 18]. Training load encompasses both external and internal dimensions. It is understood that greater ELs, particularly those common to the variable demands of team-sport training and competition, increase metabolic energy costs and soft tissue force absorption/production [19], consequently increasing ILs. This acute dose-response paradigm forms the basis of training theory [20] and is important for understanding the specific internal responses associated with various external training doses [21]. A better understanding of the relationships between internal and external training loads could enhance training prescription, periodization, and athlete management through a detailed assessment of training fidelity and efficacy [21, 22]. Additionally, IL-EL relationships can provide evidence for the construct validity and sensitivity of specific IL indicators [23]. Previous studies in team sports have shown that the correlation magnitudes between IL and EL range from trivial to very large, indicating that the relationship between these variables is not fully understood and raising questions about the validity of specific IL measures [24]. In these studies, IL has shown a possibly very large correlation with total distance, likely large correlations with accelerations and impacts, and likely moderate correlations with high-speed running distance [11]. Exploring the behaviour of IL and EL variables is pertinent in this context. Furthermore, there is a notable gap in understanding whether RPE can accurately represent or correlate with the EL experienced by athletes during specific training blocks within a training session because most existing studies associate RPE with the overall intensity of entire training sessions.

Therefore, this study aimed to compare the behaviour of IL (RPE) and EL (distance per min, sprint distance per min, accelerations, and decelerations) variables across blocks of a game-based training session. Identifying patterns in these relationships could facilitate a better understanding of the studied variables, providing coaches with insights about monitoring training loads during training sessions. The hypothesis is that the longer the block duration, the greater the IL and the lower the EL. Additionally, it is hypothesized that IL experiences a sharp increase when passing blocks due to the accumulation of fatigue, while EL would show the opposite trend. This, in turn, allows for adjustments in work and rest ratios, customization of activity volumes, modification of rules in training-based games, and adaptation of other components within the training session to optimize athlete performance and minimize the risk of injury or overtraining.

Material and methods

Study design

This study utilized a descriptive cross-sectional design to compare IL and EL variables across different blocks of a game-based Rugby Sevens training session. Conducted on a single day during the pre-season, the study monitored athletes during a full-field, game-based training session characterized by touch rugby rules and adapted regulations. In this modified format, when one player made contact with another using both hands to simulate a tackle, the player in possession of the ball was required to go to the ground and present the ball. A ruck with the attacking teammates would then be initiated. Conversely, the defending player who made the touch had to touch their chest to the ground and quickly return to their feet to resume play. During the blocks, if one team committed an infraction or scored a try, another ball was given to the opposite team, which was required to restart play immediately, ensuring continuous play throughout each block. The training session comprised four blocks of 1 min each (B1, B2, B3, and B4), two blocks of 2 min each (B5 and B6), and one block of 3 min (B7) of ball-in-play, with 1-min intervals between blocks of the same duration and 2-min intervals between blocks of different durations. RPE data were collected both before and after each block. GPS data were extracted using the Playertek Sync Tool software and transferred to Microsoft Excel® (version 16.79.1) after the training session. Time splits were applied live using the Playertek+ software to differentiate the workload experienced during each period. Only the workload within these designated periods was recorded, distinguishing it from efforts performed during other times. After the training session, EL (GPS data) and IL (RPE data) from each block were recorded for subsequent statistical analysis.

Participants

Twenty-eight female professional athletes (mean age = 26 ± 8 years; mean height = 170 ± 12 cm; mean body mass = 76 ± 21 kg; 7.5 ± 3.04 years of practice; 3.2 ± 2.6 years of professional experience) participated in this study. These athletes were actively engaged in games and competitions at the national first division (Brazil) and international levels. Their weekly routine consisted of four strength training sessions, each lasting 60 min, and 5–7 on-field training sessions, each lasting 45–75 min, with two days off (Wednesday and Sunday). The participants were classified at tier 4 of the Participants Classification Framework, indicating their competitive level within the sport [25]. Eligibility criteria included the following: (i) participation in at least one match of the Super Sevens 2023 championship; (ii) no injuries or illnesses in the 16 weeks before and during the experiment; and (iii) being part of the team for at least one full season before the study's commencement.

