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Original Article

Tolerance to chronic neuromuscular fatigue during a training microcycle in a European Rugby Team

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ABSTRACT

The aim of this study was to analyze the chronic neuromuscular fatigue over the course of training microcycle (one week) in 27 rugby players, differentiating between professional ($n = 10$) and non-professional ($n = 17$) athletes from the same team, as well as considering training load distribution and playing positions. A retrospective observational study was conducted, in which participants performed countermovement jumps (CMJ) before and after training sessions using a Chronojump Boscosystem contact platform. A total of 464 jumps were analyzed (234 pre- and 230 post-training), recording metrics such as jump height, flight time, average propulsive power, and initial velocity.

Professional players showed higher values in jump height (39.36± 4.24 cm), average power (1348.34±149,72 W) as well as a better reactive strength index (0.57), compared to non-professionals, who exhibited accumulated reductions in jump height (35,32± 6.80 cm), power (1176,62±26,96 W), and initial velocity (2,65±0,26 m/s) throughout the microcycle, indicating greater neuromuscular fatigue. Regarding playing positions, front-row players demonstrated lower average jump height (34.95±7,97 cm), while backline players stood out for higher speed (2.823±0,15 m/s) and power for back row (1381.92±171,87 W).

A positive effect of gym-based activation exercises prior to field training was observed, associated with improvements in jump height (38.62±6,07 cm vs. 36.31±6,05 cm; $F = 14.8$; $p < 0.01$; SE=0.03) power (1298.48 ±203,3 W vs. 1231.26±166,47 W), and initial velocity (2.75±025 m/s vs. 2.66±0,22 m/s). suggesting a post-activation potentiation (PAP) effect that could temporarily enhance neuromuscular performance. Therefore, incorporating PAP protocols before field sessions may be an effective strategy to optimize athletes' physical performance.

Introduction

The different codes of rugby—namely rugby union, rugby league, and rugby sevens (hereafter referred to as rugby)—are team sports that place multiple complex demands on players, particularly physical challenges.[1] Rugby is characterized by intermittent gameplay that alternates between high-intensity efforts and physical contact, interspersed with periods of lower intensity,[2] across two 40-minute halves. The specific features of each sport, including rugby, define the physical demands and fundamental movement patterns that shape their specific activity profiles.[3]

Senior rugby league matches typically result in significant muscle damage, neuromuscular fatigue, and perceptual fatigue.[4] In rugby, fatigue is defined as a reduced capacity to perform performance-related

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tasks, underpinned by time-dependent negative homeostatic changes across multiples domains particularly the cognitive, neuromuscular and physiological domains.[1] Neuromuscular fatigue in humans has been described as any exercise-induced reduction in maximal voluntary strength or power produced by a muscle or muscle group, influenced by the type of muscle contraction, exercise intensity, and duration.[5] This residual fatigue and/or muscle damage may worsen perceptions of well-being and muscle soreness, reduce external load output, and impair athletes' ability to perform high-intensity movements in subsequent training sessions and matches.[6]

Evidence suggests that the inclusion of movements involving the stretch-shortening cycle (SSC)[7] offers a more specific assessment of neuromuscular fatigue. The SSC in human skeletal muscle provides unique opportunities to study both normal and fatigued muscle function.[8] Since the SSC places substantial mechanical stress on skeletal muscles, its influence on reflex activation becomes evident and notably different from isolated forms of muscular action. Consequently, fatigue phenomena are normally and expectedly explored during SSC-based activities.[9]

One of the most widely used performance tests is the vertical jump. Among these, the countermovement jump (CMJ) has been utilized to monitor (a) the positive effects of strength, endurance, speed, and plyometric training, and (b) the mechanical and neuromuscular fatigue status in both individual and team sports.[10–12]

The CMJ has been frequently investigated and is commonly employed as a monitoring tool in elite sport.[10,13] In contact sports such as rugby, where physical demands are high and variable, the CMJ has become a valid and practical tool to monitor neuromuscular status, power, and reactivity.[14,15] CMJ testing is considered a key performance metric in rugby league, and the force platform is the recommended tool for evaluating CMJ performance in this cohort.[16] Averaged jump results could be more sensitive than the highest jump when it comes to detecting fatigue or supercompensation chronic effects.[17]

