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**Section:** Original Investigation

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**Authors:** Amber E. Rowell[1,2], Robert J. Aughey[1], William G. Hopkins[1,3], Andrew M. Stewart[1] and Stuart J. Cormack[4]

**Affiliations:** [1]ISEAL (Institute of Sport, Exercise, and Active Living), Victoria University, Melbourne, Australia. [2]Melbourne Victory Football Club, Melbourne, Australia. [3]Defense Institute, Oslo, Norway. [4]Australian Catholic University, Melbourne, Australia.

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# Identification of sensitive measures of recovery following external load from football match play.

Original Investigation

Amber E. Rowell[1,2], Robert J. Aughey[1], William G. Hopkins[1,3], Andrew M. Stewart[1] and Stuart J. Cormack[4]

[1]ISEAL (Institute of Sport, Exercise, and Active Living), Victoria University, Melbourne, Australia.
[2]Melbourne Victory Football Club, Melbourne, Australia.
[3]Defense Institute, Oslo, Norway.
[4]Australian Catholic University, Melbourne, Australia.

Corresponding Author:
Name: Dr Stuart Cormack
Institution: Australian Catholic University, 115 Victoria Pde, Fitzroy, VIC 3065
T: +61 3 9953 3133
Email: Stuart.Cormack@acu.edu.au

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## Abstract

Objective measures of recovery from football match-play could be useful for assessing athletes' readiness to train, if sensitive to preceding match load. **Purpose:** To identify the sensitivity of countermovement-jump (CMJ) performance and concentration of salivary testosterone and cortisol relative to elite football match load. **Methods:** CMJ performance and salivary hormones were measured in 18 elite football players before (27-, 1-h) and after (0.5-, 18-, 42-, 66-, 90-h) three consecutive matches. Match load was determined via accelerometer derived PlayerLoad™ and praised into tertiles. Sensitivity of CMJ performance and hormone concentrations to match load was quantified with t-statistics and magnitude-based inferences (change in mean as % ± 90% confidence interval (CI)) derived with a linear mixed model. **Results:** Jump height was reduced in medium- and high-load at 0.5-h (10% ± 7% and 16% ± 8%) and 18-h (7% ± 4% and 9% ± 5%) post match. There was a 12% ± 7% reduction in Flight time:contraction time (FT:CT) ratio in high-load at 0.5-h post, with reductions in medium- and high-load at 18-h. Reductions in FT:CT persisted at later post-match time-points than changes in Jump height. Increased cortisol (range: 55% to 165%) and testosterone (range: 17% to 20%) was observed in all match loads at 0.5-h post with individual variability thereafter. **Conclusions:** Measures of CMJ performance and hormonal concentrations were sensitive to levels of A-League football match load. Although jump height was reduced immediately post-match, FT:CT provided a more sensitive measure of recovery. Football match play induces an acute hormonal response with substantial individual variability thereafter.


**Keywords:** Football, neuromuscular fatigue, testosterone, cortisol, monitoring

## Introduction

Monitoring the external load performed by an athlete and the response to that load is critical to determine when to apply the next training stimulus.[1] Velocity and distance metrics are commonly reported measures of external load, yet they may underestimate the load in sports such as football where frequent changes of velocity and direction occur.[2] Tri-axial accelerometers are used to measure global exercise load.[3,4] PlayerLoad™, representing the instantaneous rate of change of the medio-lateral, anterior-posterior, and vertical accelerometer vectors is a valid and reliable measure of external load in team sports.[3] PlayerLoad™ discriminates between levels of performance and is modified due to fatigue.[3,4] PlayerLoad™ thus may provide a more complete measure of football load than traditional distance and velocity metrics. A commonly quantified response to external load is neuromuscular fatigue.[5-7] Although gold standard assessment of neuromuscular fatigue requires magnetic or electrical nerve stimulation, this approach is impractical in the applied sport setting.[8] To overcome this limitation, neuromuscular fatigue can be quantified via countermovement jump performance (CMJ).[5-7] Of the variables measured via CMJ, some display high ecological validity as they respond negatively to Australian Rules football match play, and also impact subsequent match exercise intensity.[5,9,10] The CMJ response to football match play has generally been measured via jump height.[6,11,12] The flight time:contraction time (FT:CT) ratio, may provide a more precise quantification of neuromuscular fatigue in team sport athletes than jump height due to it reflecting a change in movement strategy.[6] Therefore jump height measurement may underestimate the magnitude of neuromuscular fatigue.[5,7,13] Importantly, altered CMJ performance should be sensitive to preceding exercise load if it is a valid measure of fatigue in the sporting context, but this concept has only received limited attention in the literature.[14]

The hormonal response to match play (testosterone (T) and cortisol (C) concentration in particular) is also commonly reported.[1] Testosterone is an anabolic hormone with an important role in promoting protein synthesis whilst cortisol is a catabolic hormone important in metabolism.[12,15] The concentration of T and C are often combined as the T:C ratio, which represents the anabolic:catabolic balance.[12,15] Australian Rules football match play resulted in an acute increase in C with little impact on T, whilst the T:C ratio was reduced for up to 48 hours post-match, suggestive of a somewhat catabolic state for this relatively short period.[12]

Despite support for the use of both CMJ performance and the hormonal response to assess the impact of football match play, the influence of preceding match load on the magnitude of the post-match response is not well understood. Therefore the aim of this research was to determine the impact of football match load on CMJ performance, T, C and the T:C ratio.

