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Training loads and intensities: Impact on performance in amateur rugby players

Enric Conesa-Milian[1,2], Carme Jové-Deltell[1,2], Vicenç Hernández-González[1,2], Saül Aixa-Requena[1,2,*], Teresa Fonseca[3], Joaquín Reverter-Masia[1,2]

ABSTRACT

The article addresses the physical demands of amateur rugby, using global positioning system technology to analyze player performance during matches and training sessions. The results show that matches are more physically demanding than training, with greater distances covered, more sprints, and a higher number of impacts. However, training sessions adequately replicate accelerations and decelerations, although there are fewer physical contacts to avoid injuries. Additionally, an improvement in players' aerobic capacity was observed after five weeks of training, highlighting the need to personalize training sessions to optimize individual performance.

KEYWORDS: rugby; training toad; GPS tracking; physical performance; aerobic capacity; player monitoring.

INTRODUCTION

In the context of high-performance sports, the ability to continuously monitor and control players has become a key aspect of organization and competitive preparation (Busbridge et al., 2022; Jones et al., 2015). In sports like Rugby Union, characterized by its complex dynamics and high level of physical contact, players' physical capacities are essential to optimize individual performance. Since the professionalization of rugby in 1995, there has been a considerable increase in research related to the physical and conditional demands of this sport, especially in professional male players (Cunningham et al., 2016; Pollard et al., 2018; Yamamoto et al., 2020).

To analyze player performance in the game, time-motion analysis (TMA) has been a useful tool, though it has limitations due to its laborious nature and impracticality for continuous and detailed assessments (Deutsch et al., 2007). However, with the incorporation of global positioning system (GPS) technology, there has been a significant improvement in the accuracy, speed, and reliability of the data obtained. These devices measure key aspects such as distance covered, speed, the number of accelerations and decelerations, contacts, and the physical load on players, among other parameters. The detailed analysis of these data enables the creation of specific player profiles based on their position, playing style, and competition characteristics, contributing to more personalized and effective training (Campbell et al., 2018; Reardon et al., 2015; Zanin et al., 2021).

However, while GPS-based analysis provides valuable insights into external load parameters, understanding internal load, such as heart rate responses and subjective effort perception, is crucial to comprehensively evaluate training adaptations and physiological stress (Gabbett, 2016; Taylor et al., 2020). Training impulse method (TRIMP) has used as method to evaluate the internal load analyzing the high heart rate exertion (Dubois et al., 2017). Nevertheless, in rugby union the HR max is around 80%, therefore it should not be a limiting factor, but it can help the coaching staff to

[1]University of Lleida, Human Movement Research Group – Lleida, Spain.
[2]University of Lleida, Physical Education and Sport Section – Lleida, Spain.
[3]Instituto Politecnico da Guarda – Guarda, Portugal.

*Corresponding author: Avenida De l'Estudi General, 4 – CEP: 25001 – Lleida, Spain. Email: saul.aixa@udl.cat

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develop certain drills and constraint situations (Blair et al., 2018; Dubois et al., 2017).

Given the growing body of research focused on the physical demands of Rugby Union at the professional level (Blair et al., 2018; Dubois et al., 2017), it is crucial to understand how these findings can be extrapolated or adjusted to amateur contexts, where physical, technical, and tactical characteristics may differ considerably. This study aims to analyze the demands of an amateur rugby team using GPS data to better understand the game's demands and assess their impact on player performance and aerobic capacity throughout the season practices.

METHOD

The study employed a quasi-experimental longitudinal design, collecting data before and after a five-week training intervention to assess changes in players' physical performance, with GPS technology used to compare variables between training sessions and matches, as well as across different player positions.

Participants

All participants were recruited based on the general inclusion criteria. The sample consisted of 10 active players with more than six years of rugby experience (age: 28.67 ± 6.66 years). A non-probabilistic convenience sampling method was used. Players who had suffered injuries in the four weeks prior to the study or who had not completed the regulation 80 minutes of matches were excluded. The players were classified into two groups: forwards (front row, hooker, second and third rows) and backs (scrum-half, fly-half, centers, wings, and fullback). The anonymity and confidentiality of participants were always ensured. The collected data were coded, so no information that could personally identify the participants was stored. The data were used exclusively for research purposes and were kept on secure servers, accessible only to the research team.

Although the sample size was relatively small (n = 10), strict inclusion criteria and rigorous statistical procedures were implemented to maximize the reliability of the findings.

Additionally, all participants were informed of the study's objectives and provided written informed consent prior to participating. The measures taken comply with current regulations on personal data protection and the Declaration of Helsinki on ethical principles for research involving human subjects.