It is also important to assess accumulated neuromuscular fatigue throughout a training microcycle during the competitive period, as this allows for better control of training loads and, consequently, enhanced performance in both professional and non-professional players. One of the main objectives of coaching staff is training periodization. This is organized into training days and weekly microcycles. Load design, planning, and distribution are tailored to playing position and aim to achieve an appropriate balance to generate positive adaptation while minimizing injury risk[18–21] and avoiding excessive neuromuscular fatigue. It has also been observed that muscle performance during the CMJ can be significantly enhanced following heavy resistance training if an adequate recovery period of approximately 8 min is allowed,[22] and that post-activation potentiation (PAP) may help counteract fatigue during endurance exercise.[23]

In European rugby—particularly in leagues with limited financial resources—players with varying levels of professionalization often coexist. This heterogeneity in player status entails differences in training availability and recovery capacity, which may directly influence training responses. To better categorize player development and competitive level, athletes can be grouped into tiers. Professional players belong to levels 3–4 of the McKay classification: have reached a high national or international level, achieving medals and finalist positions in national, continental, and international competitions, demonstrating competitive skills. In contrast, non-professional players are classified at level 2; they are in a developmental stage, without a specific performance standard and with limited skill development.[24]

The aim of the present study was to investigate accumulated neuromuscular fatigue over the course of a training microcycle, comparing professional and non-professional players from the same team, considering differences in training loads and playing positions, and to determine whether post-activation potentiation (PAP) prior to training sessions optimizes players' physical performance.

Method

A total of 27 rugby players from the first team of UE Santboiana, a club competing in Spain's División de Honor rugby league (age range: 20–32 years), participated in the study during a competitive microcycle in February of the 2023/24 season. The forwards group ($n = 15$) had an average height of 183 cm ± 11 cm and a body weight of 104 kg ± 14 kg, while the backs ($n = 12$) had an average height of 175 cm ± 10 cm and a body weight of 81 kg ± 11 kg. Of the 27 players, 10 had full professional contracts, while the remaining 17, despite having contractual ties with the club, combined rugby with other professional or academic commitments.

The inclusion criteria required all participants to be of legal age and members of the first-team squad. Any jumps not recorded both before and after training were excluded from the analysis. All players were evaluated within their usual training routines, ensuring no additional injury risk because of study participation. Both the players and the club were fully informed about the objectives, potential benefits, and risks of the study, and provided informed consent. Players were also assured that they could withdraw consent or request exclusion of their data at any time without affecting their team involvement or training program.

Each weekly microcycle followed a systematic and recurring schedule:

- Monday: rest and active recovery
- Tuesday and Wednesday: double sessions for professional players, consisting of strength training and technical–tactical work in the morning, followed by group training in the evening for both professionals and non-professionals (the latter completed strength training in the gym prior to the evening session)
- Thursday: rest
- Friday: an evening group session divided into two parts—a first component focused on strength and individual technique, followed by a second component of team-based match preparation involving both professional and non-professional players
- Saturday: depending on the competitive calendar, players either rested, traveled, or played a match in the afternoon
- Sunday: generally reserved for official matches held at midday if not played on Saturday.[2]

Additionally, each player followed an individualized injury-prevention program including strength routines or specific exercises performed before group training sessions. To compensate for differences in competitive load, players who had limited playing time over the weekend completed compensatory training on Mondays[25,26]

Data processing was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki, as revised in Fortaleza (World Medical Association, 2013). The study protocol was approved by the Clinical Research Ethics Committee of the Sports Administration of Catalonia (reference number: 012/CEICGC/2022).

All evaluations were conducted under the direct supervision of the team's two strength and conditioning coaches, who also served as co-authors of this study (PP and TC), ensuring consistency in the execution and data recording. Eighteen of the participants had also taken part in a related performance variable study during the same season.[27]

Study design

A retrospective observational study was conducted over the course of one season involving a professional rugby team (UE Santboiana). Data collection was carried out during the third week of February 2023, coinciding with the ongoing 2022/23 season of the Spanish División de Honor men's rugby league.

