**Article title:** Resistance and Endurance Training Are Similarly Effective When Delivered in Separate Versus Combined Formats in Female Rugby Players

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## BOTTOM LINE UP FRONT

In the interests of time efficiency, women's' rugby coaches can programme resistance training and endurance and technical/tactical training within a single session, achieving the same level of adaptation as when those activities are programmed separately, into two bouts, within the same day.


## ABSTRACT

With women's club rugby in England now played on a semi-professional basis, coaches face new challenges in structuring training programmes. The purpose of the study was to examine the effects of two different training configurations on strength, speed and endurance in elite female rugby players (n = 20) who undertook six weeks of resistance training (RT) and endurance and technical training (ETT), twice per week. Participants were divided equally between a group that performed RT in the morning and ETT in the evening, separately (SEP); and a group which performed each training type combined (COMB) within one continuous session. In both groups, the intensity and volume of the applied training programmes were the same. Tests for one repetition maximum squat and bench press, 10 m sprint and maximum aerobic speed (MAS) were conducted. Repeated measures ANOVAs (Baseline – Follow-up), showed a significant effect of time for lower body strength (Squat: SEP 93.1-98.5 [+6.2%] vs. COMB 97.5-101.5 kg [+5.5%]), upper body strength (Bench press: SEP 61.0-65.0 [+6.9%] vs. COMB 60.7-63.1 kg [+4.1%]), 10 m (SEP 1.93-1.90 [+1.4%] vs. COMB 1.98-1.95 s [+1.6%]) and MAS (SEP 3.5-3.7 [4.2%] vs. COMB 3.5-3.7 m/s [5.9%]). After the intervention, no significant group x time interactions were detected for any of the utilised performance tests. For elite female rugby players, the combination of RT and ETT training types into the same session does not seem to be detrimental to overall physical fitness. Based on these results, coaches can programme RT and ETT separately, or in the same session, in female rugby players, based on their specific daily commitments.


**Key words**: Women, strength, conditioning, speed, periodisation

## INTRODUCTION

Rugby union is a collision sport which demands high levels of physical fitness in terms of strength, speed, agility, power and endurance (12). The intermittent nature of activity in rugby places great stress on the creatine phosphate-ATP energy system, while the aerobic system underpins performance during repeated efforts over the course of an 80 minute game (9). Recently, it has been demonstrated that female participants have been underrepresented in sports science research and this has given rise to the suboptimal trend of extrapolating findings in males to female populations (5). This is not a trivial issue in collision sports, such as rugby, given that there are sex-related differences in the pattern of delayed onset muscle soreness (5) and concussion (2). Moreover, in recent years, women's rugby has seen increased professionalisation with the establishment of the Premier 15s competition in England, whose national squad is also fully professional. However, due to its relatively short history, there is a paucity of research in women's rugby and using guidelines for the structuring of training in men's rugby, for women players, is questionable in light of evidence that shows that the physical demands of the female game are different to those of males (16). For instance, in rugby matches, female players travel lower distances, at a lower speed, also engaging in fewer actions of physical contact such as tackles and rucks (16). This could result in a more open form of play which has implications for the way in which the female player is trained. Accordingly, research into training in the women's game is a necessity.

With women's club rugby in England played on a semi-professional basis, coaches face logistical challenges in structuring of players' training programmes. For instance, some teams will possess a mixture of professional, semi-professional and amateur players, each of whom will differ in the amount of time they have to devote to training. Typically, training consists of a mixture of endurance and technical training (ETT) (9,19) and resistance training (RT), completed in different compositions during the weekly microcycle, depending on an individual's playing status. However, whereas the professional and semi-professional players may have the opportunity to recover between a morning RT and an evening ETT, conducted on the same day, amateur players often need to carry out RT and ETT within a single continuous session, due to time constraints. This seems suboptimal as it could place additional strain on the player given that fatigue that is accumulated in the first part of a training session could negatively affect performance in the latter part, potentially reducing the magnitude of adaptation over time (27). Indeed, training disparate physical qualities in one continuous bout conflicts with conventional recommendations for coaches to allow between six and 24 hours of rest time between sessions, so as to allow fatigue to dissipate (27).