The procedures of this study were approved by the Clinical Research Ethics Committee of the Sports Administration of Catalonia (30/CEICGC/2020).

The participants' anthropometric characteristics are presented in Table 1.

Measures

The devices used were Catapult One GPS units with a sampling frequency of 10 Hz, placed on the upper middle back of the players using adjustable vests, which allowed for precise recording of variables such as distance covered, maximum speed, accelerations and decelerations, impacts, and sprints. These devices were placed on the upper middle back, between the shoulder blades, using adjustable vests recommended by the manufacturer, ensuring precise measurement of the physical variables. These devices don't give heart rate information just external load parameters.

Procedures

The study was designed to analyze the physical demands of rugby union players from a first division amateur team, using GPS technology with built-in accelerometers. Data was collected during both official matches and training sessions throughout the 2023–2024 season, specifically in the months of February and March. Five consecutive microcycles were analyzed, which included a total of 10 training sessions and 5 matches.

Before the intervention, initial assessments were conducted to describe the players' physical and conditional profiles. The Bronco Test was also used to assess the participants' aerobic capacity, and it was repeated at the end of the five microcycles to analyze possible improvements in this capacity.

Statistical analysis

The data were analyzed using descriptive and comparative statistics. Means and standard deviations (M ± SD) were calculated for each quantitative variable. To compare differences between matches and training sessions, as well as between groups (forwards vs. backs), Student's t-tests for dependent samples were used when the data met the normality assumptions (verified by the Shapiro-Wilk test). In cases where the normality assumption was not met, the Wilcoxon test was used. The significance level was set at $p < .05$. Effect sizes were also calculated using Cohen's d to assess the magnitude of the observed differences, with the following interpretation criteria: small (0.2), moderate (0.5), and large (0.8). All statistical analyses adhered to standard normalization assumptions. The Shapiro-Wilk test was used to verify normality, and appropriate parametric or non-parametric tests were applied accordingly to ensure the validity of the comparisons. Statistical analysis was performed using the IBM

Table 1. Anthropometric characteristics.

	Age (years)	Height (cm)	Weight (kg)
Forwards	28.67 ± 6.66	182.33 ± 9.07	105.33 ± 18.58
Backs	28.43 ± 6.13	177.33 ± 2.31	79.43 ± 6.21

Statistical Package for Social Sciences (IBM SPSS Statistics, v. 24.0 WINDOWS).

RESULTS

The data obtained reveal clear differences between training sessions and matches in terms of physical demands, as recorded by the GPS. The most important results are highlighted below:

- Distance covered: Both forwards and backs covered less distance during training sessions (5.37 ± .65 km) compared to matches (6.17 ± .97 km), with a significant difference (p = .002, d = 1.96) (Table 2). This difference was more pronounced in the backs, who showed greater variation in total distance covered between the two situations (Table 2). Consequently, the distance covered per unit of time (*m/min)* is higher in matches than during training sessions (88.70 ± 28.65 m/min vs. 48.10 ± 5.39 m/min; p = .005, d = 1.66) (Table 3).
- Sprint distance (> 18 km/h): A significant difference was observed in the distance covered at high speed. No player, whether a forward or back, exceeded 50% of the sprint distance covered during training compared to matches (509.17 ± 300.74 m vs. 187.68 ± 110.21 m; p = .005, d = 1.61).
- Top speed: No significant differences were found in the maximum speed values reached between training sessions and matches (30.02 ± 2.54 km/h vs. 28.80 ± 3.73 km/h; p = .259, d = .47).
- Accelerations and decelerations: No significant differences were found in the number of accelerations and decelerations (> 3 m/s^2) between training sessions and matches. However, these actions were slightly higher during matches (88.94 ± 20.71 vs. 87.36 ± 30.10; p = .832, d = –.08).
- Impact*s* (> 5G): The number of impacts was significantly higher during matches (7.52 ± 2.56) than in training sessions (5.04 ± 2.77; p = .029, d = 1.08), reflecting the greater demands for physical contact in a competitive context.
- Aerobic capacity: All players showed improvement in their Bronco Test results after the five training microcycles (Table 4), with improvements ranging from 2% to over 10% (from 5:19 ± 0:12 min to 5:02 ± 0:20 min (p = .007, d = 1.52). This indicates a significant improvement in aerobic fitness, although individual responses varied among players.

In summary, the results indicate that competition presents greater physical demands than training, especially in distance covered, sprints, and impacts. Additionally, the improvement in aerobic capacity suggests that the training applied contributed to the development of the players' physical performance.

DISCUSSION

Distance covered

The shorter distance covered during training compared to matches can be attributed to the modification of spaces and the inclusion of small-sided games in training sessions. These adaptations limit the movement area and, along with the specific rules of the exercises, restrict the need for longer-distance running. Additionally, with less need for repositioning

Table 2. GPS values from matches and training sessions per position.