Participants performed a countermovement jump (CMJ), a widely used test to help coaches assess changes in performance[28] and fatigue levels.[29] Jump performance was assessed via flight time using the

Chronojump Boscosystem contact platform (v.1.7.0 for Windows, CHRONOJUMP Boscosystem®, Barcelona, Spain), which has demonstrated good reliability for vertical jump measurement (ICC = 0.95) .[30]

The protocol identified as most time-efficient for professional rugby players consists of averaging three jump height attempts.[31] Thus, each athlete performed three jumps, and data analysis included the mean jump height, reactive strength index, average power output, and peak power output. A 30-second recovery period was provided between jumps. During the knee and hip flexion movement, athletes were instructed to maintain an upright trunk posture to prevent any influence of torso extension on lower-limb performance. For each attempt, the athlete stood on the platform, facing forward, with hands on hips. They executed a fast downward movement (eccentric phase) to approximately 90° of knee flexion (isometric or coupling phase), keeping the trunk close to the vertical axis, followed by an upward propulsion (concentric phase) to achieve maximal vertical take-off. During flight, athletes were required to maintain full extension of the lower limbs and trunk until landing back on the platform.[31, 32]

A familiarization session was held during the previous week's microcycle, allowing players to practice proper technique. Landing mechanics required the player to initially receive the impact in plantar flexion at the ankle (ankle joint extension), followed by knee and hip extension, before absorbing the ground reaction force via flexion of the lower-limb joints.[32]

Following a short warm-up (approximately 10 min) consisting of dynamic stretches, joint mobility, and lower-body activation drills, maximal effort CMJs were performed roughly 3 min post-warm-up, with each of the three jumps separated by 30 s of rest.

Workload programming, both conditional and technical–tactical, followed a consistent structure across mesocycles, with an average duration of 6 ± 2 weeks to ensure homogeneity in training stimuli.

Performance variables

Jump height (HJ) in centimeters (cm), flight time (FT) in seconds (s), average propulsion power (Pwr) in watts (W), and initial velocity (Vel.) in meters per second (m/s) were the recorded variables for each valid jump performed.[32] Reliability was determined, showing the following intraclass correlation coefficient (ICC) 95 % CI = 0.03 to −0.05; coefficient of variation (CV) interval values at 95 % CI = 0.09 – 0.16, and effect size (ES) = Cohen's d 0.0 – 0.4.[27]

Statistical methods

All data are presented as mean ± standard deviation (SD). After conducting a descriptive analysis of central tendency and confirming the normal distribution of the sample with the Shapiro-Wilk test, one-way ANOVA test was applied to identify potential differences between variables and groups. A Bonferroni post-hoc test was used to assess possible differences between playing positions. All statistical analyses were performed using JASP software version 0.11.1 (The JASP Team, Amsterdam, Netherlands). The significance level was set at $p < 0.05$.

Results

A total of 464 valid jumps were analyzed from 472 jumps performed attending to the inclusion criteria (98,31 %), 234 before each training session (PRE) and 230 after the completion of training (POST). These were performed before and after the sessions throughout a weekly microcycle consisting of five sessions (two morning and three evening) for PRO and three evening sessions for NONPRO. Each player completed 24.42 ± 6.5 jumps, with a range of 2 to 10 tests performed depending on their participation in full training sessions (8.14 ± 5.5). The mean values (±SD) for the variables analyzed were HJ: 37.58 ± 5.89 cm; FT: 0.55 ± 0.05 s; Pwr.: 1268.34 ± 182.92 W; and Vel.: 2.71 ± 0.22 m/s.

Considering the descriptive results, at the individual level pooled data showed, prior to training sessions (PRE), the mean height was 37.68 cm (± 5.60), with a maximum of 51.38 cm and a minimum of 23.29 cm; flight time was 0.55 s. (± 0.04), with a maximum of 0.65 s. and a minimum of 0.44 s.; mean power output was 1272.09 W (± 183.62), with a maximum of 1800.56 W and a minimum of 964.39 W; and initial velocity was 2.71 m/s. (± 0.21), with a maximum of 3.18 m/s. and a minimum of 2.14 m/s. After training sessions (POST), the mean values were: height of 37.48 cm (± 6.19), with a maximum of 50.40 cm and a minimum of 17.41 cm; flight time of 0.55 s. (± 0.05), with a maximum of 0.64 s. and a minimum of 0.38 s.; mean power output of 1264.54 W (± 182.53), with a maximum of 1646.69 W and a minimum of 941.36 W; and initial velocity of 2.70 m/s. (± 0.23), with a maximum of 3.14 m/s. and a minimum of 1.85 m/s (Table 1).