IL

RPE

To assess the RPE for the training blocks, the Borg CR-10 scale was used [13]. The scale was adapted into Brazilian Portuguese while maintaining equivalence to the original instrument [26]. The scale was explained to the athletes before the study, who were already familiar with it from their daily training sessions over the past four years. Immediately after the end of each block (defined as a pre-established period of uninterrupted ball-in-play during the game-based training session), each athlete was approached by a researcher to collect the RPE through verbal communication. Athletes did not communicate with each other before reporting their RPE. Values obtained at the end of each training block were used for mean comparisons.

EL

Distance per min, sprint distance per min, accelerations per min, and decelerations per min (GPS metrics)

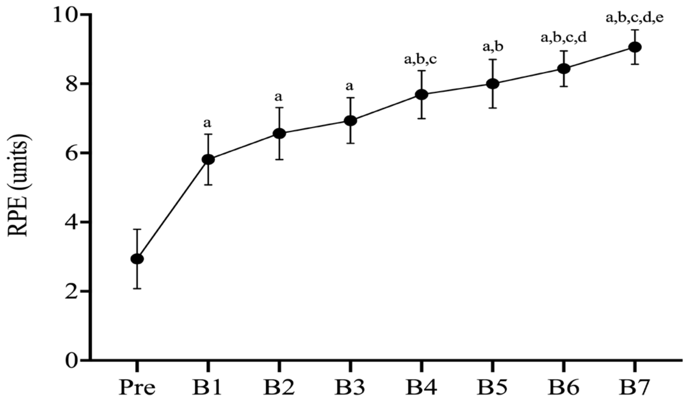
Data on distance per min (m/min), sprint distance per min (> 16 km/h), accelerations, and decelerations per min (> 3 m/s) were extracted using Playertek GPS units (GPS/GNSS 10 Hz, inertial sampling rate of 400 Hz recorded at 100 Hz; Catapult Sports, Australia). The validity and reliability of this specific device have not been communicated in the published literature. However, during lab-based trial tests, non-significant differences were observed between criterion measures and registered metrics for total distance and sprint distance [26]. Additionally, it was demonstrated that Playertek GPS devices did not show significant differences in running distances performed versus registered metrics on straight-line running protocols [27]. These units were equipped with a triaxial accelerometer and a gyroscope, which captured information on collisions and high-intensity efforts. The devices were secured in a small harness worn on the player's upper back. Device activation occurred 15 min before the start of the training session and ceased immediately after its conclusion. Athletes were familiar with the equipment, having used it regularly in their daily training sessions. The EL variables were analyzed for each training block.

Statistical analysis

Before conducting the analysis, tests for data distribution (Kolmogorov–Smirnov) and homogeneity (Levene's) were performed on all variables. Descriptive statistics were presented as mean ± standard deviation (*SD*) along with the 95% confidence interval. RPE, distance, sprint distance, acceleration, and deceleration measurements were assessed using repeated-measures ANOVA with a Tukey's post-hoc test to identify significant results among pre, B1, B2, B3, B4, B5, B6, and B7. Partial eta squared (η_p^2) was used to test the effect size of ANOVA (ES). Ferguson's classification for the ES was used: no effect (< 0.04); minimum effect (0.04–0.25); moderate effect (0.26–0.64); and strong effect (> 0.64) [28]. Statistical analyses were conducted using SPSS version 26 (IBM Corporation, New York, NY, USA) and Prism version 8.0 (GraphPad, San Diego, CA, USA), with a significance level set at $p < 0.05$.