Position	Distance (km)		Sprint distance > 18 km/h (m)		Top speed (km/h)		m/min (m)		Acc/dec > 3 m/s^2		Impacts > 5G	
	Match	Training	Match	Training	Match	Training	Match	Training	Match	Training	Match	Training
Front row	4.98 ± 1.04	4.40 ± 1.14	147.51 ± 93.11	82.97 ± 98.59	27.53 ± 2.39	28.62 ± 3.31	65.32 ± 4.56	40.57 ± 7.93	56 ± 15.11	64.60 ± 41.36	5.54 ± 2.17	3.10 ± 2.17
Hooker	6.18 ± 0.86	5.79 ± 0.56	294.94 ± 111.48	120.12 ± 80.49	26.72 ± 1.92	25.73± 2.45	73.46 ± 3.89	50.19 ± 4.03	73.46 ± 15.82	68.15 ± 22.91	6.77 ± 3.34	3.30 ± 2.14
Second row	4.96 ± 1.25	4.59 ± 1.01	178.24 ± 168.97	30.85 ± 29.21	29.41 ± 2.38	23.49± 2.11	47 ± 4.09	41.22 ± 6.97	47 ± 17.37	80.58 ± 45.72	5.67 ± 3.16	2.42 ± 3.16
Back row	6.40 ± 1.04	5.44 ± 1.19	545.77 ± 200.68	225.43 ± 176.62	29.86 ± 1.30	27.01± 2.82	102.81 ± 6.78	48.86 ± 8.47	102.81 ± 28.86	91.17 ± 34.54	9.96 ± 4.95	4.42 ± 4.95
Scrum-half	7.67 ± 0.30	6.18 ± 1.23	840.96 ± 189.05	245.15 ± 162.23	30.42 ± 1.53	30.19± 2.70	115.54 ± 4.33	55.47 ± 7.10	115.54 ± 16.03	125.25 ± 48.36	12.23 ± 4.28	9.08 ± 4.28
Fly-half & centers	6.85 ± 0.36	5.78 ± 1.21	783.80 ± 196.35	323.10 ± 196.79	32.10 ± 1.93	33.93± 3.29	127.27 ± 4.75	51.25 ± 7.15	127.27 ± 20.45	101.08 ± 27.16	7.50 ± 4.59	9.42 ± 4.59
Wings & fullback	6.14 ± 1.06	5.44 ± 1.10	772.99 ± 239.89	286.13 ± 214.08	34.11 ± 1.75	32.61± 3.61	89.47 ± 7.10	49.14 ± 7.56	89.47 ± 27.46	91.77 ± 33.75	5 ± 2.81	3.54 ± 2.81

in small-sided games, especially for players away from the ball, the total distance covered decreases significantly compared to competition (Zanin et al. 2021).

Sprint distance (> 18 km/h)

The greatest difference observed between training and competition is in the distance covered at high speed (> 18 km/h). The lack of sprints in training could be related to the absence of tasks involving high-speed running. To mitigate the risk of injuries during matches, it would be advisable to include exercises or situations that demand higher-speed movement. While it is not necessary to continuously expose players to these demands, replicating competition-like demands during training would better prepare the players and reduce the gap in exposure to these speeds (Blair et al. 2018; Gabbett 2006; Yamamoto et al. 2020).

Maximum speed

No significant differences were observed in the peak speed values reached between training and matches. This suggests that players could reach their maximum speeds in both training and competition, indicating that the training conditions, while not perfect, allow players to perform high-intensity efforts. However, it could be beneficial to introduce specific tasks that stimulate players to reach and improve their maximum speed values in game-like situations. Reproducing high-intensity situations, in this case, maximum speed, during training could help reduce muscle injuries (Malone et al. 2017).

Distance per unit of time (m/min)

The higher meters covered per minute in matches compared to training is partly due to the competitive intensity of matches. In competition, players are more motivated, leading them to run more and react faster to the changing demands of the game. Training sessions, on the other hand, include lower-intensity periods, focused on recovery, and technical and tactical learning, which explains the difference in relative intensity. Additionally, in an actual match, the dynamics are continuous, with fewer opportunities for rest, which also contributes to players covering more ground compared to training (Deutsch et al. 2007; Dubois et al. 2020).

Accelerations and decelerations

The results show that training adequately replicates acceleration and deceleration situations, especially through small-sided games. These exercises allow players to experience a similar physical demand profile to that of matches in terms of quick speed changes. Therefore, the designed training sessions seem effective in replicating this type of physical demand, providing an appropriate environment for developing players' capacity for accelerations and decelerations (Campbell et al. 2018).

