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The Neuromuscular, Endocrine and Mood Responses to a Single Versus Double Training Day in Soccer Players.

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Abstract

Objectives: This study profiled the 24 hour (h) neuromuscular, endocrine and mood responses to a single versus a double training day in soccer players.

Design: Repeated measures

Methods

Twelve semi-professional soccer players performed small-sided-games (SSG's; 4vs4 + goalkeepers; 6x7-min, 2-min inter-set recovery) with neuromuscular (peak-power output, PPO; jump height, JH), endocrine (salivary testosterone, cortisol), and mood measures collected before (pre) and after (0h, +24h). The following week, the same SSG protocol was performed with an additional lower body strength training session (back-squat, Romanian deadlift, barbell hip thrust; 4x4 repetitions, 4-min inter-set recovery; 85% 1 rep-max) added at 2h after the SSG's.

Results

Between-trial comparisons revealed possible to likely small impairments in PPO (2.5 ±2.2 W·kg^{-1}; 90% Confidence Limits: ±2.2 W·kg^{-1}), JH (-1.3; ±2.0 cm) and mood (4.6; ±6.1 AU) in response to the double versus single sessions at +24h. Likely to very likely small favourable responses occurred following the single session for testosterone (-15.2; ±6.1 pg·ml^{-1}), cortisol (0.072; ±0.034 ug·dl^{-1}) and testosterone/cortisol ratio (-96.6; ±36.7 AU) at +24 h compared to the double session trial.

Conclusions

These data highlight that performance of two training sessions within a day resulted in possible to very likely small impairments of neuromuscular performance, mood score and endocrine markers at +24h relative to a single training session day. A strategy of alternating high intensity explosive training days containing multiple sessions with days emphasising submaximal technical/tactical activities may be beneficial for those responsible for the design and delivery of soccer training programs.

Key Words: Fatigue, recovery, concurrent training, training prescription.

Introduction

Soccer players are required to maintain and develop multiple physical qualities aligned to successful soccer performance, including but not limited to: strength, power, speed, agility, aerobic capacity, repeated sprint ability, as well as engaging with technical and tactical training. [1,2] As limited training time separates fixtures, the ability to simultaneously develop such physical, technical, and tactical qualities is desirable. [1,2,3] Accordingly, concurrent training methods with the aim of maintaining and developing multiple physical qualities often occur, with multiple sessions often undertaken on the same day and within 24 h of each other. [1,2,3] Indeed, professional players often perform soccer-specific and resistance training sessions on the same day, before training again 24 h later. [1,2,3] However, for adaptation to occur, the training stimulus should be applied in an order that facilitates recovery to a point where players are able to meet the demands of each training session. [4]

The recruitment of high threshold motor units has been reported necessary for inducing neural adaptations associated with speed, agility and power. [5] However, if fatigue and muscle damage is present then athletes may be unable to perform the high intensity explosive movements required to recruit these fast twitch muscle fibers. It is therefore recommended that training sessions aimed at maximizing these neural adaptations should be performed when the athletes are not fatigued and in an optimal condition. Recent work has shown that whilst there is an impairment of neuromuscular function immediately after a small sided games (SSG) session in soccer (countermovement jump height -3.2 ± 1.9 cm; peak power output -1.1± 0.9 W·kg^{-1}), there may be a temporary recovery at 2 h post, before further impairment after 24 h (countermovement jump height -2.5 ± 1.2 cm; peak power output -0.9 ± 0.8 W·kg^{-1}). [2] Therefore, it seems that the performance of a second intense neuromuscular training session after 2 h of passive recovery may not be dampened. However it is unclear whether the addition of a second intense session may further impair performance and recovery status at 24 h post. This may be worthy of investigaion, given that professional team sport players often train on concecutive days, and also on the day following a double session. [3,6] Having this information would better allow the coach to make informed decisions about the use of twice daily training and the placement and type of sessions they wish to have the athlete perform during the rest of the training week.