Results

Figure 1 depicts the IL variable (RPE) throughout the training session. A progressive increase was observed [F (3.71, 55.66) = 62.65; p = 0.001; η_p^2 = 0.807], with significant elevations from B1 (η_p^2 = 0.421), B2 (η_p^2 = 0.460), and B3 (η_p^2 = 0.488) compared to pre-intervention levels (p = 0.001 for all cases). RPE for B4 was significantly higher than the pre-intervention level (p = 0.001; η_p^2 = 0.502), as well as B1 (p = 0.010; η_p^2 = 0.282) and B2 (p = 0.004; η_p^2 = 0.331). Similarly, B5 showed a significant increase over pre-intervention (p = 0.001; η_p^2 = 0.557) and B1 (p = 0.005; η_p^2 = 0.378). RPE for B6 was significantly higher than pre-intervention (p = 0.001; η_p^2 = 0.567), B1 (p = 0.001; η_p^2 = 0.298), B2 (p = 0.001; η_p^2 = 0.201), and B3 (p = 0.002; η_p^2 = 0.195).



a, b, c, d, e – different from pre, B1, B2, B3, B4, respectively

Figure 1. Rate of perceived exertion (RPE) mean values throughout training session blocks

Finally, RPE for B7 was greater than pre-intervention, B1 (η_p^2 = 0.553), B2 (η_p^2 = 0.522), B3 (η_p^2 = 0.499), and B4 (η_p^2 = 0.467; p = 0.001 for all cases).

Most of the EL variables showed a consistent reduction across blocks. Specifically, distance showed significant differences in ANOVA [F (3.65, 54.84) = 8.79; p = 0.001; η_p^2 = 0.370], with smaller distances in B5 compared to B1 (p = 0.021; η_p^2 = 0.296). Additionally, distances in B7 were reduced compared to B1 (η_p^2 = 0.274), B2 (η_p^2 = 0.251), B3 (η_p^2 = 0.223), B4 (η_p^2 = 0.199), and B6 (η_p^2 = 0.155; Figure 2A). For acceleration [F (3.40, 51.09) = 10.24; p = 0.001; η_p^2 = 0.406], B5 (η_p^2 = 0.221), B6 (η_p^2 = 0.202), and B7 (η_p^2 = 0.176) had significantly smaller values than B1 (p = 0.001 for all cases) (Figure 2C). Similarly, deceleration [F (3.30, 49.60) = 6.46; p = 0.001; η_p^2 = 0.301] for B5 (η_p^2 = 0.189), B6 (η_p^2 = 0.202), and B7 (η_p^2 = 0.236) was significantly smaller compared to B1 (p = 0.005 for all cases) (Figure 2D). Finally, there were no significant differences in sprint distance across blocks [F (3.47, 52.05) = 0.72; p = 0.729; η_p^2 = 0.046] (Figure 2B).

Discussion

This study aimed to assess the EL and IL experienced by female Rugby Sevens athletes during game-based training sessions. The study demonstrated a tendency for a reduction in work rates (m per min, accelerations, and decelerations above 3 m/s) as block times increased, and an increased tendency in IL, not only as block times increased but also with the accumulation of volume across blocks and the training session. When comparing EL between blocks, no differences were found between one block and its preceding block, except for the distance per min between B6 and B7. This occurred despite a 2-min interval between them, suggesting that longer bouts of ball-in-play and increased total volume during a training session may lead to fatigue accumulation. This accumulation could contribute not only to transient fatigue, characterized by a period of reduced intensity immediately following a peak, but also to more persistent fatigue, which hinders proper recovery between consecutive high-intensity efforts [4]. Similarly, Ball et al. [29] observed a decline in match intensity between halves, indicating player fatigue during matches. The two-min interval between halves may not provide adequate recovery for players to maintain intensity throughout the entire match [5, 30]. Additionally, research on Rugby Sevens-related injuries suggests that fatigued muscles are less capable of absorbing forces, increasing the likelihood of injury, with a higher incidence observed in the second half [31].