## Methods

### Subjects

Data (expressed as mean ± SD) were collected from 18 elite football players (age 23.3 ± 4.1 y, height; 180.0 ± 10.0 cm and mass; 75.7 ± 4.4 kg) from one Australian A-League club across three consecutive pre-season Football Federation Australia matches.

### Design

A maximal CMJ and saliva sample was collected at 27-h and 1-h pre-match; 0.5-h, 18-h, 42-h, 66-h and 90-h post-match. Athletes were familiarized with CMJ and saliva collection techniques during a 4-week period prior to the first match. The research was approved by the Victoria University Human Research Ethics Committee with informed consent obtained prior to commencement.

**Methodology**

Athletes completed a standardized 2-minute dynamic warm-up with 3 practice jumps prior to a maximal CMJ.[5] The CMJ was performed on a force plate (400 Series Platform Plate; Fitness Technology, Adelaide, Australia) connected to manufacturer-supplied software (Ballistic Measurement System; Fitness Technology, Adelaide, Australia). Participants performed one CMJ for maximum height with a self-selected depth whilst maintaining hands in position on the hips.[5] Jump height (m), peak velocity ($m.s^{-1}$), relative peak and mean power ($W.kg^{-1}$), relative peak force ($N.kg^{-1}$), contraction time (s) and FT:CT ratio were analysed.[9]

Athletes maintained their usual dietitian-prescribed diet throughout the testing period and were instructed to ingest only water in the 60 min prior to providing a saliva sample.[5] To account for diurnal variation, collection of T and C samples generally occurred between 0900 and 0930 with the exception of 1-h pre and 0.5-h post-match. Game 1 and 2 1-h pre-match samples were collected between 1245 and 1315 and game 3 between 1420 and 1450. The 0.5-h post game samples were collected between 1600 and 1630 for games 1 and 2 and between 1730 and 1800 following game 3. Athletes provided 2 mL of unstimulated passive drool directly into a plastic tube.[5] Samples were frozen at -80°C for later analysis. Duplicate enzyme-linked immunosorbent assay (Salimetrics, PA, USA) using a microplate reader (SpectraMax 190, Molecular Devices, CA, USA) determined C [$\mu g.dL^{-1}$] and T [$pg.mL^{-1}$] concentration.[5] Accelerometer (100 Hz) derived PlayerLoad™ expressed in arbitrary units (au) accounted for match load. Match load was parsed in to three levels: low-load (0-499 au), medium-load (500-1000 au) and high-load (>1000 au). The distribution of PlayerLoad™ from subsequent training relative to low-, medium- and high-loads from the match is displayed in Figure 1. The low-load group trained at 18-h post match following data collection after games 1 and 2. Following matches 1, 2 and 3, all groups trained following data collection at 42- and 66-h following matches 1 and 2 only. Following match 1, 90-h post was a day off. There was a crossover with 90-h post match 2 also match 3 and this was accounted for in the statistical model. Regardless of match-load, all players trained at 90-h post match 3.

### Statistical Analysis

Separate analyses were performed for each of the measures derived from the countermovement jump and the saliva samples. Each analysis was performed with the same mixed model using the general linear mixed-model procedure (Proc Mixed) in the Statistical Analysis System (version 9.4, SAS Institute, Cary NC). The fixed effects in the model estimated means for each time point, each game and each of the three levels of match-load. Athlete identity and its interaction with match identity were included as random effects to account for repeated measurement on athletes' within- and between-matches, while a different residual error was specified for each of the seven time points to allow for individual differences in the response to the match load. Jump height and peak velocity had the smallest residual error on the last time point (90-h), which was therefore used as the reference level for estimating changes in performance between time points.

All measures were log-transformed before analysis then back-transformed to express the changes in percent units. To compare the sensitivity of the measures to the effects of match-load, the changes were expressed as t-statistics, which represent a signal-to-noise ratio. The t-statistics were provided directly by the mixed-modeling procedure. The changes were also expressed in standardized units for assessment of magnitude. Standardization was performed by dividing the change score of the log-transformed measure by the between-subject standard deviation derived from the random effects for athlete identity and its interaction with match identity; this between-subject standard deviation represents the differences between athletes at any given time point free of residual (measurement) error. Uncertainty in the changes was expressed as 90% confidence intervals and interpreted via the non-clinical magnitude-based inference approach.[16] Standardized changes (ES) of 0.20, 0.60, 1.20, 2.0, and 4.0 were thresholds for small, moderate, large, very large and extremely large effects respectively. When the confidence interval for a change included small positive and negative effects, the change was deemed unclear. For clear effects, the likelihood that the true effect was substantial was indicated with the following scale: *possibly* (25% to 75%), *likely* (75 to <95%), *very likely* (95 to 99.5%) and *most likely* (>99.5%).