In order to elaborate on the aforementioned training problem about combining resistance training with endurance training, previous evidence suggests that there are some incompatibilities between the various types of training required to enhance different physical qualities (22,31). For example, Rønnestad et al. (31) reported that combined RT and endurance training resulted in impaired strength and hypertrophy when compared to singular training modalities in trained cyclists. However, evidence from other populations does not seem to support the findings of these studies. For example, McCarthy et al. (26) allocated sedentary males to RT, endurance training or combined training conditions and found that the combined training did not impair strength over a ten week period. Though only the RT group experienced significant increases in both type I and type II muscle fiber sizes, an increase in the size of the latter in the combined training group was also apparent. Similarly, Kilen et al. (20) carried out an intervention in which volume-equalised strength and endurance protocols were performed in micro- and traditional-dosing formats. Microtraining comprised frequent shorter-duration sessions (9x15-mins weekly) compared to less-frequent longer-duration sessions (3x45-mins weekly). The authors reported that there were no significant differences between the groups after the intervention, indicating that the weekly configuration of the training did not affect the outcomes. The results of these studies are encouraging for the strength and conditioning coach who is met with the considerable challenge of managing the workloads of players who have varying amounts of time to devote to training.

Consequently, the purpose of this study was to examine the effects of two different training configurations on measures of upper and lower body strength, speed and endurance in female rugby players. Based on previous evidence (20,26), it was hypothesised that there would be significant increases in performance over time, with no significant differences between the group that divided training between the morning and the evening (SEP) and that which carried it out within a single continuous session (COMB).

## METHODS

### Approach to the problem:

This training intervention study included a group of rugby players divided equally between a group that performed RT in the morning and ETT in the evening, separately (SEP); and a group which performed these training types combined (COMB) within one continuous session. In both groups, the intensity and volume of the applied training programmes was the same. As the players operated within these groups based on lifestyle factors, randomisation was not possible. For the SEP group, there was a seven hour break between morning and evening sessions.

**Subjects:**

The participants (n = 20 [10 per group]; average mass = 75.5±16.1 kg; average height = 168.0 ±13.4 cm) were playing for the same team from the English Premier 15s competition. Before participation, all gave informed consent to partake and could withdraw at any time. They were allocated to the SEP and COMB groups based on their playing status (professional and/or semi-professional vs. amateur) and, accordingly, time available to carry out training. Both groups had virtually identical levels of training experience. Similar to other previously published training studies, a non-training group (control) could not be incorporated as the two experimental groups were national level elite players and there were no comparable players available that would provide similar baseline values. The study received ethical approval from the institutional review board and conformed to the Declaration of Helsinki. All subjects were informed of the benefits and risks of the investigation prior to signing any documents to participate in the study.

**Procedures:**

The participants were familiar with all of the utilised tests through their habitual rugby training programmes. To determine muscular strength, the players were tested for one repetition maximum (1RM) efforts in the back squat and bench press exercises. This method is considered a reliable way of measuring muscular strength in trained females (ICC > 0.91) (32). Running speed was measured with the 10 m sprint test (10 m) and endurance (maximal aerobic speed [MAS]) was measured with a 1200 m time trial. Prior to testing, all participants conducted a warm up. For the strength testing, this consisted of ten of each of the following: bodyweight lunges, bodyweight squats, spidermans, push-ups, band pull-downs. Three heavy rack pulls were also performed. For the 10 m and MAS tests, the participants undertook a 50 m jog followed by dynamic stretching of the hamstrings and quadriceps. They also performed bilateral pogo jumps, A-skips, B-skips and 5 m accelerations. Both before and after the intervention period, the tests were conducted across two days in identical order: Day 1: 10 m and 1RM back squat; Day 2: 1RM bench press and MAS.

Players were required to complete a 1RM parallel back squat using progressively heavier weights to work up to a single maximal lift. A minimum of five minutes of rest was allowed between sets to ensure the participants were able to lift to their full potential. Standing in a stable position, with the bar positioned across the trapezius muscles, participants flexed their knees into a position in which the knees were at a 90 degree angle, which was visually inspected by the strength and conditioning coach. Upon reaching this point, the participants ascended back into the starting position, ensuring safe and proper technique was utilised. Participants' final maximal lift was used for analysis.

For the bench press exercise, participants lay on their back on a weight bench apparatus and grasped the bar, which was positioned over eye level (15). They adopted a self-selected grip width that was most comfortable and which has been shown to be most practically relevant and ecologically valid when assessing maximal bench press strength (24). At the coach's signal, the bar was lifted from the adjoining rack with the arms initially held in a straight position. The participants then flexed their arms until the bar descended to make a brief, and light, contact with the chest. Upon contact, the arms were extended as the individual attempted to return the bar to the starting position. Participants' final maximal lift was used for analysis.

The sprint test was conducted on an indoor sports hall surface and involved players maximally accelerating through single-beam timing gates (Fusion Sport, Australia) over a 10 m distance. This apparatus has been shown to be highly reliable in field sport athletes (ICC = 0.84) (25). The gates were positioned with one at the start point of the course and another set at the 10 m point. Players were told to sprint between and through the gates, starting immediately behind the first gate. When ready, the participants initiated movement at their convenience. The time for each player were recorded on a digital hand-held device. The fastest of three efforts was recorded for analysis.