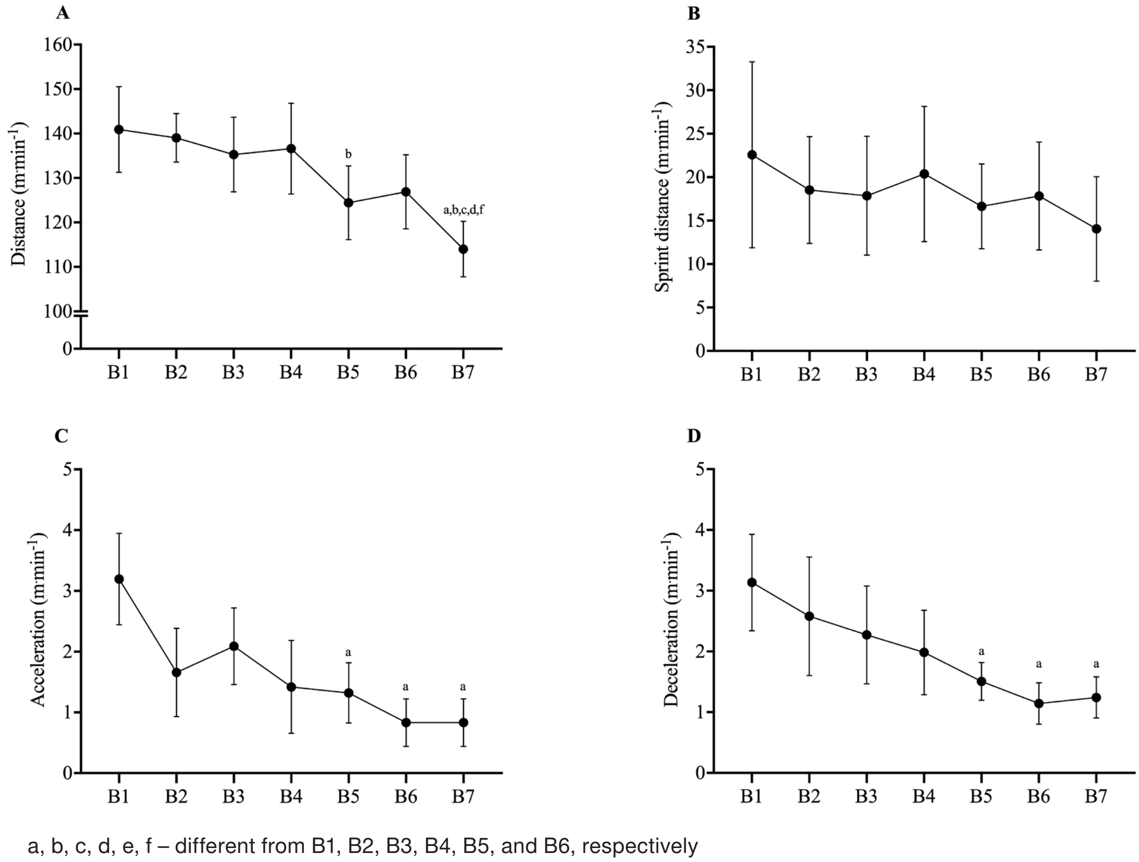


Figure 2. Distance (A), sprint distance (B), acceleration (C), and deceleration (D) mean values throughout training session blocks

Therefore, strength and conditioning coaches should incorporate training loads in their sessions that simulate worst-case scenarios to prepare athletes' anaerobic and aerobic systems to sustain work rates during moments of metabolic stress and facilitate recovery for subsequent plays. This approach aims to enhance performance and mitigate the risk of injuries.

Subjective RPE showed a progressive increase across blocks. This indicates that longer periods of ball-in-play can elevate RPE values, even as relative work rates decrease significantly. This finding aligns with Conte et al. [32], who found a strong relationship between total distance covered and RPE values during female Rugby Sevens matches, suggesting that RPE is more closely associated with volume rather than intensity of efforts. Conversely, Epp-Stobbe et al. [33] demonstrated that RPE encompasses various components contributing to athletes' load. In female Rugby Sevens, both the number of contacts and playing time influence how athletes perceive exertion during competition, with some factors remaining unexplained. Blair et al. [34] found no relationship between RPE values and EL in Rugby Sevens players. We also observed no significant differences in IL when comparing blocks longer than 2 min (B5, B6, and B7). This suggests that 2 min of ball-in-play in Rugby Sevens are sufficient to cause a considerable increase in IL compared to shorter efforts, given the intermittent and high-intensity nature of the game [3, 4].