The majority of research looking at the responses to multiple training sessions in a day has examined the combined effects of similar training modalities (e.g resistance training twice daily) [7,8,9], and it is unclear how neuromuscular function was affected in the 24 h following the double session training day, and whether these changes differed according to the number of sessions performed. Additionally, whilst multiple daily resistance training sessions are often undertaken by weightlifters, [9] team sport players are often required to undertake both on-field training and weightlifting sessions on the same day. [3,6]

Johnston et al. [6] compared the 24 h responses from a single (speed) session to a double (speed & weights) session training day in Rugby players. Their data indicates that the addition of a weight training session 2 h after a speed session did not influence endocrine responses or neuromuscular capability 24 h post stimulus, despite the participants reporting a higher perception of soreness.

Intense dyanmic exercises containing repeated eccentric and/or stretch shortening cycle actions are likely to result in infammatory processes; more specifically muscle damage [10, 11], muscle soreness [10, 11], and reduced neuromuscular performance. [2] In addition, these types of exercise may induce changes in testosterone [8], and cortisol [12] release, which could influence both neuromuscular function and adaptation to training. [13] Therefore, it is important to consider the combined effect of two sessions performed within close proximity to each other, to determine if the addition of a second training session results in elevated fatigue in the 24 h that follow. Considering that team sport players regularly train on consecutive days, this data would be valuable to those responsible for the design of programming in team sports.

To date, no studies have reported the fatigue and recovery profiles of combined soccer and weight training sessions on the same day. This is somewhat surprising given the prevalence of such practises in applied scenarios. It has been suggested that variation in exercise stimuli and muscle contraction are factors that may exacerbate the inflammatory response. [14] The addition of a second training session may therefore result in greater metabolic stress and reduced neuromuscular performance in the 24 h following a double training day. This information would allow coaches to make informed decisions on where to structure double training sessions throughout the week, and the impact this may have on the subsequent days training. Therefore the aim of this study was to compare the 24 h fatigue response from a single versus a double training session day on neuromuscular function, endocrine and mood responses.

Methods

Each experimental protocol was completed over two days on consecutive weeks. The study took place midway through the 2017-2018 competitive season with players being given 72 h rest before test involvement. Countermovement jump (CMJ; peak power output: PPO; jump height: JH), saliva (testosterone and cortisol concentrations), and brief assessment of mood (BAM+) responses were collected before (pre), and after (0 h, +24 h) SSG training. These measures have been used extensively in previous research to measure neuromuscular function of the lower body (CMJ), anabolic/ catabolic activity (salivary testosterone and cortisol) and for monitoring the fatigue and recovery cycles in elite athletes (BAM+). [2, 6 15] The following week, players returned and completed the exact same protocol, with the inclusion of a lower body weight training session 2 h after the SSG session. The 0 h time-point remained immediately post the completion of the SSG's on week 2.

Data are presented from 12 male semi-professional soccer players (age: 21 ± 2 years, mass: 74.8 ± 5 kg, height: 1.81 ± 0.06 m). Despite the involvement of goalkeepers in the SSG protocol, only data from outfield players was included in the current study from a range of playing positions. All players were considered healthy and injury-free at the time of the study and were in part-time training. Players were in the maintenance phase of their training season, undertaking resistance training programs, team-based conditioning sessions, and technical and tactical training. On a typical microcycle which consisted of 1 game per week, players were completing two on-field training sessions (1.5-2 h) and one resistance training session (1 h). The training week was structured so that the team performed both on-field training and resistance training on match day -2 and a single on-field training session on match day -1. Ethical approval was granted by the ethics advisory board of Swansea University. Players were also informed of the risks and benefits and provided written informed consent prior to participation in the study.