Considering the results throughout the week regarding jump height, non-professional players (NONPRO) had a mean height of 36.83 cm (± 6.56) during the first training session (Tuesday afternoon); 35.57 cm (± 7.49) in the second session (Wednesday afternoon); and 34.22 cm (± 6.11) in the third and final session (Friday afternoon). Professional players (PRO) averaged 39.26 cm (± 4.94) in the first training session (Tuesday morning); 40.12 cm (± 4.99) in the second session (Tuesday afternoon); 38.68 cm (± 2.44) in the third session (Wednesday morning); 38.69 cm (± 2.44) in the fourth session (Wednesday afternoon); and 39.96 cm (± 3.77) in the fifth and final session (Friday afternoon).

Furthermore, when considering the average results for the entire microcycle, the mean jump height for PRO was 39.36 cm (± 4.24), while for NONPRO it was 35.32 cm (± 6.80) (Table 2).

A greater mean standard deviation was observed in the NONPRO players (± 6.80) compared to the PRO players (± 4.24).

A decrease in jump height values throughout the week was also observed, although an increase occurred during the double training sessions for the professional players (PRO), with an increase of >1 cm in the final session of the microcycle (Table 3.1). In contrast, the non-professional players (NONPRO) showed a continuous decline in jump height values throughout the entire microcycle (Table 3.2).

Jump height, power, and initial velocity were higher in players who performed strength exercises in the gym (Gym) prior to the CMJ test. The mean jump height was 36.31 cm (± 6.04) for the NoGym group and 38.62 cm (± 5.57) for the Gym group; mean power output was 1231.26 W (± 166.40) for NoGym and 1298.34 W (± 190.48) for Gym; and initial velocity was 2.66 m/s (± 0.23) for NoGym and 2.75 m/s (± 0.21) for Gym (Table 4).

The subsequent statistical analysis showed that, for all team members, significant differences were observed in jump height (HJ) depending on whether they had performed gym work before the start of training or not ($F = 14.8$; $p < 0.01$; w^2=0.02). By playing positions, differences were also found ($F = 24.43$; $p < 0.01$; w^2=0.07). The post-hoc analysis revealed significant differences between each of the positions (front row, second row, and back row; halves, and back three). Significant differences were only not found between front row and second row, and between back row and halves. The test showed significant differences ($t = 2.12$ – -8.41; $p < 0.01$; Cohen's d = 0,41 – 0,08).

Discussion

The present study aimed to analyze the behavior of neuromuscular fatigue throughout a competitive microcycle in professional and non-professional rugby players, using the countermovement jump (CMJ) as the primary tool to assess performance status. This test has proven sensitive to both acute and chronic variations in training load,[33] enabling the detection of neuromuscular alterations due to accumulated load.

By analyzing data such as jump height, generated power, initial velocity, and flight time[33,34] it was possible to identify differentiated response patterns between players of different professional levels, as well as among playing positions. Additionally, the effect of prior

Table 1
Mean results of jumps before (PRE) and after (POST) training sessions during a competitive microcycle.

	HJ		FT		Pwr		Vel	
	PRE	*POST*	*PRE*	*POST*	*PRE*	*POST*	*PRE*	*POST*
Valid	234	230	234	230	234	230	234	230
Missing	0	0	0	0	0	0	0	0
Mean	37.68	37.48	0.55	0.55	1272.09	1264.54	2.71	2.70
Std. Deviation	5.60	6.19	0.04	0.05	183.62	182.53	0.21	0.23
Shapiro-Wilk	0.96	0.98	0.95	0.96	0.96	0.96	0.95	0.96
Minimum	23.29	17.41	0.44	0.38	964.39	941.36	2.14	1.85
Maximum	51.38	50.40	0.65	0.64	1800.56	1646.69	3.18	3.14

Table 2
Comparison of results between non-professional (NONPRO) and professional (PRO) players during a competitive microcycle.

	HJ		FT		Pwr		Vel	
	NONPRO	PRO	NONPRO	PRO	NONPRO	PRO	NONPRO	PRO
Valid	219	251	219	251	219	251	219	251
Missing	0	0	0	0	0	0	0	0
Mean	35.32	39.36	0.53	0.57	1170.97	1348.34	2.62	2.77
Std. Deviation	6.80	4.23	0.05	0.03	122.99	187.31	0.26	0.15
Shapiro-Wilk	0.99	0.96	0.99	0.94	0.96	0.95	0.99	0.94
Minimum	17.41	23.78	0.38	0.44	941.36	964.39	1.85	2.16
Maximum	51.38	49.64	0.65	0.64	1461.86	1800.56	3.17	3.12

Table 3.1
Jump height (cm) results of professional players throughout the competitive training microcycle, consisting of 5 sessions (2 mornings and 3 afternoons).