It is important to highlight that during the first three blocks of the training session, no changes in EL and IL were found. In B4, an increase in IL was observed compared with B1 and B2, even though no differences were found for EL variables in comparison with previous blocks. This suggests that IL can show changes even if the players' capacity is maintained during specific training sessions based on small games with proportional work and recovery times. These findings align with McLaren et al. [11], who found that IL correlates more closely with total distance covered than with any other variable. As the blocks progress, the accumulation of total volume causes an increase in IL, indicating that RPE might not be the best choice for measuring the intensity of specific drills or small games.

Conversely, RPE appears to be a tool that could help control volume during training sessions, as IL seems to be more dependent on this variable. A deeper understanding of the relationship between EL and IL could lead to practical changes in training sessions, particularly regarding the volume, duration, and intervals of training drills and small games, based on athletes' subjective perceptions during training sessions. This approach offers a simple and cost-effective method, especially for physical trainers lacking sophisticated equipment to monitor session load. Further studies in rugby should compare and correlate total distance with IL during training sessions and compare small games with and without contact to determine how tackles, rucks, and breakdown situations affect players' IL.

Practical applications

– A deeper understanding of the relationship between EL and IL can lead to practical changes in training sessions, including adaptations in duration, volume, work rate, and intervals based on athletes' subjective perceptions during these sessions, thereby reducing the need for additional equipment.

– Coaches can implement training protocols for specific periods and monitor whether changes occur in athletes' IL with the same EL. Such changes would suggest a potential positive adaptation of athletes to the stimulus.

Conclusions

The findings of the present study were observed in relative distance work rates (m/min), accelerations, and decelerations, which decreased significantly during longer bouts of ball-in-play. Additionally, higher values of RPE were reported across blocks, particularly in those of longer duration. It was also demonstrated that IL appears to be more volume-dependent and, therefore, should not be used as a tool to measure the intensity of specific training drills or small games within a training session. However, it can help in controlling the volume of training sessions according to the coach's objectives. The RPE responses within training session blocks offer new insights into the dynamic changes in perceived effort throughout training and warrant further investigation. Future research could explore the potential correlation between relative work rates and subjective perception of effort to better understand their relationship.

Ethical approval

The research related to human use has complied with all the relevant national regulations and institutional policies, has followed the tenets of the Declaration of Helsinki, and has been approved by the Ethics Committee Universidade Federal de Mato Grosso (approval No.: 6.052.619).

Informed consent

Before participation, all participants were informed about the experimental procedures and associated risks of the research. They provided voluntary written informed consent and were aware they could withdraw from the study at any time.

Conflict of interest

The authors state no conflict of interest.

Disclosure statement

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References

[1] Duthie G, Pyne D, Hooper S. Applied physiology and game analysis of rugby union. Sports Med. 2003;33(13):973–91; doi: 10.2165/00007256-200333130-00003
[2] Ball S, Mark H, Orr R. Movement demands of Rugby Sevens in men and women: a systematic review and meta-analysis. J Strength Cond Res. 2019; 33(12):3475–90; doi: 10.1519/JSC.0000000000003197.
[3] Cunningham DJ, Shearer DA, Carter N, Drawer S, Pollard B, Bennett M, Eager R, Cook CJ, Farrell J, Russell M, Kilduff LP. Assessing worst case scenarios in movement demands derived from global positioning systems during international rugby union matches: rolling averages versus fixed length epochs. PLOS ONE. 2018;13(4):e0195197; doi: 10.1371/journal.pone.0195197.
[4] Furlan N, Waldron M, Shorter K, Gabbett TJ, Mitchell J, Fitzgerald E, Osborne MA, Gray AJ. Running-intensity fluctuations in elite Rugby Sevens performance. Int J Sports Physiol Perform. 2015;10(6):802–7; doi: 10.1123/ijspp.2014-0315.
[5] Higham DG, Pyne DB, Anson JM, Eddy A. Movement patterns in Rugby Sevens: effects of tournament level, fatigue and substitute players. J Sci Med Sport. 2012;15(3):277–82; doi: 10.1016/j.jsams.2011.11.256.
[6] Lacome M, Peeters A, Mathieu B, Marrier B, Carling C, Piscione J. Can we use GPS for assessing sprinting performance in Rugby Sevens? A concurrent validity and between-device reliability study. Biol Sport. 2019;36(1):25–9; doi: 10.5114/biolsport.2018.78903.