## Results

### Selecting the most sensitive countermovement jump measure

Although there was variability relative to match-load and time-points, jump height, FT:CT and peak velocity displayed the largest ES and t-statistic values (ranges of: 0.2 to 3.0, 0.4 to 3.9 and 0.0 to 3.0 respectively) compared to baseline (90-h post). Peak velocity and jump height displayed the same pattern of response; however the standardised effects for jump height were nearly twice that of peak velocity. As jump height is a commonly reported measure of CMJ performance; it was selected ahead of peak velocity as the variable for further analysis.

### Magnitude of change compared to baseline

Mean jump height and FT:CT response to match load is displayed in Figures 2 and 3 with the change in mean from baseline displayed in Table 1. At 0.5-h and 18-h post there was a moderate and small *likely* reduction (10%, ±7% and 7%, ±4%) in jump height for medium-load. High-load displayed a *very likely* (large and moderate effects) reduction in jump height (16%, ±8% and 9%, ±5%) at the same time-points respectively. At 42-h, the change in jump height was *unclear* across all levels of load. High-load had a *very likely* 12%, ±7% reduction (moderate effect) in FT:CT at 0.5-h post. At 18-h, there was a *most likely* and *likely* reduction (moderate effects) in FT:CT in medium- and high-load respectively.

Mean C, T and T:C response to the match load tertiles is displayed in Figures 4, 5 and 6 respectively, with the change in mean from baseline in Table 1. Compared to 90-h post, at 0.5-h post there was a *very likely* (moderate effect) increase in C in low-load, *most likely* increase in medium-load (very large effect) and *most likely* increase in high-load, with a large effect (range: 55% to 165%). At 18-h, the change in C was *unclear*. Testosterone displayed *likely* increases in low- and high-load respectively and *very likely* increase with moderate effects in medium-load (range: 17% to 20%) at 0.5-h post. There were varied responses thereafter. Low-load resulted in a *likely* reduction (moderate effect) in T:C with moderate and high-load resulting in *most likely* reductions at 0.5-h post with very large and large effects respectively. There were *unclear* changes in T:C in all load tertiles at 18-h, with small (low-load) and moderate (medium- and high-load) effects of an increased T:C at 42-h.

**Magnitude of Change from Baseline between levels of PlayerLoad™ (au)**

The magnitude of change from baseline between match load tertiles in all variables is presented in Table 2. At 0.5-h, there was a moderate *likely* greater reduction (12%, ±11%) in jump height in medium-load and large *very likely* greater reduction (18%, ±11%) in high-load compared to low-load. There was a small *likely* greater reduction (8%, ±9%) in FT:CT in high-load compared to medium-load at the same point. Whilst at 18-h, there was a moderate *likely* greater reduction (12.4%, ±11.8%) in FT:CT in medium-load compared to low-load. There was a moderate *very likely* increase (72%, ±77%) in C in medium-load compared to low-load at 0.5-h post. Differences in the T response between load tertiles were variable whilst the differences in T:C was predominantly *unclear*.

## Discussion

The aim of this research was to determine the sensitivity of CMJ performance, T, C, and the T:C ratio to load accumulated during football match play. Elite level football match load altered athletes’ subsequent CMJ and hormonal response. Match load mediated the degree of change in jump height and FT:CT, with FT:CT more sensitive to match and subsequent training load. The results of this study highlight the need to consider multiple markers of recovery from match-load.

The magnitude of reduction in jump height at 0.5 and 18-h post appears to be modified by match-load. For example, the change was *unclear* at these times in low-load, yet *very likely* reduced with large effects in high-load. Further, at 0.5-h, when compared to low-load, there was a *likely* and *very likely* (moderate and large effects) lower jump height in medium and high-load respectively, but no clear difference between medium- and high-loads. Given this finding, it appears plausible that there is a minimum threshold match-load that negatively impacts CMJ height post-match. Similarly a maximum threshold seems to exist beyond which, there is limited additional clear impairment of jump performance. As the results indicate a dose-response relationship; this finding provides some support for the ecological validity of jump height as a sensitive measure of an immediate neuromuscular response to football match play. Whilst the mechanisms responsible for the reduction in post-match jump height cannot be determined in this study, there are numerous possibilities.[12,17] These include central and peripheral factors including structural changes due to muscle micro-trauma or reduced central drive .[11] At 42-h there were unclear changes in jump height, whilst at 66-h there was individual variability in the jump height response to a given match-load. This variability may be a function of the post-match training load, or related to individual athlete characteristics such as lower body strength or fitness impacting athletes tolerance to match loads.[14] Similar to the findings shown here, reduced jump height has been shown to last between 24-h and 72-h with variation according to level of football competition, timing of testing and match vs. simulated activity.[11,17,18]

