Internal-training-load monitoring, notational and time-motion analyses, psychometric status, and neuromuscular responses in elite rugby union

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Internal Training Load Monitoring, Notational and Time Motion Analyses, Psychometric Status, and Neuromuscular Responses in Elite Rugby Union

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Q1 ***Purpose:*** The present study aimed to verify if practicing tackles during rugby union training sessions would affect the players' internal training load and acute strength loss. ***Method:*** A total of 9 male Italian *Serie A* rugby union players (age: 21 [2] y) were monitored by means of an integrated approach across 17 sessions, 6 with tackles (WT) and 11 with no tackles (NT). Edwards training load was quantified using heart rate monitoring. Global positioning system devices were used to quantify the total distance and time at >20 W. Work-to-rest ratio was quantified by means of a video analysis. Before (PRE) and after (POST) the session, the players' well-being and rating of perceived exertion were measured, respectively. The countermovement jump and plyometric push-up jump tests were performed on a force plate to record the players' PRE–POST concentric peak force. Linear mixed models were applied to quantify the differences between WT and NT in terms of training load and PRE–POST force deltas, even controlling for other training factors. ***Results:*** The Edwards training load (estimated mean [EM]; standard error [SE]; WT: EM = 214, SE = 11.8; NT: EM = 194, SE = 11.1; $P = .01$) and session rating of perceived exertion (WT: EM = 379, SE = 21.9; NT: EM = 277, SE = 16.4; $P < .001$) were higher in WT than in NT. Conversely, no difference between the sessions emerged in the countermovement jump and plyometric push-up concentric peak force deltas. ***Conclusions:*** Although elite rugby union players' external and internal training load can be influenced by practicing tackles, upper- and lower-limb strength seem to not be affected.

Q2 ***Keywords:*** integrated analysis, ~~training load~~, concentric force, contact sport, team sport

Rugby union is an invasive field team sport highly characterized by several technical and tactical factors.[1,2] Among these, collision events, such as tackles, can be considered relevant for the players' training load and effects on force performance.

Q3 Regarding the quantification of training load, a recent study[3] examined accelerometer metrics, correlating them to collisions (recorded by means of video analysis) and running demands performed during an under-18 rugby union match play. In general, accelerometer metrics reported large correlations with collision data, despite with some differences in relation to forward and back tactical roles, as also reported for rugby league.[4] Furthermore, the correlation between accelerometer metrics and total distance was nearly perfect. However, although accelerometer metrics can be successfully used to quantify running demands when other methods are unavailable, relying solely on these metrics to quantify activity demands may lead to an underestimation of the real load experienced by players.[5,6] Rugby union has been also monitored for running and skill-related performance, classifying international under-20 players in relation to their exposure time and appurtenance to 2 teams during an intensified tournament. The results on external parameters, such as total and peak 5-minute high metabolic load distances covered, reported no effects, highlighting that players with the highest exposure to match play were able to maintain skill-related performance, similar to less exposed counterparts.[7]

In a more recent study,[8] players were examined in relation to perceptual and neuromuscular fatigue, thus considering internal training load parameters too. However, although these players were subdivided into 2 subgroups according to high and low match-play exposure time, no evident differences emerged for high-speed running distance between groups, and no clear tendency for a progressive decrease in well-being scores prior to or following matches was observed in both subgroups, thus confirming the results reported in the previous study. In addition, no evidence emerged for the possibility of small reductions in postmatch countermovement jump (CMJ) performance in both subgroups. As a result, these authors tend to highlight that players generally maintained their performance and readiness to play across the intensified tournament, regardless of the exposure time in match-play, also suggesting the need for holistic player monitoring programs. However, in contrast with these findings, a study on rugby league players[9] reported peak force decreases at 30 minutes postmatch (about 19%). Similarly to the latter study, decreases in plyometric push-up (PPU) peak force were reported after the performance of a rugby union intensive period of competition (ie, 3 games within 5 d)[10] or in the flight-time evaluated after the match (immediately after = 15%; after 24 h = 12%; after 48 h = 4%; and after 72 h = 1%).[11] Q5

Different trends were shown for the evaluation of the neuromuscular response in rugby union training contests. In particular, a study[12] provided a crossover design (ie, intervention with a planned training session) to assess the magnitude of change in markers of upper- and lower-body neuromuscular function. ~~The last~~

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Q6 ~~measurements~~ have been conducted by means of dynamic power-based movements, such as PPU and CMJ, as reported by previous studies,[8,13,14] whereas training load parameters, such as the mean heart rate (HR), session rating of perceived exertion (session-RPE), perception of well-being, and global positioning system (GPS) parameters, were considered to be secondary outcomes. The results reported that the inclusion of contacts during training was able to determine an increase in the HR and session-RPE values, and a decrease in PPU and perception of well-being 24-hour posttraining, respectively. In contrast, the exclusion of contact increases running intensity and distance, and determines decreases in lower-body Q7 neuromuscular function.[12] Similarly, in another study on rugby league,[10] the influence of physical contact on fatigue after the practice of small-sided games has been investigated, highlighting moderate reductions in lower- and upper-limb force following the noncontact and contact game, respectively. Although practitioners can benefit from the findings of these studies, training can be characterized by heterogeneous types of exercise and load, which Q8 can substantially influence the corresponding players' effects.