[7] Impellizzeri FM, Marcora SM, Coutts AJ. Internal and external training load: 15 years on. Int J Sports Physiol Perform. 2019;14(2):270–3; doi: 10.1123/ijspp.2018-0935.
[8] Granatelli G, Gabbett TJ, Briotti G, Padulo J, Buglione A, D'Ottavio S, Ruscello, BM. Match analysis and temporal patterns of fatigue in Rugby Sevens. J Strength Cond Res. 2014;28(3):728–34; doi: 10.1519/JSC.0b013e31829d23c3.
[9] Vescovi JD, Goodale T. Physical demands of women's Rugby Sevens matches: female athletes in motion (FAiM) study. Int J Sports Med. 2015;36(11); 887–92; doi: 10.1055/s-0035-1548940.
[10] Tee JC, Lambert MI, Coopoo Y. GPS comparison of training activities and game demands of professional rugby union. Int J Sports Sci Coach. 2016;11(2):200–11; doi: 10.1177/1747954116637153.
[11] McLaren SJ, Macpherson TW, Coutts AJ, Hust C, Spears IR, Weston M. The relationships between internal and external measures of training load and intensity in team sports: a meta-analysis. Sports Med. 2018;48(3):641–58; doi: 10.1007/s40279-017-0830-z.
[12] Foster C, Florhaug JA, Franklin J, Gottschall L, Hrovatin LA, Parker S, Doleshal P, Dodge C. A new approach to monitoring exercise training. J Strength Cond Res. 2001;15(1):109–15; doi: 10.1519/00124278-200102000-00019.
[13] Haddad M, Stylianides G, Djaoui L, Dellal A, Chamari K. Session-RPE method for training load monitoring: validity, ecological usefulness, and influencing factors. Front Neurosci. 2017;11:612; doi: 10.3389/fnins.2017.00612.
[14] Quarrie KL, Raftery M, Blackie J, Cook CJ, Fuller CW, Gabbett TJ, Gray AJ, Gill N, Hennessy L, Kemp S, Lambert M, Nichol R, Mellalieu SD, Piscione J, Stadelmann J, Tucker R. Managing player load in professional rugby union: a review of current knowledge and practices. Br J Sports Med. 2017;51(5):421–7; doi: 10.1136/bjsports-2016-096191.
[15] Comyns T, Flanagan EP. Applications of the session rating of perceived exertion system in professional rugby union. Strength Cond J. 2013;35(6): 78–85; doi: 10.1519/SSC.0000000000000015.
[16] Foster C. Monitoring training in athletes with reference to overtraining syndrome. Med Sci Sports Exerc. 1998;30(7):1164–8; doi: 10.1097/00005768-199807000-00023.
[17] Comyns T, Hannon A. Strength and conditioning coaches' application of the session rating of perceived exertion method of monitoring within professional rugby union. J Hum Kinet. 2018;61(1): 155–66; doi: 10.1515/hukin-2017-0118.
[18] Robertson S, Bartlett JD, Gastin PB. Red, amber, or green? Athlete monitoring in team sport: the need for decision-support systems. Int J Sports Physiol Perform. 2017;12(Suppl 2):273–9; doi: 10.1123/ijspp.2016-0541.
[19] Vanrenterghem J, Nedergaard NJ, Robinson MA, Drust B. Training load monitoring in team sports: a novel framework separating physiological and biomechanical load-adaptation pathways. Sports Med. 2017;47(11):2135–42; doi: 10.1007/s40279-017-0714-2.
[20] Impellizzeri FM, Rampinini E, Marcora SM. Physiological assessment of aerobic training in soccer. J Sports Sci. 2005;23(6):583–92; doi: 10.1080/02640410400021278.
[21] Bartlett JD, O'Connor F, Pitchford N, Torres-Ronda L, Robertson SJ. Relationships between internal and external training load in team-sport athletes: evidence for an individualized approach. Int J Sports Physiol Perform. 2017;12(2):230–34; doi: 10.1123/ijspp.2015-0791.
[22] Castillo D, Weston M, McLaren SJ, Cámara J, Yanci J. Relationships between internal and external match-load indicators in soccer match officials. Int J Sports Physiol Perform. 2017;12(7):922–7; doi: 10.1123/ijspp.2016-0392.
[23] Lovell TWJ, Sirotic AC, Impellizzeri FM, Coutts AJ. Factors affecting perception of effort (session rating of perceived exertion) during rugby league training. Int J Sports Physiol Perform. 2013;8(1): 62–9; doi: 10.1123/ijspp.8.1.62.
[24] Gallo T, Cormack S, Gabbett T, Williams M, Lorenzen C. Characteristics impacting on session rating of perceived exertion training load in Australian footballers. J Sports Sci. 2015;33(5):467–75; doi: 10.1080/02640414.2014.947311.
[25] McKay AK, Stellingwerff T, Smith ES, Martin DT, Mujika I, Goosey-Tolfrey VL, Sheppard J, Burke LM. Defining training and performance caliber: a participant classification framework. Int J Sports Physiol Perform. 2022;17(2):317–31; doi: 10.1123/ijspp.2021-0451.
[26] Mooney T, Malone S, Izri E, Dowling S, Darragh IAJ. The running performance of elite U20 Gaelic football match-play. Sport Sci Health. (2021);17: 771–9; doi: 10.1007/s11332-021-00760-9.
[27] Graham WJ. An investigation into GPS brand reporting differences and validation of a between-