Despite the support for jump height as a marker of recovery noted above, the results are stronger in support of FT:CT. In contrast to the *unclear* change in jump height at 0.5-h post in low-load, FT:CT was *possibly* reduced in this group and medium-load (although small effects were identified). High-load resulted in a *very likely* (moderate effect) reduced FT:CT at 0.5-h post. Although the impact of a *possible* reduction should not be overstated, it suggests a detection of a change in performance, and provides different information about neuromuscular status than jump height. Compared to jump height at 18-h post, there was a more likely reduction in FT:CT than jump height; supporting the contention that FT:CT is a more sensitive measure.[5,19] The likelihood of a reduction in FT:CT was also generally more certain than in jump height at 42- and 66-h post, particularly in low-load where training occurred immediately after both 18- and 42-h post match jump testing. Thus, FT:CT may be more sensitive to acute load changes than jump height. The observed response may also be representative of the bi-modal pattern of recovery from repetitive stretch-shortening cycle exercise.[5,6] Regardless of mechanism, this finding adds weight to the concept that impairments to neuromuscular function result in a reorganization of jump strategy in order to maintain a similar output (e.g. height).[6,18] In such a case, the outcome measure of flight time or jump height is relatively unaffected, but when considered relative to a measure of jump strategy (i.e. contraction time), a decrement is revealed.[4,6,18]

In the comparison of the magnitude of change between load groups from 18- to 66-h post, neither jump height nor FT:CT change with more certainty. It is possible that the arbitrary division of external load used here was too narrow to detect clearly meaningful differences between the match load tertiles. Support for this contention exists in the largely *unclear* differences in both jump height and FT:CT when comparing medium and high match loads. Beyond the 500 au threshold of low match load, it appears that individual variability (demonstrated by the wide confidence intervals) plays an important role. These individual differences may be related to position, tactics and physical characteristics.[14] As PlayerLoad™ represents accelerations in 3 planes it could be that some players have completed relatively more or less low speed activity, high speed running, sprinting, accelerating, decelerating and changes of direction than others to produce the same absolute match load.[20] It could be that the distribution of activity profile has an impact on the FT:CT response, such that players involved in relatively more intermittent high intensity activities may respond differently than those involved in a higher number of low speed continuous actions. In addition, players within the same match load group could be nearly 500 au apart, which may have impacted the results.

The intensity of A-League match play resulted in an immediate increase is salivary C across all load tertiles. As with CMJ variables, it is difficult to compare this result to other work, as the activity profile has not generally been accounted for. Intercollegiate male soccer players and rugby league players have had a more than 200% increase in C after match play.[15,21] Whilst in Australian Rules football players, C increased immediately and 24-h post-match by 34% and 42% respectively.[5] Although all load tertiles resulted in increased C post-match, the increases were greater in medium- and high-load compared to low. It appears that A-League match play is of sufficient volume and intensity to cause an increased secretion of C.[15] Unlike the modified CMJ performance, the same dose-response relationship is not evident in C, which appears due to substantial individual variation. The reason for this variation is not obvious, however the biochemical response to team sport exercise appears to be influenced by intermittent endurance fitness and similar mechanisms may be at play up until 18-h post.[14] In addition, C is influenced by psychological factors that may have played a role in the current results.[15,22] For example, higher post-match values were observed in starters compared to non-starters in collegiate football.[23] By 42-h post, clear reductions in C are evident in the medium and high-load (small and moderate effect respectively), although the difference between these groups is unclear. Finally, the impact of circadian variation on the results due to some inconsistency in sample time collection around matches cannot be ruled out.[21,22]

All load tertiles exhibited meaningful increases in T post-match, with no clear difference in the magnitude of change between tertiles. Variable responses are common, with an average 15% increase post-match in collegiate football, an approximate 20% reduction following rugby match play and no change after elite football match play.[15,21,24] At 18-h post and beyond, the T response appears to be a function of substantial individual variability. The division of match load into the three broad groups and the potential impact of circadian variation as mentioned previously, may have caused such variability.[21,22] Similar to the contention posed for FT:CT, it may also be that despite a similar external load, players could have achieved this outcome with a markedly different activity profile, impacting individual T responses.