However, to the best of our knowledge, no study related to elite rugby union investigated, with an integrated (ie, controlled with different performance variables) and ecological (ie, with no intervention) approach, the relationship between training load and tackles. Therefore, the aim of the present study was to verify if the rugby union training sessions performed by a single team with the inclusion (with tackles [WT]) or exclusion (with no tackles [NT]) of tackles can affect the players' internal training load and acute strength loss.

Methods

Experimental Approach to the Problem

The study was approved by the ethical committee of the University Q9 of Turin (Protocol Number: 458273). A within-group repeated-measures design was used in order to assess the response to WT and NT training sessions in terms of external and internal training parameters, and the neuromuscular function of upper limbs and lower limbs. Data were collected from 17 (ie, 6 WT, 11 NT) field-based training sessions during an in-season period. The WT sessions were characterized by exercises and games, including tackles. In these sessions, the coaches verbally encouraged the use of tackles. On the other hand, the NT sessions mainly consisted of exercises and game phases, in which the defending player was not interested in bringing to ground the ball carrier. In addition, the researchers did not request the modification of a training plan to manipulate the choices of the coaches, fully guaranteeing ecological experimental circumstances. Each training session was characterized by the experimental schedule described in Figure 1. Q10

~~In line to~~ a previous study on rugby union,[12] the authors hypothesized that the players' ~~Indian Tennis League (~~ITL~~)~~ would be higher in WT than in NT sessions. In addition, according to the literature,[10,12] CMJ and PPU variations for the trials performed before (PRE) and after (POST) training sessions would emerge for NW and WT, respectively. However, the ecological approach promoted in the present study could determine less marked training conditions with respect to the interventions provided in other studies,[10,12] minimizing the above expected effects. Q11 Q12

Participants

A total of 9 rugby union Italian *Serie A* (ie, the second senior national division) players (6 backs: age 21 [1] y; height 182 [6] cm; body mass 86.0 [7.4] kg; 3 forwards: age 20 [2] y; height 188 [5] cm; body mass 97.2 [6.2] kg) participated in the study. All players were recruited from the same team, had at least 8 years of experience in rugby training and competition, and were free from any injury for at least 6 months. The players typically practiced 4 training sessions per week (120 min/session), including resistance training, rugby skills, and conditioning, and a competitive match at