The 1200m test took place on a rugby field. Players were required to start on the try line and to complete twelve 100 m lengths, with a turn at the try line at the other end of the field. The test was hand-timed with a stop watch. The total number of seconds taken to completion was divided by the traversed distance (1200 m) to determine a MAS score (m/s) (1). This score was then used for analysis. This test has been found to be highly reliable in both males and females (ICC = 0.99) (18).

**Training Intervention**

The six-week training programme followed by the groups is displayed in Tables 1 (RT) and 2 (ETT). All training undertaken by both groups was the same and took place during the in-season period of the year, between October and December. The only differences related to the aforementioned division of morning and evening training in the SEP group. Both groups took part in two RT and ETT sessions per week in addition to their standard rugby skills training (two team sessions, an individual skills session and one game). RT sessions were 45 mins in duration. On Mondays, the players performed an upper body RT session and off-feet conditioning. On Tuesdays they undertook lower body RT and ETT. On Thursdays, the participants performed a full-body RT session and ETT. The ETT was performed at 110% of MAS.

**Table 1 Resistance training program**

**Table 2 Endurance and technical/tactical training program**

**Statistical analysis:**

Statistical analysis was carried out using JASP (version 10.2, University of Amsterdam). Data normality was determined with the Shapiro-Wilk test. The independent samples t-test was used to compare the groups at baseline. A repeated measures ANOVA was used to detect statistically significant ($P < 0.05$) changes in the dependent variables. As the repeated measures ANOVA contained just two levels, the assumption of sphericity was met. Cohen's d effect sizes (ES) were classified as 'trivial' (<0.2) 'small' (>0.2-0.6), 'moderate' (>0.6-1.2), 'large' (>1.2-2), or 'very large' (>2) (14).

## RESULTS

All data were normally distributed at baseline and no significant differences existed between the two groups in any of the outcome measures. Results are displayed in Table 3. Repeated measures ANOVAs, showed a significant effect of time for lower body strength ($F = 10.562$, $P = 0.004$, ES = 0.27), upper body strength ($F = 18.326$, $P < 0.001$. ES = 0.18), 10 m ($F = 4.783$, $P = 0.042$, ES = 0.29) and MAS ($F = 4.594$, $P = 0.046$, ES = 0.39). No significant group x time interactions were detected between the groups for any of the utilised tests.

**Table 3 Baseline to follow up data, between-group effect sizes and ANOVA (P)**

## DISCUSSION

The aim of the current study was to examine the effects of two different training configurations on measures of upper and lower body strength, sprint speed and endurance in female rugby union players. One group separated RT and ETT sessions, whilst the other combined both into the same evening session due to the other commitments of their daily schedules.

Based on previous evidence (20,26), it was hypothesised that there would be significant increases in performance over time, with no significant differences between the group that divided training between the morning and the evening and that which carried it out within a single continuous session. Our results indicate significant increases in upper and lower body strength, as well as sprint speed and endurance in both groups. Moreover, the original hypothesis was supported by the results with no significant group x time interactions between the groups observed. On the whole, the results suggest that when faced with the logistical and programming challenges associated with balancing the workloads of a squad of players with diverse professional statuses, coaches may be able to combine several training types into a continuous session to maximise the use of time without compromising the intended adaptations of the training programme. This is an encouraging result for those coaches who oversee athletes who must combine working or educational commitments with a career in elite sport, a common characteristic of women's rugby in England (21), the Gaelic sports in Ireland (28) and the National Collegiate Athletic Association (NCAA) sports, at the collegiate level, in the United States (30).

Due to factors such as the interference effect (13) and "resistance training-induced suboptimisation on endurance performance" (7), it has been pragmatically recommended that coaches should allow between six and 24 hours of rest time between exercise bouts, so as to allow fatigue to sufficiently dissipate to maximise recovery and performance (27). The residual fatigue associated with a conventional RT session can last for a number of days, directly contrasting with that of endurance training which can be recovered from in as little as 60 minutes (7). This has important implications for the strength and conditioning coach who must maximise training adaptations whilst limiting fatigue. Though much of the relevant evidence pertains to animal models only at this time, it is thought that the most recent bout of exercise determines the dominant molecular response to that particular form of exercise (29). For example, if RT is the final session completed on a given day, the lasting response to that session will be reflective of the typical adaptations associated with RT. Exercise-induced increases in AMP-activated protein kinase (AMPK) activity seem to decrease mTOR and, in turn, the synthesis of muscle proteins in response to RT (8). In such a case, it is suggested that if endurance exercise, or in this study, ETT, were to be carried out immediately after RT, there could be a lowered response relating to strength or muscle hypertrophy. Coaches must also consider the chronic responses to particular training configurations with endurance being potentially hampered by up to 72 hours following lower body RT (7). That we did not observe the effects of such processes in the current study is notable and warrants further investigation.