Low, medium and high-load resulted in moderate *likely*, very large and large *most likely* reductions in T:C respectively immediately post-match. The T:C ratio is said to be reflective of anabolic:catabolic balance and the results of the present study suggest an immediate relatively catabolic response to A League match-play.[5,15] Similar catabolic states existed following rugby union match play where T:C was 2.5 times lower compared to a rest day, and following 1st division female football match play, where there was a 32% reduction in T:C.[15,25] At 18-h post, the change in T:C is uniformly trivial *unclear*. This result appears to contrast previous work in football where T:C was reduced for 48-h compared to pre-match.[12] However, the uncertainty described here may in fact be a function of the precise statistical analysis employed and more accurately reflect the true individual variability relative to match load.[26] Interestingly, by 42-h post there are small *likely* to moderate *very likely* increases in T:C suggesting a return to an anabolic environment following the introduction of a training stimulus. It appears that there is a progressive change from a relatively catabolic to anabolic environment somewhere between immediately post-match and 42-h post. Following rugby union match play, T:C changed from an immediate post-match reduction to increased values in the following 4 days.[15] In a similar way to the reductions evident in FT:CT at 66-h post, the clear reduction in T:C in low match load is potentially a function of training load between 42- and 66-h post.[5]



## Practical Applications

Football players accumulating a PlayerLoad™ of >500 au have a reduced CMJ performance for at least 42-h. The FT:CT is sensitive to both match-load and the introduction of subsequent training load typical in a training week. Thus FT:CT is the most useful CMJ variable for assessing recovery post-match. Practitioners should consider assessing this variable from a CMJ at least 42-h post-match to help inform training prescription. The substantial individual variability and cost of analysis of hormonal response raises questions regarding the utility of regular monitoring of salivary hormones in A-League football. Individual monitoring is recommended within a team environment.

## Conclusion

External load accumulated during A-League match play results in a reduction in CMJ performance and increased C and T concentrations. Reductions in jump height were greatest in medium and high loads at 0.5- and 18-h post match, suggestive of a dose-response relationship. The FT:CT ratio detected an immediate alteration in jump performance associated with higher match loads, and was reflective of altered movement strategy post-match. This study identified wide individual variation, particularly with the hormonal response beyond immediately post match. Therefore to fully understand the complexities of accounting for individual athlete recovery via neuromuscular and hormonal response to match play within the team environment, sophisticated modeling is needed.

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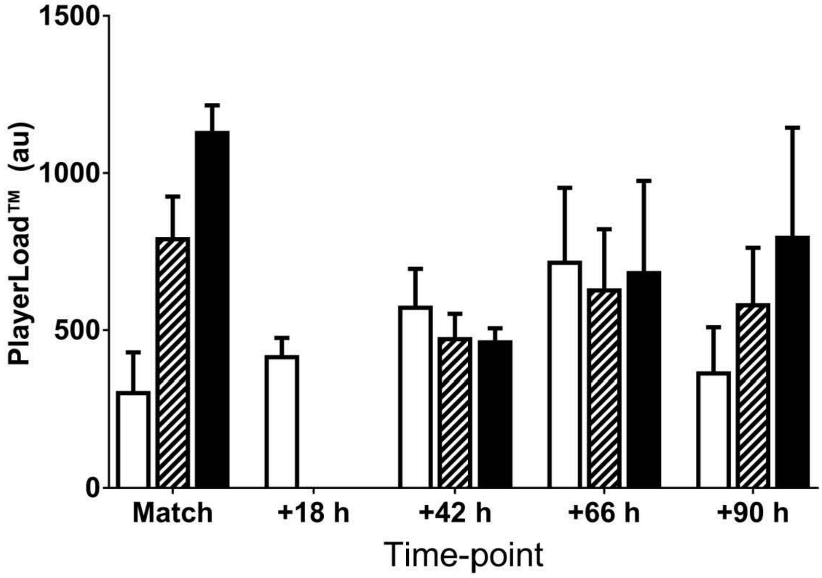


**Figure 1.** Distribution of match and training PlayerLoad™ (au) for low-, medium- and high-load groups. Data is presented as group means ±SD. Low-load is depicted in the un-filled columns, medium-load in the hatched columns and high-load in the solid columns.

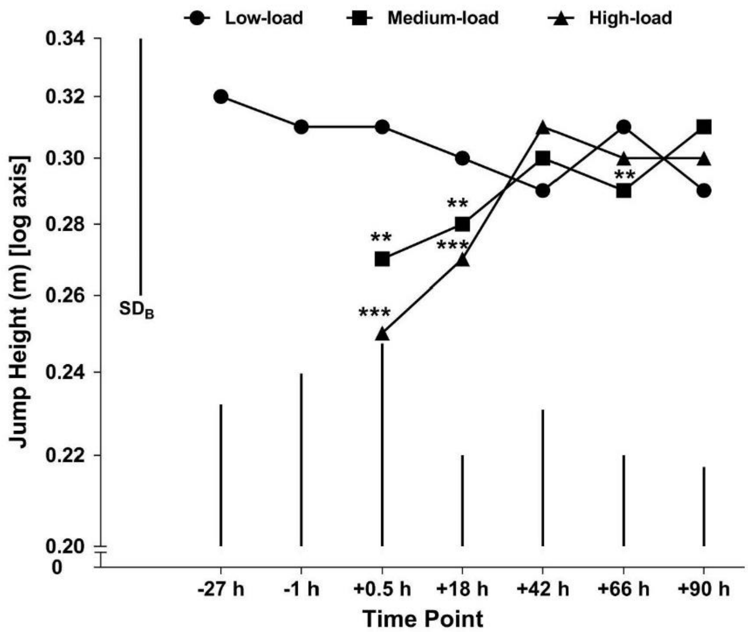


**Figure 2.** Mean Jump height from 27h pre to 90h post of low, medium and high match loads. Mean values are displayed in log scale with the overall between subject SD shown by the bar labelled $SD_B$. The single bars underneath each time-point represent the within subject SD specific to that time-point. Changes exceeding the ES (0.2) with the qualitative descriptor of likely ** (75 to <95%), very likely *** (95 to 99.5%) and most likely **** (>99.5%) is displayed. m: meters.