	HJ				
	S1-M	S2-A	S3-M	S4-A	S5-A
Valid	63	46	49	51	42
Missing	0	0	0	0	0
Mean	39.26	40.12	38.68	38.97	39.96
Std. Deviation	4.94	4.95	2.44	4.29	3.77
Shapiro-Wilk	0.92	0.85	0.98	0.99	0.96
Minimum	26.16	23.78	32.65	28.53	31.91
Maximum	47.57	49.64	42.98	49.48	47.87

Table 3.2
Jump height (cm) results of non-professional players throughout the competitive training microcycle, consisting of 3 sessions (3 afternoons).

	HJ		
	S2-A	S4-A	S5-A
Valid	63	78	72
Missing	0	0	0
Mean	36.83	35.57	34.22
Std. Deviation	6.56	7.49	6.11
Shapiro-Wilk	0.97	0.98	0.98
Minimum	21.99	17.41	23.29
Maximum	48.35	51.38	50.40

Table 4
Results of players who do not perform strength training in the gym and those who do perform strength training before the training sessions of the competitive microcycle.

	HJ		Pwr		Vel	
	NoGym	*Gym*	*NoGym*	*Gym*	*NoGym*	*Gym*
Valid	208	256	208	256	208	256
Missing	0	0	0	0	0	0
Mean	36.31	38.62	1231.26	1298.48	2.66	2.75
Std. Deviation	6.04	5.57	166.40	190.37	0.23	0.21
Shapiro-Wilk	0.98	0.93	0.96	0.97	0.98	0.92
Minimum	22.08	17.41	954.65	941.36	2.08	1.85
Maximum	51.38	49.64	1683.0	1800.56	3.17	3.12

strength work as a possible neuromuscular activation stimulus was explored. These findings not only reflect the utility of the CMJ as a diagnostic instrument[13,14,33] but also open the door to reflecting on key aspects such as training programming, load planning and individualization, the need for tailored training, and the effectiveness of recovery strategies.

Results showed that professional players outperformed non-professionals in all neuromuscular performance metrics evaluated via CMJ. Professionals exhibited higher jump heights (39.36 cm vs. 36.83 cm), greater mean power (1348.34 W) and maximum power (1800.56 W), as well as a more favorable reactive strength index (0.57), evidencing a more developed physical profile. This result aligns with previous research associating explosive action performance with the quality and volume of accumulated training over years, as well as sustained competitive exposure, endowing professional players with better physical capacities compared to non-professionals with less training volume.[35,36]

These differences were not limited to absolute performance values but were also evident in the capacity to respond to training. Professionals experienced minimal changes in performance levels after sessions (variation of only −0.195 cm), suggesting a high load management capacity and fatigue tolerance.[37,38] In contrast, non-professionals showed a downward trend across the microcycle, with an accumulated reduction of 1.17 cm in CMJ height. This decline, along with reductions in power (−43 W) and initial velocity (−0.05 m/s), indicates an uncompensated fatigue accumulation, suggesting that the proposed loads may be exceeding their recovery capacity, with implications for both performance and injury risk. Literature highlights that poor load and fatigue management can increase the likelihood of muscular and joint injuries[26,39] and the pattern observed in non-professionals could represent a window of risk. A 10–15 % reduction in accumulated weekly load could represent a reasonable starting point, with CMJ testing serving as a useful tool for load control.[40]

Noteworthy is the positive effect of gym work performed prior to field training. Players who engaged in gym activation before the session presented a mean jump height of 38.62 cm, compared to 36.31 cm in the non-activation group, representing an improvement of 2.31 cm. Increases in power (1298.48 W vs. 1231.26 W) and initial velocity (2.75 m/s vs. 2.66 m/s) were also observed. This result points to a phenomenon known as post-activation potentiation (PAP), where submaximal strength stimuli can "prime" the neuromuscular system to produce a more powerful response in subsequent efforts.[22] While this effect has been previously documented in controlled environments, findings from this study indicate its potential efficacy in real training contexts.[41] Incorporating this type of neuromuscular activation prior to training could benefit both professional and non-professional players, especially if implemented in key microcycle sessions or before tasks requiring maximal neuromuscular activation, such as sprints, high intensity contact phases, or simulated competition scenarios. The differences observed between professional and non-professional players could be due to an improved tolerance to chronic neuromuscular fatigue during training.[42] However, to ensure effectiveness and prevent adverse effects, appropriate dosing and personalized adaptation based on player profiles, particularly for those with poorer conditioning, would be essential.