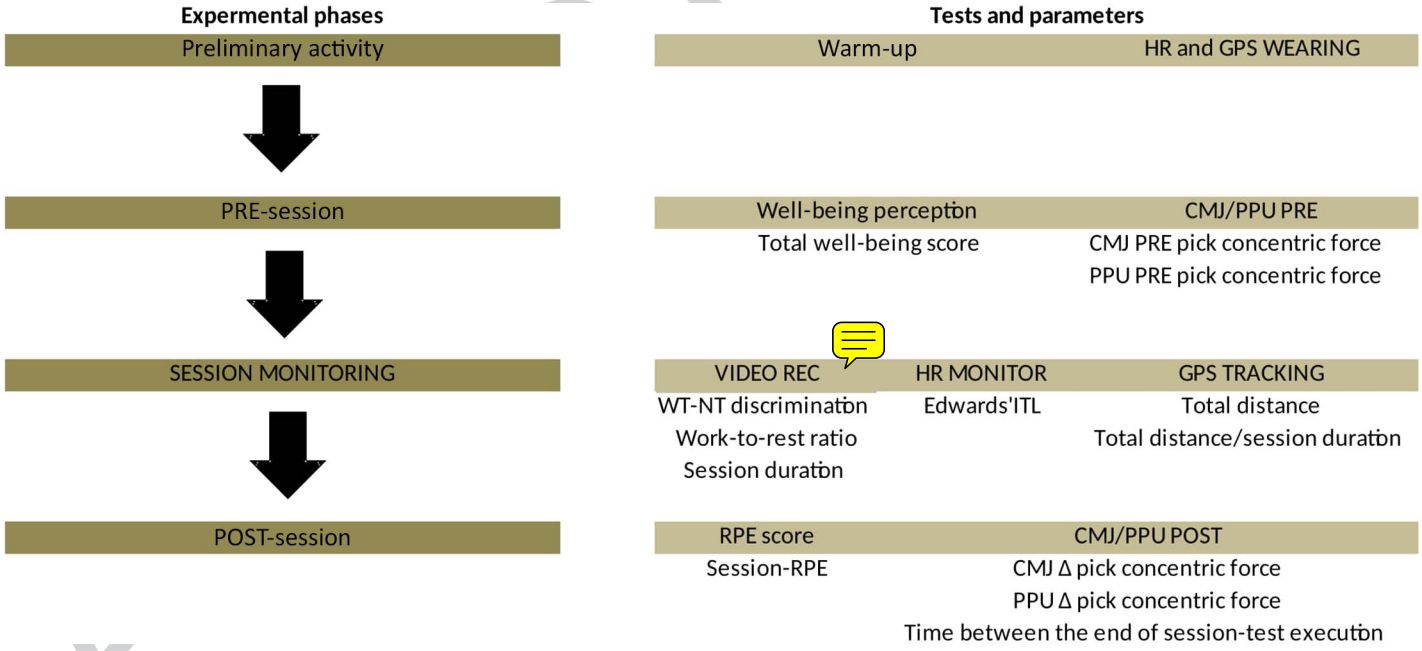


Figure 1 — Tests and corresponding parameters of the experimental phases that occurred during each training session. CMJ indicates countermovement jump; GPS, global positioning system; HR, heart rate; PPU, plyometric push-up; RPE, ratings of perceived exertion; NT, with no tackle; WT, with tackles.

the end of the week. For each training session, the players usually performed 15- to 20-minute warm-up (ie, physical exercises performed first without and then with the ball) and 5- to 10-minute cooldown (ie, stretching, walking) routines. All the participants provided their written informed consent before participation in the study in accordance with the ethical standards provided in the 1964 Declaration of Helsinki.

Preliminary Activities

About 30 minutes before the beginning of each training session, the participants wore a GPS unit sampling at 10 Hz (Spin_GNSS_50 Hz; Spinitalia S R L, Italy), placed within a pocket in the vest so that the unit was positioned on the upper thoracic spine between the scapulas.[8,15] In addition, each participant wore an HR monitor (Team Pod; Firstbeat Technologies Oy, *Jyväskylä*, Finland) sampling at 1-second intervals, which was connected wirelessly with a mobile computer (ASUS Notebook Series; ASUSTek Computer Inc, Taipei, Taiwan). Finally, a standardized warm-up consisting of 3 minutes of self-paced cycle ergometry and 2 minutes of dynamic stretching was performed. Afterwards, the participants performed 2 practice trials of submaximal CMJs and PPUs to familiarize themselves with the tests.

Well-Being Perception

~~The participants completed~~ a questionnaire[9] consisting of 5 areas (ie, fatigue, sleep quality, muscle soreness, stress levels, mood), each evaluated according to a 5-point Likert scale (range score 1 [the worst condition] to 5 [the best condition]). The overall well-being perception was determined by summing the 5 scores. This questionnaire was individually administered 20 minutes before each training session.

Neuromuscular Function Evaluation

Lower- and upper-limb neuromuscular ~~function was~~ evaluated using peak concentric force during the execution of the CMJ and PPU tests. Both tests were quantified through a piezoelectric portable force platform with charge amplifier (~~9286AA Kistler, Zurich~~, Switzerland). The ground forces were sampled at 2048 Hz, converted to digital data with a 16-bit analog to digital converter (EMG-Quattrocento; OT Bioelettronica s.r.l., Turin, Italy), and filtered using a low-pass filter with a cutoff frequency of 50 Hz.

After the warm-up, 2 trials of CMJ and PPU tests were performed, with a 1-minute rest in between. For the CMJ, the participants were instructed to stand still on a force platform for the initial 2 seconds of the data collection period in order to determine body weight.[11] Each participant started in a standing position on the force platform, with knees extended and feet in a position of their choice,[3] and they were asked to keep their hands on their hips.[16] They were instructed to perform the jumps bending their knees to a freely chosen angle and performing a maximal vertical thrust, keeping their body vertical throughout the jump and landing with their knees fully extended.[17] For the PPU, the participants started in the press-up position, with their hands in a self-selected position on the force platform and with extended arms. The participants were instructed to flex and extend their elbows so that their hands left the platform, without requiring a specific upper-limb angle.[18]

For the CMJ and PPU, vertical force was obtained from the ground reaction force minus individual body weight. The center-of-mass velocity was determined by dividing the ground reaction force (minus body weight) by the body mass and then integrating the product using the trapezoid rule.[19–21] According to McMahon et al,[20] the concentric phase of both tests was identified between the instant that the center-of-mass velocity exceeded 0.01 $m \cdot s^{-1}$ and the instant of takeoff (ie, when the vertical ground reaction force fell below 5 times the SD of the flight phase force). Concentric peak force was defined as the maximal vertical force during the concentric phase.