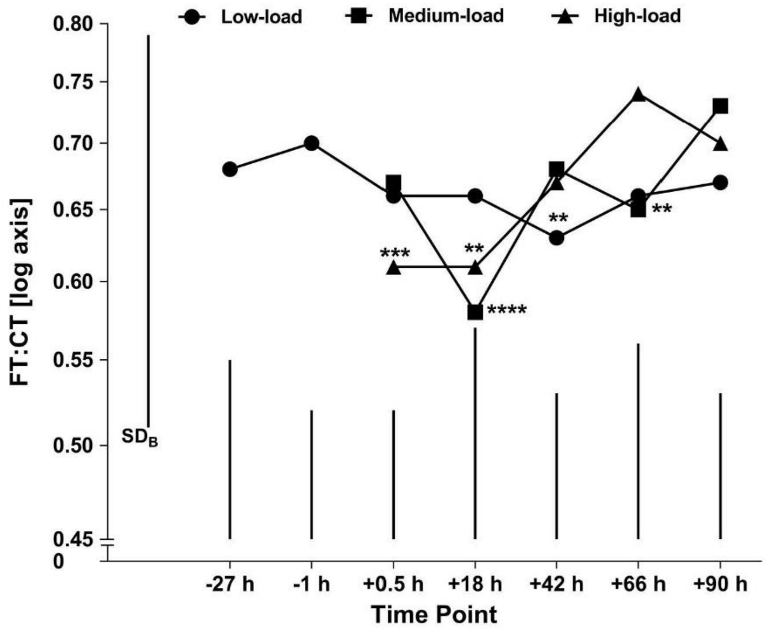


**Figure 3.** Mean FT:CT from 27h pre to 90h post of low, medium and high match loads.. Mean values are displayed in log scale with the overall between subject SD shown by the bar labelled $SD_B$. The single bars underneath each time-point represent the within subject SD specific to that time-point. Changes exceeding the ES (0.2) with the qualitative descriptor of likely ** (75 to <95%), very likely *** (95 to 99.5%) and most likely **** (>99.5%) is displayed. m: meters.

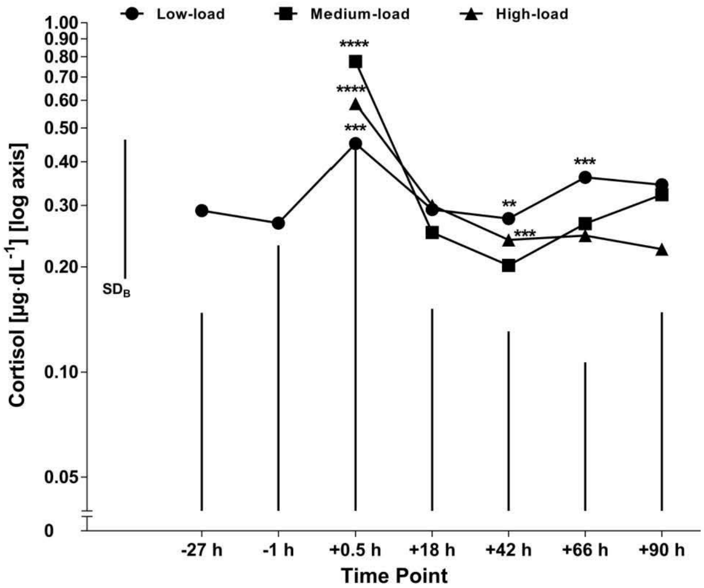


**Figure 4.** Mean Cortisol from 27h pre to 90h post of low, medium and high match loads. Mean values are displayed in log scale with the overall between subject SD shown by the bar labelled $SD_B$. The single bars underneath each time-point represent the within subject SD specific to that time-point. Changes exceeding the ES (0.2) with the qualitative descriptor of likely ** (75 to <95%), very likely *** (95 to 99.5%) and most likely **** (>99.5%) are displayed [$\mu g.dL^{-1}$]: micrograms per deciliter.