On arrival at the training centre (~17:00 h), pre salivary samples, BAM+ mood questionnaire scores and CMJ performance was assessed. Prior to CMJ testing, players completed a 5-min standardized warm up consisting of jogging and dynamic stretching. The SSG training session began at 17:30 h. Follow up measures (saliva, BAM+, CMJ's) were collected at 0 h and +24 h post-training. The following week, players performed the same procedure but with the inclusion of a lower body strength training session 2 h after the completion of the SSG's (~20:30 h). Immediately after the 0 h testing on both trials, players were provided with water, a banana and a protein bar (Energy: 171 kcal, Fats: 3.7 g, Carbohydrate: 20 g, Sugars: 9.3 g, Protein: 14 g).

After a five-min warm-up, which consisted of dynamic stretching and short sprints, players were split into four teams of five by coaching staff. The teams were organized such that playing positions were balanced within each team (e.g., one goalkeeper, one defender, one winger, one midfielder, and one striker). The sport surface was a modern third generation artificial grass pitch and players wore their normal soccer boots during the SSG's. Players were instructed to play against another team for six blocks of seven-min (overall work: 42-min) with two-min between each game being allowed for players to drink water and passively rest before the next repetition. Pitch size was 24 x 29 m and full-sized goals with goalkeepers were used. Further, players were allowed unlimited touches of the ball and the aim was to score as many goals as possible. This SSG format complemented the player's training regimes and was similar to previous literature.[2,16] The total time that the participants were on the field from the beginning of the warm-up to the end of the SSG's was 59-min.

The physical demands of the SSG's were collected via 10 Hz global positioning system (GPS) units embedded with 100 Hz tri-axial accelerometers (OptimEye X4, Catapult Innovations, Melbourne, Australia), which have shown to hold an acceptable level of reliability and validity when tracking player movements.[17] Each unit was attached to the upper back of players using a specifically designed vest garment. The data was downloaded and processed automatically using Catapult Sports software (Openfield, Catapult Innovations, Melbourne, Australia). The high speed running (HSR) threshold was defined as the total distance (m) covered at a velocity >5.5 $m \cdot s^{-1}$, and was set in line with previous work in soccer time-motion analysis.[18, 19] Player load [Playerload™] is defined as the sum of gravitational forces on the accelerometer in each individual axial plane (anteroposterior, mediolateral and vertical), and has been reported previously in soccer time-motion analysis.[2, 20]

The lower body strength training content was selected to both match the exercises that the players were familiar with in their normal routines whilst also being within the guidelines for the development of strength.[6] Players were only included who had a minimum of 1 year of strength training experience. Specifically, the session consisted of four sets of four repetitions of the parallel back squat, Romanian dead lift, and the barbell hip thrust, all at 85% of current 1 repetition maximum (RM) with four-min recovery between sets and exercises. Each exercise was preceded by two sets of four at 50% and 70% 1RM. The strength training session lasted approximately one hour. Prior to test involvement, each participant was required to perform a 3RM testing session of all three exercises, which occurred exactly a week prior to testing. Using the 3RM data, 1RM was estimated using an equation which accurately predicts 1RM.[21] The session was supervised by an accredited strength and conditioning coach (United Kingdom Strength and Conditioning Association; UKSCA) to ensure appropriate technique was maintained throughout.

A portable force platform (Type 92866AA, Kistler) was used to measure performance of the lower body. This required CMJ's to be performed at maximum effort, with arms akimbo to isolate the lower body musculature. Two CMJ's were completed after a standardized warm-up at each timepoint. The vertical ground reaction forces from the jumps were used to assess PPO from previously reported methods.[2, 6, 22] This data was converted into relative peak power ($W \cdot kg^{-1}$) by dividing PPO by the player's body mass in kilograms. Additionally, JH was calculated by multiplying the velocity at each sampling point by the time (0.005 s). It was then defined as the difference between vertical displacement at take-off and maximal vertical displacement. Test-retest reliability (intraclass correlation coefficient) for PPO, and JH were 0.89 and 0.84, respectively. The coefficient of variation (CV) for PPO and JH were 2.3% and 3.2%, respectively.