Both tests were performed twice at PRE and twice at POST. The best PRE-trial and POST-trial (ie, highest recorded peak concentric force) of each session was considered for the analysis. The absolute and relative percentage delta changes on peak concentric force between the PRE-session and POST-session were calculated. In addition, the time between the end of the training session and the beginning of the POST tests was recorded for the following statistical analysis. All data were analyzed by using custom-written software in MATLAB (R2017b; MathWorks, Natick, MA).

Time Motion Parameters (GPS and Video Analyses)

The GPS data were recorded during training sessions and successively downloaded using customized software (LagalaColli 10.03; Spinitalia S R L). Total distance, total distance over session duration, and duration of training performed at >20 W intensity were recorded for the quantifying volume, mean intensity, and high-intensity parameters, respectively. In addition, a video analysis (Canon Legria HF R46 camera; Canon Inc, Tokyo, Japan) was performed to consider the work-to-rest ratio (ie, density parameter) of each player. In particular, this analysis was performed by an expert observer (ie, with a master's degree in sports science and at least 5 y of experience in rugby match analysis), who has been ~~tested~~ in terms of intrareliability (0.98) and interreliability (0.95)~~, and satisfactory considered according to literature~~.[22]

Edwards and Session-RPE Internal Training Load

The internal training load was assessed by means of the Edwards HR method,[23] which considers the session time (expressed in minutes) performed at 5 HR zones, multiplied by a corresponding coefficient (ie, 50%–60% = 1; 60%–70% = 2; 70%–80% = 3; 80%–90% = 4; 90%–100% = 5). The sum of all 5 values determined the Edwards internal training load (expressed in arbitrary units). ~~Differently, for~~ session-RPE, not sooner than 20 minutes and not later than 30 minutes after each training session, the players individually provided an RPE about the whole training session using the Italian translation of the modified CR-10 version[24] of the Borg scale.[25] Each individual RPE value was multiplied by the corresponding session duration (expressed in minutes) to estimate the session-RPE of each player.

Statistical Analysis

To account for the nonindependence of observations (eg, observations from the same subjects), the following linear mixed-effects models were structured by considering players as random intercept effects.

A series of linear mixed-effects models was applied to determine the differences between WT and NT (fixed effect) in relation to each single parameter regarding the PRE trials (ie, well-being total score, and each subcategory, CMJ and PPU performance), the

monitoring of sessions (ie, total distance, total distance over session duration, and time >20 W, work-to-rest ratio), and the POST-trials (ie, CMJ and PPU performance). Successively, ~~2~~ linear mixed models were performed using (1) Edwards internal training load and (2) session-RPE as dependent variables, whereas the type of training (WT and NT), well-being score, CMJ at PRE, PPU performed at PRE, total distance, total distance over session duration, time >20 W, work-to-rest ratio, and session duration were entered as fixed effects. Finally, 2 linear mixed models were calculated to highlight the WT and NT differences in terms of CMJ and PPU individual peak concentric force PRE–POST deltas (dependent variable). The type of training (WT and NT), Edwards internal training load, well-being score, work-to-rest ratio, session duration, and time between the end of training and the beginning of test execution have been included as fixed effects.

Cohen *d* effect sizes (ESs) with a 95% confidence interval (95% CI) were calculated from the resultant *t* ratios to describe the practical meaningfulness of the differences in mean values.[26] The absolute ES value was evaluated according to the following thresholds: <0.2 = trivial, 0.2 to 0.6 = small, 0.7 to 1.2 = moderate, 1.3 to 2.0 = large, and >2.0 = very. All of the statistical analyses were carried out using statistical package R (~~version 3.5.2~~), with the packages lme4 (version 1.1.19), emmeans (version 1.3.2) and compute.es (version 0.2.4).

Results

The linear mixed-effects model, focused on comparing WT and NT in each single parameter, reported the effects for session-RPE, GPS parameters (total distance, total distance over session duration, and time >20 W), and work-to-rest ratio. Conversely, no effect emerged for the Edwards ITL, total well-being, and subscale scores at the PRE and POST parameters (Table 1).