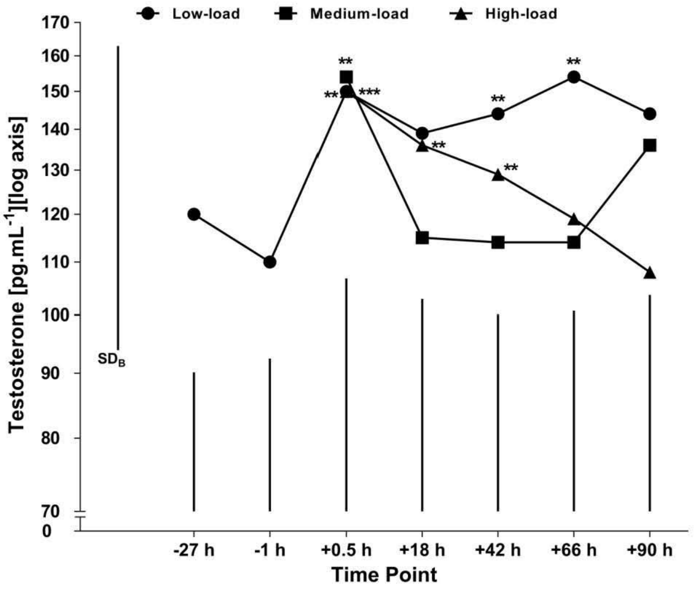


**Figure 5.** Mean Testosterone response from 27h pre to 90h post of low, medium and high match loads. Mean values are displayed in log scale with the overall between subject SD shown by the bar labelled $SD_B$. The single bars underneath each time-point represent the within subject SD specific to that time-point. Changes exceeding the ES (0.2) with the qualitative descriptor of likely ** (75 to <95%), very likely *** (95 to 99.5%) and most likely **** (>99.5%) are displayed. [pg.mL$^{-1}$]: pictogram per milliliter.

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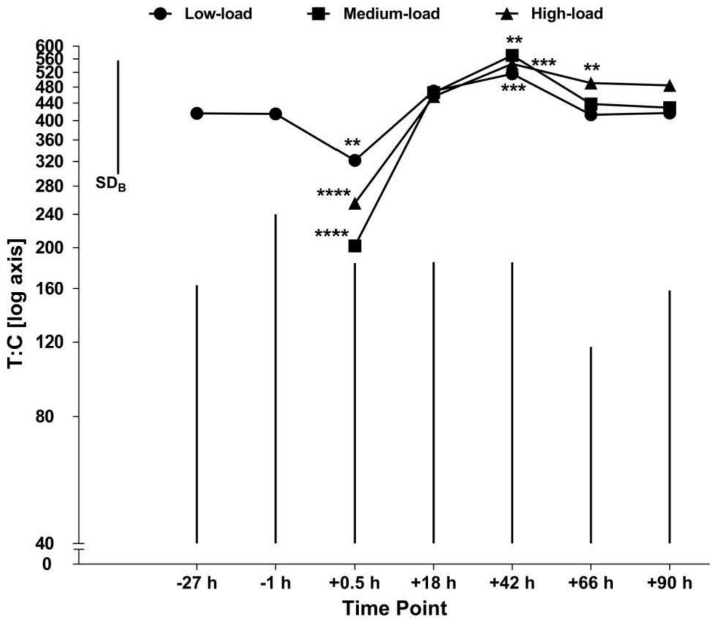


**Figure 6.** Mean T:C response from 27h pre to 90h post of low, medium and high match loads. Mean values are displayed in log scale with the overall between subject SD shown by the bar labelled $SD_B$. The single bars underneath each time-point represent the within subject SD specific to that time-point. Changes exceeding the ES (0.2) with the qualitative descriptor of likely ** (75 to <95%), very likely *** (95 to 99.5%) and most likely **** (>99.5%) are displayed.

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**Table 1**. The difference in the magnitude of change from baseline of Jump Height, Flight Time:Contraction Time (FT:CT) ratio, Cortisol (C), Testosterone (T) and Testosterone:Cortisol (T:C) ratio between levels of match load.