At all timepoints, 2 ml of saliva was collected by passive drool into sterile containers. Saliva samples were stored at -20 °C for seven days until assay. After thawing and centrifugation (2000 $\text{revolutions} \cdot \text{min}^{-1}$ x 10 min), the saliva samples were analyzed in duplicate for testosterone and cortisol concentrations using commercial kits (Salimetrics LLC, USA). The minimum detection limit for the testosterone assay was 6.1 pg·ml^{-1} with an inter-assay CV of 5.8%. The cortisol assay had a detection limit of 0.12 ng·ml^{-1} with inter-assay CV of 5.5%

Mood state was assessed using a modified version of the brief assessment of mood questionnaire (BAM+). [15] This 10-item questionnaire is based on the Profile of Mood State assessment and consists of a scale where players mark on a 10 cm scale about how they feel at that moment in time. Scale anchors ranged from 'not at all' to 'extremely'. The questions assess the following mood adjectives: anger, confusion, depression, fatigue, tension, alertness, confidence, muscle soreness, motivation and sleep quality. Players completed the questionnaires in isolation of teammates and it took approximately two minutes to complete. The BAM+ questionnaire has been shown to be an effective tool for monitoring the fatigue and recovery cycles in elite athletes. [2, 15] The scores were totalled up by giving the 6 unfavourable questions (anger, confusion, depression, fatigue, tension and muscle soreness) a positive value, and the 4 favourable questions (alertness, confidence, motivation and sleep quality) a negative value. The original total mood score ranged from -40 – 60, before adding 40 to each score so that the scale ranged from 0 – 100, with 0 indicating the best mood and 100 indicating the worst. [2, 15]

Data are reported as mean ± SD. Visual inspection of the residual plots revealed no clear evidence of heteroscedasticity, so all analyses were performed on the raw untransformed data. Custom-made spreadsheets were used to analyze the effect of training session (single, double) on our measures of neuromuscular function, endocrine and mood responses. [23] The analysis of within training session effects was made using the post-only crossover spreadsheet, with the analysis of between-group changes (single training session vs double training session) made using the before and after parallel-group spreadsheet. Here, we used the pre value of the dependent variable as a covariate to control for pre imbalances between the single and double training sessions. The uncertainty of our estimates is expressed as 90% confidence limits (CL). Standardised thresholds for small, moderate and large effects derived from between-player standard deviations of the pre values (0.2, 0.6 and 1.2, respectively) were used to assess the magnitude of all effects and effect probability of the effect was interpreted using the following scale: 25–75%, possibly; 75–95%, likely; 95–99.5%, very likely; >99.5%, most likely. [24] We classified the magnitude of effects mechanistically, whereby if the 90% CL overlapped the thresholds for the smallest worthwhile positive and negative effects, the effect was deemed unclear. [25] A paired samples T-test was used to determine if there were any differences between the GPS metrics on week 1 (single session) and week 2 (double session). GPS metrics for total distance (single, 4475 ± 397 m; double, 4315 ± 641 m), HSR (single, 21 ± 22 m; double, 30 ± 35 m) and Playerload™ (single, 452 ± 59 AU; double, 443 ± 85 AU) were similar between trials ($p > 0.05$).

Results

Between trial (single vs double) comparisons revealed that the double session day resulted in a *possibly small* compromized mood score between pre and +24 h and 0 h and +24 h (see Figure 1A & Table 1). Within-session effects revealed a *very likely moderate* decrease (0 h and +24 h) and a *likely moderate* increase (pre and 0 h) for the single session, with a *likely moderate* increase (pre and 0 h) and a *possibly moderate* decrease (0 h and +24 h) for the double session.

There was a *possibly small* impairment in CMJ height following the double training session day in comparison to the single session, both between pre and +24 h and 0 h and +24 h (see Figure 1B & Table 1). Within-trial analyses revealed predominantly *small* changes between timepoints for the single and double sessions (see table 1). A *likely small* impairment in relative PPO was observed after the double session compared to the single session between time points +24 h and baseline and 0 h and +24 h (see Figure 1C & Table 1). Within-trial effects for the single and double sessions revealed predominantly *small* changes across timepoints (see table 1).