Examining the impact of the sequencing training, Collins and Snow (4) exposed 23 females and eleven males to seven weeks of strength training before endurance training or endurance training before by strength training (4). As in the current study, these researchers found that upper and lower body strength increased by 15.2% and 11.9% respectively, whilst aerobic capacity improved by ~6.5%. With no post-intervention differences between the groups, the researchers concluded that any accumulated fatigue in the first session did not seem to affect performance in the second, meaning coaches could viably interchange the training types without compromising exercise-related molecular responses. Similarly a study by Kilen et al. (20), performed in both men and women, adopted a similar design to our own. In that investigation, one group performed nine short (15 min) RT or endurance training sessions per week. Both sessions were performed separately while another group conducted RT and endurance training on three days per week with equalised overall workloads. The researchers reported no significant differences between the groups in any of the measured parameters, which included endurance capacity and maximal force of the knee extensors. The authors concluded that volume-equalised short, frequently-executed training sessions and longer, less-frequent training sessions were equally effective. However, they did suggest that longer sessions could be more likely to improve high intensity endurance performance whilst shorter sessions could favour the development of strength. In our investigation, the COMB group seemed to follow the above described courses of adaptation (4,20) in that their strength, speed and endurance levels remained uncompromised by a higher density of work within a single training bout, and did not differ from the SEP group which enjoyed a less dense training structure.

Despite the above, the lack of any significant differences in the SEP and COMB groups does not suggest that training should not be structured to avoid the downregulation of mTORC signalling, nor does it imply that the separation of RT and ETT into separate bouts does not represent a viable approach to programming. This type of training structuring may still be optimal for those players who have the time to engage with it. By the same token, coaches could request that time-constrained individuals perform RT in a morning session, perhaps prior to work or educational commitments, and perform ETT in the evening alongside the rest of the playing squad. However, this could also impose a greater stress on the athlete if they are required to carry out an additional training session at an inconvenient time of the day (23), such as early morning, and could also disturb sleep and affect the individual's physical and cognitive performance (10). In such cases, it can be of benefit for coaches to know that alternative training configurations can also yield encouraging results.

Further, there is much to be said about the minimisation of the interference effect, regardless of the training type or order of configuration. Docherty and Sporer (6) previously proposed a model that implied that overlapping training modes, which focused concurrently on enhancing peripheral adaptations, would give rise to a 'zone of interference' within which an athlete could encounter suboptimal adaptations to training. The authors suggested this zone to be entered when RT exceeded 10 RM, and when ETT exceeded 95% of maximal aerobic power. Theoretically, if these thresholds can be respected, adaptations could be optimised. It has been suggested in a recent review that multiple studies have only demonstrated an interference effect when the amount of endurance sessions exceeds three per week (3), which did not occur in the current study. Moreover, it is also important to consider the training type with conventional, low-intensity, high distance endurance training more specifically associated with inhibition of mTOR pathway activation and, by extension, a greater negative effect on strength (27).

The current study does have some limitations that warrant discussion. Firstly, despite our logical results, molecular responses to RT and ETT can only be speculated upon here meaning that additional work could examine relevant measures of training-related AMPK and mTOR activity in female rugby players. Due to the difficulty in obtaining a control group of female rugby players who were not engaged in either RT or ETT, it was impossible to include such a condition in this study. It should be highlighted that the main objective of the study was to examine differing training configurations, as opposed to the effectiveness of RT and ETT as methods in and of themselves, but the addition of a control group could nonetheless enhance future work. Related to this, due to the elite status of these athletes, the sample size is understandably low. Some of the evidence reported in this field refers to untrained cohorts, who may be more likely to adapt more readily to concurrent training (11) and, is thus, less likely to be applicable to such elite athletes. Researchers and coaches should be aware of the training ages of their participants and athletes respectively, to ensure optimal outcomes and research designs.

## PRACTICAL APPLICATIONS

Strength, speed and endurance-related adaptations in response to RT and ETT seem to be similar in female rugby players, regardless of how training is configured. The structuring of these training types into a single session does not seem to negatively affect performance and, indeed, might be beneficial if it can enable a time-constrained athlete to carry out the necessary training in a more efficient manner. Coaches are encouraged to programme training activities for athletes based on their daily commitments. Professional rugby players may possess the necessary time to rest between training sessions, ensuring that recovery is maximised between bouts. Amateur players could also take this approach, though due to time constraints, this could be suboptimal and the combination of training types into the same session does not seem to be detrimental to overall physical fitness.

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