Finally, regarding playing positions, different profiles appear to reflect the specific demands of each rugby role in neuromuscular metrics. Front row players showed lower average jump height (34.95 cm) but maintained better relative strength in short-duration, high-intensity gestures, indicating greater specialization in short, powerful movements rather than high-speed locomotion actions.[43]

Conversely, third row and back three players displayed higher speed levels (2.77 m/s) and movement power (1298.48 W), reflecting positions that require more frequent and faster displacements in open spaces.[44] This functional diversity reinforces the need to design differentiated training plans by position, not only in technical-tactical aspects but also in physical preparation, prioritizing components such as explosive strength, reaction speed, or acceleration capacity according to role.

Conclusion

The study results demonstrate superior performance metrics in professional players compared to non-professional players. Additionally, neuromuscular fatigue tolerance accumulated throughout the training microcycle is greater in professional players, who even improved their records by the end of the training week.

Significant differences were also observed according to playing position. Front row players showed higher levels of relative strength, whereas third row and back three players stood out for their greater speed and power values.

Finally, it was identified that including gym sessions prior to training contributes to improving parameters such as average jump height, generated power, and initial movement velocity. In this context, coaches and performance professionals are encouraged to consider incorporating post-activation potentiation (PAP) prior to field sessions as a tool to optimize athletes' physical performance, to enhance performance and adaptations in both professional players, who are more accustomed to tolerance to chronic neuromuscular fatigue during training, and non-professional players, to improve their performance parameters.

Limitations

This study presents certain methodological limitations that should be considered when interpreting the results. First, it was not possible to record data from the entire sample on all scheduled measurement days, as some players who started the study discontinued participation due to injuries or medical advice, which reduced the effective sample size and impacted data continuity. Whoever, one week of training could not be sufficient to generalize main findings. Although the volume of jumps recorded is high due to the large number of players on a rugby team, various circumstantial factors may influence the results, and more observations are needed to enhance consistency. Another limitation of the study is the lack of previous data during the competition to normalize present values due to the short monitoring period presented in the study.

Furthermore, during the data collection period, individual physical load exposure during training sessions was not recorded, making it difficult to precisely evaluate the relationship between fatigue and the specific characteristics of each training session. This is particularly relevant given the differences in task content adapted to various playing positions on the field.

Practical applications

Based on the results obtained, the study offers several relevant practical applications for sports training. First, coaches can adjust training strategies, cumulative load, and the alternation of high- and low-intensity exercises to address the specific needs of each group, contributing to improved capacities through personalized programs.

Additionally, incorporating structured strength work before training is a promising strategy to maximize the benefits of post-activation potentiation without generating residual fatigue, showing applicability for both professional and non-professional players.

Considering these factors, it is essential that coaching staff modify programming, planning, and session design to promote necessary adaptations, enabling players to successfully meet the demands encountered during competition.

While position-specific periodization is a common practice in high-performance teams, its application at non-professional levels remains limited due to factors such as limited technical staff availability, material resources, and training time. Nevertheless, even in resource-constrained contexts, implementing training blocks aimed at different physical profiles can represent a significant step toward more contextualized and effective physical preparation.

Future research directions

This study opens several lines of research. Longitudinal studies would be relevant to evaluate how fatigue and performance evolve over an entire season, allowing observation of whether the differences between professional and non-professional players, as well as among positions, persist throughout seasonal mesocycles.

Furthermore, complementing the CMJ test with control systems such as biochemical and advanced neuromuscular analyses would facilitate a more precise evaluation of fatigue and performance. Finally, it would be valuable to analyze which strength exercises are most effective to maximize post-activation potentiation in rugby players.

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IRB approval

Data processing was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki, as revised in Fortaleza (World Medical Association, 2013). The study protocol was approved by the Clinical Research Ethics Committee of the Sports Administration of Catalonia (reference number: 012/CEICGC/2022).

Conflicts of interest

During the study SG was the head coach of the team, and PP and TC their Strength & Conditioning coaches.

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