***** TABLE 1*****

Between-trial comparisons revealed *likely small* higher testosterone concentrations following the single compared to the double training session between time points +24 h and baseline and 0 h and +24 h (see Figure 1D & Table 2). Within-trial analyses revealed that despite no changes in testosterone following the single session, after the double session there were *possible small* decreases (pre and +24 h, 0 h and +24 h). There were higher concentrations (*likely small*) in cortisol following the double compared to the single session (pre and +24 h, 0 h and +24 h) (see Figure 1E & Table 2). Following the single session, there were *possible small* decreases between all timepoints (see table 2). Between-session comparisons revealed *very likely small* (pre and +24 h) and *possibly small* (pre and 0 h) decreases in the testosterone to cortisol (T/C) ratio following the double compared to the single session (see Figure 1F & Table 2). Within-trial comparisons revealed *possible* to *very likely small* changes across all timepoints following for the single and double sessions (see table 2).

*****TABLE 2 *****

*****FIGURE 1 *****

Discussion

The primary aim of this study was to compare the 24 h responses of neuromuscular, endocrine and mood markers following a single session training day consisting of small-sided games, to a double training session day consisting of small-sided games and a weight training session performed 2 h later.

On both trials, the SSG training (6 x 7 min; 42 min total playing time) induced immediate fatigue as evidenced by *moderate* disturbances in mood (single, 9.8 ± 11.2 AU; double, 10.4 ± 7.2 AU) and *small* decreases in jump height (single, -1.6 ± 2.7 cm; double, 1.7 ± 3.8 cm). The addition of a weights training session 2 h after SSG's resulted in *small* impairments in neuromuscular performance (PPO; -2.5 ± 2.2 $W \cdot Kg^{-1}$; JH; -1.3 ± 2.0 cm), mood (4.6 ± 6.1 AU), endocrine markers (testosterone; 15.2 ± 6.1 $pg \cdot ml^{-1}$; cortisol; 0.072 ± 0.034 $ug \cdot dl^{-1}$; T/C ratio; -96.6 ± 36.7 AU) at +24 h, indicating additive fatigue effects.

It is unsurprising that immediately after the SSG's on both trials, there were *likely moderate* disturbances in mood score combined with *possible to likely small* impairments of neuromuscular performance. An explanation for the initial impairment in neuromuscular performance at 0 h may relate to a reduced functioning of the muscle fiber contractile mechanisms in the presence of metabolites (i.e., hydrogen ions, adenosine diphosphate, inorganic phosphate) accumulated during exercise. [26] Moreover, a decreased calcium ion release from the sarcoplasmic reticulum, resulting in less calcium ion binding to troponin and a negative influence on actin-myosin interactions during cross-bridge cycling may also have contributed. [26] Interestingly, the single session did not result in impaired neuromuscular performance or mood at +24 h; a finding which contradicts previous data in response to the same SSG protocol in professional players [2], whereby higher playing intensities may have resulted from full-time professional players as opposed to semi-professional players. Nevertheless, comparisons between the present data and that from the professional players appeared broadly similar for total distance (semi-professional, 4475 ± 397 m; professional, 4388 ± 231 m), high speed running (> 5.5 $m \cdot s^{-1}$; semi-professional, 21 ± 22 m; professional, 41 ± 30 m), and Playerload™ (semi-professional, 452 ± 59 AU; professional, 483 ± 38 AU). [2] For the pitch size used, it may be that the common and comparable metrics collected across both studies were not sensitive enough to measure the discrepancies in playing intensity that may have occurred.