Impacts

The number of impacts is significantly lower in training than in matches, which is an intentional measure to reduce injury risk. Training sessions typically focus on technique and tactical preparation, limiting strong physical contact (Paul et al. 2022). Additionally, the intensity of training is lower than that of matches due to the absence of competitive pressure. This aligns with World Rugby recommendations, which suggest not exceeding 15 minutes of actual contact per week as part of a strategy to preserve physical condition and minimize injuries throughout the season (World Rugby, 2021).

Aerobic fitness level

The Bronco Test, widely used internationally, is effective for assessing players' aerobic fitness levels. The results indicate an improvement in all players after the five weeks of training, suggesting that both specific training and competition contribute to improving aerobic capacity, at least in amateur players. However, the variability in improvement among players reflects the differences in level within the

Table 3. GPS values from matches and training sessions from all players.

	Match	Training	*p*	*d*
Distance (km)	6.17 ± 0.97	5.37 ± 0.65	.002**	1.96
Sprint distance (> 18 km/h) (m)	509.17 ± 300.74	187.68 ± 110.21	.005**	1.61
Top Speed (km/h)	30.02 ± 2.54	28.80 ± 3.73	.259	.47
m/min	88.70 ± 28.65	48.10 ± 5.39	.005*	1.66
Acc/dec (> 3 m/s²)	87.36 ± 30.10	88.94 ± 20.71	.832	–.08
Impacts > 5G	7.52 ± 2.56	5.04 ± 2.77	.029*	1.08

$^*p < .05$; $^{**}p < .01$.

Table 4. Pre- and post-bronco test results.

Position	Pre-test (min)	Post-test (min)	p	d
Front row	5:46	5:29		
Hooker	5:36	5:17		
Second row	5:18	5:03		
Back Row	5:30	4:49		
Scrum-half	4:52	4:44		
Fly-half & centers	5:31	5:27		
Wings & fullback	4:46	4:27		
All players	5:19± 0:12	5:02± 0:20	.007**	1.52

$^{**}p<0.01$.

team, a common characteristic in groups of amateur players. This highlights the importance of individualizing training where possible to address the different needs of each player (Hu et al. 2024).

Study limitations and suggestions for future research

This study provides valuable insights into the physical demands of amateur rugby players, but it has some limitations that should be considered. The small sample size limits the generalizability of the results, so future studies should include more participants. Additionally, the five-week study duration may not be sufficient to observe long-term physical adaptations. Longer studies would allow for the assessment of training impacts over an entire season. Moreover, the GPS units used did not record heart rate data, preventing the analysis of individual physiological responses to effort.

Using the tactical periodization as a coach's strategy to develop practices in order to replicate game demands could be an approach to enhance physical performance and improve the relevance and efficiency (specificity) of training (Hu et al., 2024; Tee et al., 2018).

There is also a lack of comparisons with professional players, which would help identify key differences in physical demands and training strategies between competitive levels. Future research should expand physical monitoring, include additional technologies, explore injury prevention strategies, and conduct studies with female players, as women's rugby has been under-researched. These steps would enhance the understanding of rugby demands in different contexts and help optimize training programs.

CONCLUSIONS

Replicating the conditions of competition in training is challenging, especially in a contact sport, as the inherent constraints of the tasks and the high risk of injury make it difficult to create scenarios with high similarity. The total distance covered in training is significantly lower than in matches, which can be explained by the nature of the activities performed in training, such as small-sided games and the modification of spaces. These adaptations, while useful for technical and tactical learning, do not fully replicate the physical demands of a real match. With regard to sprint distance, there is a clear difference in the distance covered at high speed between training and matches, particularly for back positions. This lack of exposure to high-speed running during training may increase the risk of injuries in competition, so it is recommended to include exercises that demand high-speed movement.

In terms of maximum speed, no significant differences were observed between training and matches. This suggests that training conditions allow players to reach speeds comparable to those of matches, although it would be beneficial to replicate situations that induce maximum speed in training to optimize performance. Training sessions seem to adequately replicate the acceleration and deceleration demands observed in matches, particularly through the use of small-sided games. This indicates that training sessions are well-designed to develop the players' physical response capacity.

The number of impacts is considerably lower in training than in matches, which is aimed at reducing the risk of injury. However, the significant difference in the number of impacts between training and competition highlights the importance of balancing physical preparation with the preservation of players' health.

Aerobic fitness levels improved in all players after five weeks of intervention; however, we cannot attribute the improvements solely to training, as competition also played a role. The variability in individual improvements highlights the differences in level among amateur players, suggesting the importance of personalizing training based on individual needs.

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