The general linear mixed model on ITLs, with the involvement of the other parameters as fixed effects (Table 2), showed that the Edwards values were higher in the WT than in the NT sessions (ES = 0.45; 95% CI, 0.11 to 0.78; $P = .01$; Figure 2) and were positively influenced by CMJ at PRE (ES = 0.44; 95% CI, 0.11 to 0.78; $P = .01$) regardless of the type of training discrimination. Similarly, session-RPE was higher in WT than in NT (ES = 0.68; 95% CI, 0.33 to 1.02; $P = .0001$; Figure 2).

For the linear mixed model on the CMJ and PPU peak concentric force PRE–POST deltas (Table 3), no effect between WT and NT emerged (Figure 3A). However, regardless of discrimination between the types of session, the PRE–POST CMJ deltas were positively influenced by the work-to-rest ratio (ES = 0.36; 95% CI, 0.02 to 0.69; $P = .038$). Conversely, the PRE–POST PPU deltas and well-being total score (ES = −0.66; 95% CI, −1.01 to −0.32; $P = .0002$) were negatively associated. Also, for the percentage values, no effect between WT and NT emerged on the CMJ and PPU individual peak concentric force PRE–POST deltas (Figure 3B). However, despite no significant influences emerging for the CMJ test, a negative influence emerged for the PPU test in terms of the rest period between the end of session and the test execution (ES = −0.52; 95% CI, −1.83 to −0.58; $P = .0028$; Table 3).

Discussion

The present study aimed at verifying whether the elite rugby union players' internal training load and acute strength loss are influenced by the inclusion of tackles during the training sessions. For this reason, the authors adopted an integrated and ecological approach, which is novel for rugby union studies. The main findings showed that ITL is higher when performing tackles, according to both Edwards and the session-RPE parameters, although this difference does not determine any effect in terms of strength loss.

Table 1 Outcomes (EM; SE; CV%; Significance, *P* Value) of Linear Mixed Models Applied for Each Training Parameter to Compare the 2 Observed Types of Session (ie, WT; NT)

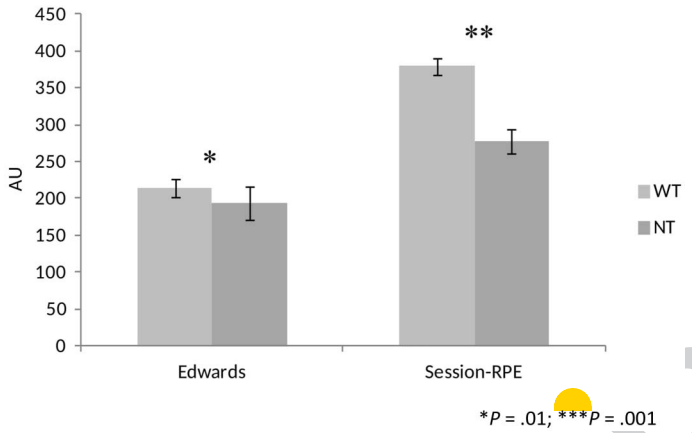
Parameters		WT			NT			
		EM	SE	CV%	EM	SE	CV%	*P* value
Edwards, AU		201	12	15.3	202	11	21.3	.974
Session-RPE, AU		363	22	26.3	294	20	36.6	<.001*
Well-being	Total score, AU	16.1	0.65	10.8	16.1	0.60	12.4	.867
	Fatigue, AU	2.89	0.12	18.6	3.03	0.11	20.9	.241
	Sleep quality, AU	3.38	0.13	17.0	3.38	0.12	21.2	.996
	Muscle soreness, AU	3.02	0.13	23.6	2.98	0.11	22.2	.811
	Stress, AU	3.14	0.22	19.2	3.21	0.21	16.0	.489
	Mood, AU	3.61	0.15	14.5	3.71	0.14	13.9	.351
GPS	Total distance, m	5020	253	18.9	6270	216	17.4	<.001*
	Total distance/session duration, m·min^{-1}	59.7	1.91	14.0	64.2	1.66	10.8	.007*
	Time >20 W, s	50.0	14.1	42.8	93.2	12.4	54.9	<.001*
Video analysis	Work-to-rest ratio	2.77:1	0.15:1	57.1	1.32:1	0.12:1	60.2	<.001*
CMJ	PRE, N	1426	30	7.2	1400	23	7.9	.488
	POST, N	1405	32	9.9	1366	24	8.5	.332
Plyometric push-up	PRE, N	929	22	10.0	903	16	11.2	.346
	POST, N	908	27	13.6	925	20	11.0	.604

Abbreviations: AU, arbitrary units; CMJ, countermovement jump; CV%, coefficient of variation; EM, estimated mean; GPS, global positioning system; NT, with no tackle; RPE, ratings of perceived exertion; SE, standard error; WT, with tackles.