The endocrine markers measured in the current study showed similar pattern to both neuromuscular function and mood, with between trial comparisons (single vs double) revealing no immediate differences at 0 h for both testosterone and cortisol. However, at +24 h there were *likely small* lower concentrations of testosterone (-15.2 ± 6.1 $pg \cdot ml^{-1}$) and *likely small* higher concentrations of cortisol (0.072 ± 0.034 $ug \cdot dl^{-1}$) following the single session in comparison to the double. This resulted in a *very likely small* beneficial response for the T/C ratio following the single session versus the double training session day (-96.6 ± 36.7 AU). With respect to their opposing roles in the regulation of protein metabolism, it has been suggested that testosterone and cortisol may differentially respond to metabolic stress. [27] Therefore, the ratio between the two hormones has been reported as a balance of anabolic and catabolic activity. [27] It is thought that a decreased T/C ratio may result in impaired physical performance.

[28] It could be that the added metabolic stress of the weights session in the current study resulted in a lower T/C ratio, which has been suggested to reduce neuromuscular performance and mood at +24 h.

Overall, our results suggest that performance of a double training session day resulted in *possible to very likely small* impairments of neuromuscular performance, mood score and endocrine markers in comparison to a single training session day at +24 h; possibly suggesting that a heavy lower body training session further exacerbated the fatigue response to the SSG protocol used here. The most likely explanation for this is that the added eccentric stress of the lower body resistance training resulted in further muscle inflammation and hydrogen ion accumulation. [6] While these mechanisms have been extensively studied across sessions separated by several days or weeks [29], limited research has examined the effects of multiple sessions performed in the same day. Our results are conflicting with previous findings on the effects of multiple daily resistance sessions, cycling sessions, and combined speed and weights training sessions [6, 9, 30]. However, the authors acknowledge that the small differences may be due to variations in the training history of the participants involved, exercises selected, and intensity of the protocols. Nevertheless, our study is the first to examine the combined response from SSG's and weight training in soccer players.

There are a number of limitations to the current study that should be acknowledged. Firstly, some teams and practitioners may schedule a rest day at 24 h post a double training session, therefore the inclusion of a 48 h post timepoint to the study design may have been useful to investigate whether fatigue still persisted. In addition, collection of internal load and/or other GPS metrics such as acceleration and deceleration activity during the SSG's may have given a better indication of the playing intensity. Finally, we did not measure player's aerobic fitness prior to the start of this study, which is a factor that may influence fatigue and recovery profiles.

Conclusion

This study shows that 42 min of SSG's combined with lower body weight training resulted in small to moderate disturbances in neuromuscular performance, mood, and endocrine markers over a 24 h period in comparison to the SSG's alone. As soccer players are often required to concurrently train multiple physical qualities in the same day (i.e. strength and soccer), this data may be of use to those responsible for the design of soccer training programs. More specifically, consideration of the added 24 h fatigue response from a double training session should be considered when programming into the training week, as players may require longer to recover and adapt.

Practical Implications

- Consideration of the added 24 h fatigue response from a double training session should be considered when programming into the training week, as players may require longer to recover and adapt.
- A strategy of alternating high intensity explosive training days containing multiple sessions with days emphasising submaximal technical/tactical activities may be beneficial.

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Figure Legends

Figures 1 A-F. Mean±SD mood (A), CMJ height (B), relative peak power output (C), testosterone (D), cortisol (E) and mood (F) responses to a single vs double training session. Qualitative inferences are shown above the figure for the between trial differences between each timepoint. (*25-75 %, *possibly*; **75-95 %, *likely*; ***95-99.5 %, *very likely*).

Table 1. Mean (± SD) fatigue marker changes between timepoints. Qualitative inferences are shown for both the withir
vs double session).