brand calibration tool for football. Brisbane: Queensland University of Technology; 2021.
[28] Ferguson CJ. An effect size primer: a guide for clinicians and researchers. Prof Psychol Res Pract. 2009;40(5):532–8; doi: 10.1037/a0015808.
[29] Ball S, Halaki M, Orr R. Movement demands of Rugby Sevens in men and women: a systematic review and meta-analysis. J Strength Cond Res. 2019;33(12):3475–90; doi: 10.1519/JSC.0000000000003197.
[30] Goodale TL, Gabbett TJ, Tsai M-C, Stellingwerff T, Sheppard J. The effect of contextual factors on physiological and activity profiles in international women's Rugby Sevens. Int J Sports Physiol Perform. 2017;12(3):370–6; doi: 10.1123/ijspp.2015-0711.
[31] Fuller CW, Taylor AE, Raftery M. Should player fatigue be the focus of injury prevention strategies for international Rugby Sevens tournaments? Br J Sports Med. 2016;50(11);682–7; doi: 10.1136/bjsports-2016-096043.
[32] Conte D, Arruda AFS, Clemente FM, Castillo D, Kamarauskas P, Guerriero A. Assessing the relationship between external and internal match loads in elite women's Rugby Sevens. Int J Sports Physiol Perform. 2022;17(4):634–9; doi: 10.1123/ijspp.2021-0097.
[33] Epp-Stobbe A, Tsai MC, Morris C, Klimstra M. The influence of physical contact on athlete load in international female Rugby Sevens. J Strength Cond Res. 2023;37(2):383–7; doi: 10.1519/JSC.0000000000004262.
[34] Blair MR, Body SF, Croft HG. Relationship between physical metrics and game success with elite Rugby Sevens players. Int J Perform Anal Sport. 2017;17(4):418–28; doi: 10.1080/24748668.2017.1348060.