Q27 **Table 2 General Linear Mixed Model Parameter Estimates (*B*; SE; Significance, *P* Value) for Internal Training Load Expressed According to the Edwards and Session-RPE Methods**

	Edwards			Session-RPE		
	B	SE	*P* value	*B*	SE	*P* value
Session with no tackle	−19.5	7.39	.010*	−101.34	25.34	<.001*
Work-to-rest ratio	5.38	2.92	.069	8.51	10.05	.399
Well-being score	0.32	1.48	.830	−2.65	4.46	.554
Total distance	35.96	20.95	.089	−25.26	70.37	.720
Total distance/session duration	−1.5	2.02	.460	2.57	6.83	.708
Time >20 W	−0.01	0.07	.841	0.32	0.23	.162
Session duration	−0.61	1.31	.644	3.6	4.42	.417
CMJ (PRE)	6.34	2.41	.010*	2.4	6.59	.719
Plyometric push-up (PRE)	−2.46	2.65	.355	5.32	7.63	.490

Abbreviation: B, beta score; CMJ, countermovement jump; RPE, ratings of perceived exertion; SE, standard error.



Q28 **Figure 2** — Estimated means, SEs, and significances of the internal training load expressed according to the Edwards and session-RPE methods and in relation to the type of training (WT; NT). AU indicates arbitrary units; RPE, ratings of perceived exertion; SE, standard error; NT, with no tackle; WT, with tackles.

Although coherent results with the literature[12] emerged in terms of ITL (ie, higher values in WT than in NT), the PRE–POST concentric peak force deltas seem to be controversial with respect to the neuromuscular effects reported for similar studies on rugby.[10,12] In fact, the practice of a contact game is usually associated with a strength loss in the upper limbs,[10,12] whereas a noncontact game determines lower-limb strength decrements as a consequence of a higher running intensity and distance.[12] Also in the present study, intensity (total distance over session duration; time >20 W) and volume (total distance) were higher in NT than WT, but no particular influence on upper- or lower-limb strength emerged considering both the simple (ie, without other parameters as fixed effects; Table 1) and complex (Table 3) linear mixed model.

The only reason for these divergent results with respect to the Q29 literature could be ~~inferred~~ to a different experimental approach. In fact, as expected, the ecological approach promoted in the present study could have determined less extreme training conditions with respect to the intervention provided in the other studies.[10,12] As a Q30 consequence, the rugby union players participating in our study were probably able to effectively prevent eventual strength loss in both types of training, despite the relevant discriminations in terms of the ITL and time motion parameters. In other words, even though no evidence can be provided, the coach's training proposals could be more effectively sustained by the players than the research interventions, which suitably aim at strongly discriminate training situations.[10,12] In particular, Roe et al[12] proposed a common series of workouts with and without contact, whereby the contact situations were substituted by passing drills in the latter training circumstance. Similarly, in the study on rugby league,[10] small-side games were conducted with and without contact. Instead, in our study, contacts such as simple contacts and withheld actions were also allowed in the NT sessions, only forbidding real tackles.

In addition, in the present study, rugby union players' upper- and lower-limb strength was tested immediately after the session and not the day after (ie, with 24 h of recovery).[10,12] Therefore, it could be speculated that the fatigue determined by training performance could be counterbalanced by a potentiation phenomenon determined by the alteration of all-out actions with enough active recovery between the actions, as already underlined in other situational sports.[17]

The work-to-rest ratio reported higher values for WT than NT, which probably contributed to showing the same trend between sessions in terms of ITL. In fact, especially for WT, this parameter was substantially above the levels reported for Super 12[27] and English Premiership[28] rugby games. However, this result is also in contrast with the other time–motion parameters, which are significantly higher in NT sessions. Therefore, it could be speculated that the enhancement of training density is more relevant on ITL than other time–motion parameters; despite its impact on lower-limb strength, loss seems to be counterbalanced by the opposite trends of volume and intensity.

The positive relationship between Edwards ITL and the CMJ peak of concentric force expressed at PRE could suggest that a higher lower-limbs neuromuscular activation can determine a higher ITL (ie, maximal HR level). However, this is just a speculation, and only further studies will be able to clarify the meaning of this relationship.