		Compari	
Variable	Trial	Pre – 0 h	Pre – 24 h
Mood Score (AU)	Single ± SD	9.8 ± 11.2 (*Moderate***)	-2.1 ± 7.7 (*T*
	Double ± SD	10.4 ± 7.2 (*Moderate***)	2.5 ± 6.8 (*Tr*
	Between trial difference ± 90% CL	0.7 ± 7.5 (*Trivial**)	4.6 ± 6.1 (*Sr*
CMJ Height (cm)	Single ± SD	-1.6 ± 2.7 (*Small**)	0.5 ± 2.7 (*Tr*
	Double ± SD	-1.7 ± 3.8 (*Small***)	-0.8 ± 1.9 (*S*
	Between trial difference ± 90% CL	-0.1 ± 1.3 (*Trivial***)	-1.3 ± 2.0 (*S*
CMJ Relative PPO ($W \cdot Kg^{-1}$)	Single ± SD	-0.3 ± 3.6 (*Trivial**)	1.0 ± 3.9 (*Sr*
	Double ± SD	-0.9 ± 3.3 (*Small**)	-1.5 ± 1.9 (*S*
	Between trial difference ± 90% CL	-0.6 ± 1.5 (*Trivial**)	-2.5 ± 2.2 (*S*

SD, standard deviation; SSG, small-sided game; AU, arbitrary units.

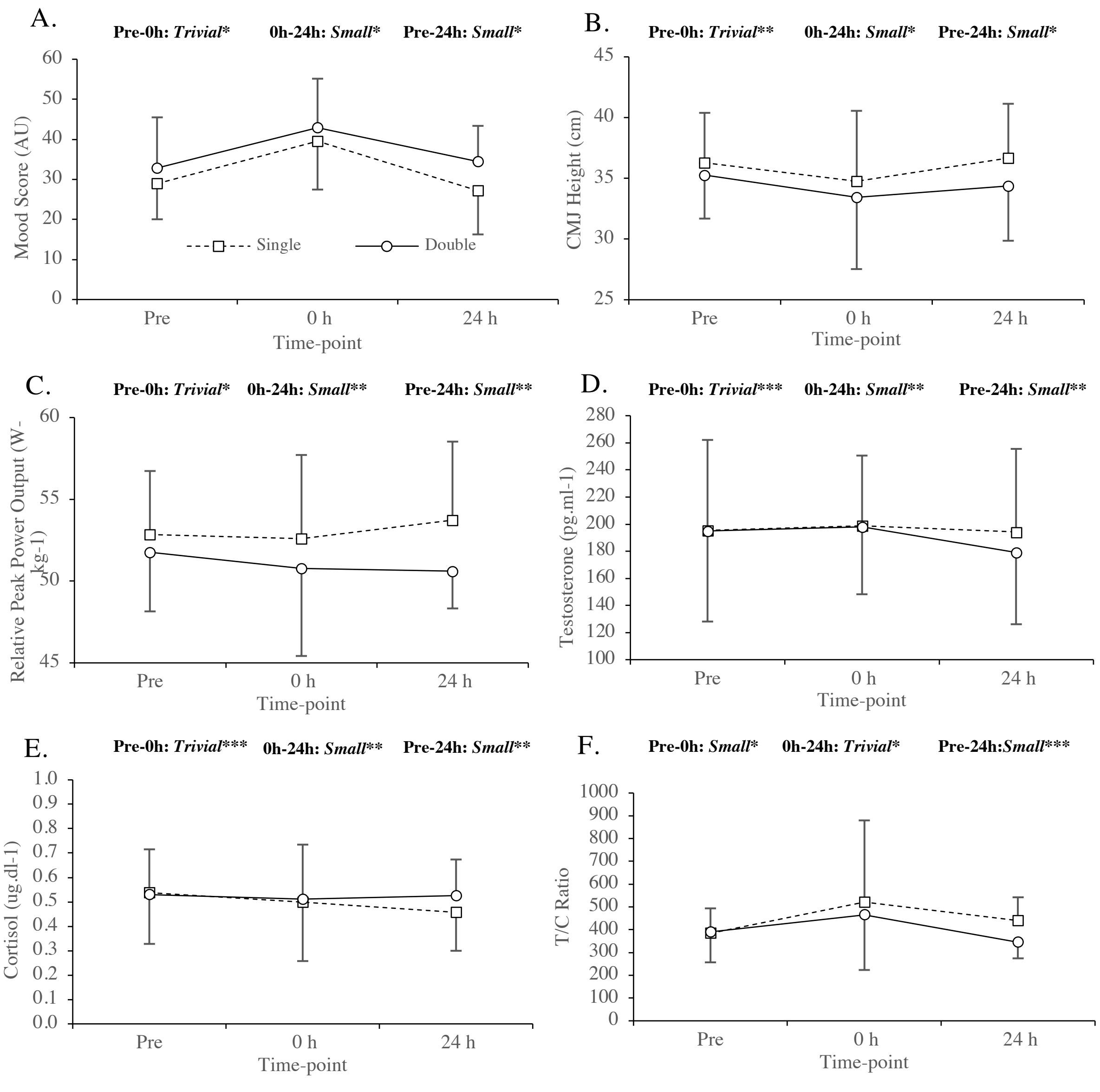
*25-75 %, *possibly*; **75-95 %, *likely*; ***95-99.5 %, *very likely*.