Regarding the strength loss analyses, ~~the work-to-rest ratio resulted associated to the CMJ PRE–POST delta~~, regardless of the Q31 WT and NT discrimination. In fact, despite ~~this parameter represents the density of training and~~ is mostly represented in WT Q32

Table 3 General Linear Mixed Model Parameter Estimates (Beta Score, *B*; Standard Error, SE; Significance, *P* Value) for PRE–POST CMJ and Plyometric Push-up Deltas, Expressed in Absolute (N) and Percentage (%) Values

	CMJ, N			Plyometric push-up, N			CMJ, %			Plyometric push-up, %		
	B	SE	*P* value	*B*	SE	*P* value	*B*	SE	*P* value	*B*	SE	*P* value
Session with no tackle	–232.19	335.81	.491	56.06	188.47	.767	1.72	8.64	.842	–7.69	8.89	.389
Edwards ITL	0.75	1.48	.611	0.48	0.83	.567	0.01	0.04	.890	–0.03	0.04	.482
Work-to-rest ratio	70.84	33.75	.039*	25.04	19.43	.201	1.40	0.83	.094	–0.68	0.88	.440
Well-being score	–21.29	11.95	.078	–26.63	6.76	<.001*	0.15	0.35	.666	–0.11	0.36	.760
Session duration	2.09	2.07	.315	0.66	1.17	.572	0.03	0.05	.500	0.01	0.05	.801
Rest period (end of session–test execution)	–0.17	0.12	.150	–0.09	0.07	.168	–0.01	0.01	.619	–0.01	0.01	.003*
Interaction between session with no tackle and Edwards ITL	1.25	1.72	.471	0.17	0.96	.860	–0.01	0.04	.941	0.04	0.05	.49

Abbreviations: B, beta score; CMJ, countermovement jump; ITL, Indian Tennis League; SE, standard error.

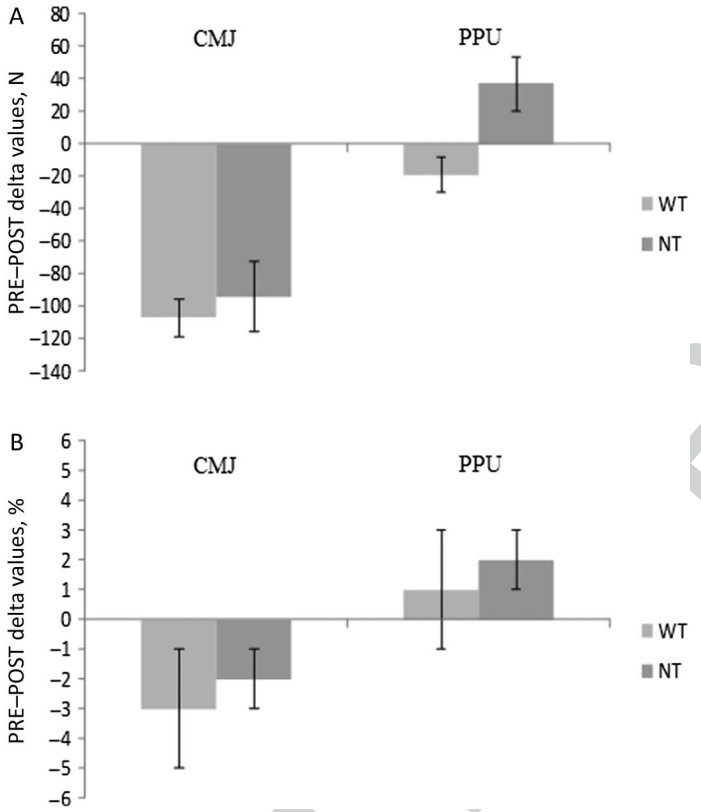


Figure 3 — Estimated means and SEs of the PRE–POST CMJ deltas (absolute values, A; percentage values, B), in relation to the type of training (WT; NT). CMJ indicates countermovement jump; PPU, plyometric push-up; NT, with no tackle; RPE, ratings of perceived exertion; SE, standard error; WT, with tackles.

according to the linear mixed model without other parameters as fixed effects (Table 1), it can be associable to the lower-limbs strength loss only in general according to the more complex model (Table 3), strengthening the importance of controlling for other parameters to provide a consistent integrated training monitoring.[29] Similarly, the opposite relationships emerged between the well-being status and the PPU PRE–POST delta, highlighting how single training parameters can be relevant in general but not in relation to a specific type of training. In this case, according to a previous article on rugby league,[9] well-being is able to influence the PPU PRE–POST delta only for the effect of the impact of the training load from the day before, and not for the type of session planned for the current day. For this reason, further analyses considering the well-being score as an effect of the training performed the day before are suggested to clarify the real meaning of this result.

For the application of the model with percentage data, the rest period between the end of the session and the test execution reported a negative relationship with respect to the PPU strength loss, underlining how this result can be highly susceptible to this particular aspect. In fact, the players sometimes spent heterogeneous rest periods performing the POST force tests because of individual detraining or talks with coaches. However, further studies will be able to clarify ~~because a similar~~ did not emerge for the lower-limb strength loss. Q33

Finally, the present study has been characterized by some limitations. First, the GPS technology adopted for the time–motion parameters could be considered obsolete with respect to the local positioning system, which currently represents the most valid and reliable device for evaluating movement patterns in team sports.[30] Second, although the research design can be considered to be more important than the sample size in sport sciences,[31] the number of players analyzed in this study was not so large, requiring further studies to consolidate the emerged findings. Third, the high coefficients of variation that emerged for the work-to-rest ratio and time >20 W were probably due to a performance heterogeneity associated to tactical roles and limited GPS reliability for high-intensity movement patterns, respectively, thus suggesting that results related to these parameters be considered with higher caution.

Conclusions

The application of an integrated (ie, the involvement of different performance and physiological parameters) and ecological (ie, without altering the coach's training plans) approach to monitoring rugby union training resulted in a valuable tool to provide controlled results. In particular, the merit of this study was in highlighting that the inclusion of tackles (1) determined a higher

ITL both for Edwards and session-RPE methods and (2) does not affect lower- and upper-strength loss after the training session.

Application to Practice

The results of this study suggest that coaches may plan an in-season session mostly focused on contact (ie, tackles) as well as motion, also preserving an optimal strength level after training. ~~As a consequence~~, rugby union coaches can benefit from these findings to be mostly aware of the real players' ITLs and adaptations, thus having evidence of a single team that may suggest how to improve trainings during the match period.

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Queries

Q1. As per journal style, “mean ± SD” should be represented as “mean (SD).” Hence, the values are changed accordingly throughout the article. Please check and confirm.

Q2. As per journal style, repeats of words in article and journal title are not allowed in keywords. Hence, the keyword "training load" was deleted.

Q3. In the sentence containing “Regarding the quantification of training load, a recent . . .” please check and confirm the suggested change.

Q4. Please ensure author information is listed correctly here and within the byline.

Q5. In the sentence containing “these authors tend to highlight that players generally maintained . . .” please check and confirm the suggested changes.

Q6. In the sentence containing “The last measurements have been” please consider rephrasing the section just quoted, mainly due to the use of “last.”

Q7. In the sentence containing “determines decreases in lower-body neuromuscular . . .” please check and confirm the suggested changes.

Q8. In the sentence containing “which can substantially influence the corresponding players’ effects” should this section just quoted be rephrased as “. . . influence the effects on the corresponding players”?

Q9. In the sentence "The study . . ." "University of Torino" has been changed to "University of Turin" please check.

Q10. In the sentence containing “fully guaranteeing ecological experimental circumstances . . .” please check and confirm the suggested changes.

Q11. In the sentence containing “In-line to a previous study” please consider rephrasing the section just quoted.

Q12. Please check whether the expansion of "ITL" is correct in the sentence "In-line to a . . . . "

Q13. Please provide city name for "Spinitalia S R L."

Q14. Please check whether the added information for "Firstbeat" is correct. If not, please make changes.

Q15. Please check whether the edit made to the sentence "Participants filled a . . . ."

Q16. Please check whether the sentence "Lower- and upper-limb neuromuscular function was . . ." can be changed to " Lower- and upper-limb neuromuscular functions were . . . ."

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Q20. In the sentence containing “and satisfactory considered according to literature” please consider rephrasing the section just quoted.

Q21. In the sentence containing “Differently, for session-RPE, . . .” please consider removing “differently.”

Q22. In the sentence containing “applied to determine differences between WT and NT . . .” please check and confirm the suggested changes.

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Q24. Please provide manufacturer name and location (city, state [if USA], and country) details for "package R," "packages lme4," "emmeans," and "compute.es."

Q25. Please provide footnote for "*" cited in Tables 1–3.

Q26. Please note that caption for Tables 1–3 are added from metadata.xml. Please confirm they are correct.

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Q28. Please provide footnote for "*" and "**" cited in Figure 2.

Q29. In the sentence containing “could be inferred to a different experimental approach” please consider rephrasing the section just quoted.

Q30. In the sentence containing “the rugby union players participating in our study . . .” please check and confirm the suggested changes.

Q31. In the sentence containing “the work-to-rest ratio resulted associated to the CMJ” please consider rephrasing the section just quoted.

Q32. In the sentence containing "In fact, despite this parameter represents the density . . ." please consider rephrasing for clarity.
Q33. In the sentence containing "because a similar did not emerge" please consider rephrasing the section just quoted.
Q34. In the sentence containing "As a consequence, rugby union coaches can benefit . . ." please consider rephrasing for clarity.
Q35. Please provide issue number if available for Ref. 5.
Q36. Please provide volume number for Ref. 31.