Table 2. Mean (± SD) endocrine marker changes between timepoints. Qualitative inferences are shown for both the w
vs double session).

Variable	Trial	Comparison	
		Pre – 0 h	Pre – 24 h
Testosterone (pg·ml^{-1})	Single ± SD	+3.6 ± 26.3 (*Trivial***)	-0.8 ± 61.7 (*Triv*
	Double ± SD	+3.0 ± 27.9 (*Trivial***)	-16.0 ± 54.8 (*Sm*
	Between trial difference ± 90% CL	-0.6 ± 5.7 (*Trivial****)	-15.2 ± 6.1 (*Sma*
Cortisol (ug·dl^{-1})	Single ± SD	-0.035 ± 0.251 (*Small**)	-0.078 ± 0.152
	Double ± SD	-0.022 ± 0.234 (*Trivial**)	-0.006 ± 0.143
	Between trial difference ± 90% CL	0.013 ± 0.020 (*Trivial****)	0.072 ± 0.034
T/C Ratio (AU)	Single ± SD	+138.3 ± 336.8 (*Small***)	+53.6 ± 93.9 (*S*
	Double ± SD	+74.0 ± 190.2 (*Small**)	-43.0 ± 69.5 (*Sm*
	Between trial difference ± 90% CL	-64.3 ± 85.0 (*Small**)	-96.6 ± 36.7 (*Sm*

SD, standard deviation; SSG, small-sided game; AU, arbitrary units.

*25-75 %, *possibly*; **75-95 %, *likely*; ***95-99.5 %, *very likely*.


A.
Pre-0h: Trivial*
0h-24h: Small*
Pre-24h: Small*
Mood Score (AU)
Single
Double
Pre
0 h
24 h
Time-point
B.
Pre-0h: Trivial**
0h-24h: Small*
Pre-24h: Small*
CMJ Height (cm)
Pre
0 h
24 h
Time-point
C.
Pre-0h: Trivial*
0h-24h: Small**
Pre-24h: Small**
Relative Peak Power Output (W-kg-1)
Pre
0 h
24 h
Time-point
D.
Pre-0h: Trivial***
0h-24h: Small**
Pre-24h: Small**
Testosterone (pg.ml-1)
Pre
0 h
24 h
Time-point
E.
Pre-0h: Trivial***
0h-24h: Small**
Pre-24h: Small**
Cortisol (ug.dl-1)
Pre
0 h
24 h
Time-point
F.
Pre-0h: Small*
0h-24h: Trivial*
Pre-24h:Small***
T/C Ratio
Pre
0 h
24 h
Time-point

Figures 1 A-F. Mean±SD mood (A), CMJ height (B), relative peak power output (C), testosterone (D), corti
single vs double training session. Qualitative inferences are shown above the figure for the between trial d
(*25-75 %, *possibly*; **75-95 %, *likely*; ***95-99.5 %, *very likely*).