| | Match load | 0.5 h post | 18 h post | 42 h post | 66 h post |
|---|---|---|---|---|---|
| Jump height | L | 2.4, ±9.1 | 0.6 ±5.2 | -2.6 ±5.3 | 1.4 ±5.8 |
| | M | -9.9, ±7.3; ↓** | -6.6, ±4.4; ↓** | 1.0, ±4.8 | -4.5, ±4.8; ↓** |
| | H | -15.8 ±8.1; ↓*** | -8.7 ±5.3; ↓*** | 3.0 ±6.9 | -1.4 ±6.5 |
| FT:CT ratio | L | -5.6, ±6.6; ↓* | -5.3, ±9.9 | -9.6, ±6.7; ↓** | -7.8, ±9.9; ↓* |
| | M | -5.0, ±6.5; ↓* | -17.0, ±7.5; ↓**** | -3.6, ±6.4; ↓* | -9.2, ±8.5; ↓** |
| | H | -12.4, ±6.6; ↓*** | -12.6, ±10.3; ↓** | -4.6, ±8.6 | 2.9, ±13.0 |
| Cortisol [$\mu g.dL^{-1}$] | L | 54.6, ±54.4; ↑*** | -0.0, ±21.6 | -5.7, ±19.9 | 34.7, ±27.0; ↑*** |
| | M | 165.4, ±72.7; ↑**** | -14.2, ±17.1; ↓* | -30.7, ±13.3; ↓*** | -1.0, ±18.0 |
| | H | 101.2, ±62.6; ↑**** | 2.9, ±21.8 | -18.0, ±16.9; ↓** | -8.2, ±17.1 |
| Testosterone [$pg.mL^{-1}$] | L | 17.0, ±17.8; ↑** | 8.3, ±15.2 | 12.1, ±14.9; ↑** | 21.6, ±20.3; ↑** |
| | M | 19.5, ±15.0; ↑*** | -10.6, ±11.4; ↓** | -11.5, ±10.7; ↓** | -9.4, ±13.3; ↓* |
| | H | 17.0, ±16.1; ↑** | 5.8, ±14.5 | 0.8, ±13.1 | -5.7, ±14.3 |
| T:C ratio | L | -27.2, ±20.6; ↓** | 6.1, ±18.0 | 16.5, ±18.0; ↑** | -12.4, ±13.4; ↓** |
| | M | -54.4, ±10.0; ↓**** | 5.1, ±16.4 | 29.0, ±18.4; ↑*** | -7.0, ±13.0 |
| | H | -42.5, ±14.4; ↓**** | 3.0, ±17.1 | 23.2, ±18.6; ↑*** | 4.1, ±14.7 |

Values are presented as % change in mean, ± 90% CI; direction of response: positive ↑ and negative↓. Symbols denote: * possibly, ** likely, *** very likely and **** most likely chance of the true effect exceeding a small (0.2) effect size. m: meters; [$\mu g.dL^{-1}$]: micrograms per deciliter; [$pg.mL^{-1}$]: pictogram per milliliter. L: low match load, M: medium match load, H: high match load.

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**Table 2.** The difference in magnitude of change between levels of match load on Jump height, Flight Time:Contraction Time (FT:CT), Cortisol (C), Testosterone (T) and Testosterone:Cortisol (T:C).

| | Match load | **0.5 h Post** | **18 h post** | **42 h post** | **66 h Post** |
|---|---|---|---|---|---|
| Jump Height | M-L | -12.0%, ±10.7%; ↓** | -7.2%, ±6.7%; ↓** | 3.6%, ±7.6% | -5.8%, ±7.1%; ↓** |
| FT:CT ratio | M-L | 0.6%, ±9.3% | -12.4%,±11.8%; ↓** | 6.6%,±10.0%; ↑* | -1.6%, ±13.4% |
| Cortisol [μg.dL$^{-1}$] | M-L | 71.7%, ±76.6%; ↑*** | -14.2%, ±24.6% | -26.4%, ±20.4%; ↓** | -26.5%, ±18.6%; ↓** |
| Testosterone [pg.mL$^{-1}$] | M-L | 2.2%, ±18.5% | -17.4%, ±14.2%; ↓** | -21.0%, ±12.7%; ↓*** | -25.5%, ±15.0%; ↓*** |
| T:C | M-L | -37.4%, ±22.4%; ↓*** | -0.9%, ±22.2% | 10.7%, ±22.5% | 6.2%, ±20.5% |
| | | | | | |
| Jump Height | H-M | -6.5%, ±11.8% | -2.2%, ±7.2% | 2.0%, ±8.4% | 3.2%, ±8.5% |
| FT:CT ratio | H-M | -7.7%, ±8.7%; ↓** | 5.3%, ±15.0% | -1.1%, ±10.4% | 13.4%, ±17.2%; ↑** |
| Cortisol [μg.dL$^{-1}$] | H-M | -24.2%, ±31.1% | 19.9%, ±33.4% | 18.3%, ±31.8% | -7.3%, ±21.8% |
| Testosterone [pg.mL$^{-1}$] | H-M | -2.1%, ±16.1% | 18.3%, ±19.8%; ↑** | 13.9%, ±17.7%; ↑** | 4.1%, ±19.5% |
| T:C | H-M | 26.2%, ±41.3% | -2.0%, ±21.3% | -4.5%, ±18.7% | 12.0%, ±20.1% |
| | | | | | |
| Jump Height | H-L | -17.8%, ±10.8%; ↓*** | -9.3%, ±7.0%; ↓** | 5.7%, ±9.1% | -2.8%, ±8.5% |
| FT:CT ratio | H-L | -7.2%, ±8.7%; ↓* | -7.7%, ±14.0% | 5.5%, ±11.4% | 11.6%, ±18.0% |
| Cortisol [μg.dL$^{-1}$] | H-L | 30.1, ±60.8% | 2.9%, ±29.7 | -13.0%, ±24.4% | -31.9%, ±17.35%; ↓*** |
| Testosterone [pg.mL$^{-1}$] | H-L | 0.0%, ±18.6% | -2.3%, ±17.1% | -10.1, ±14.7% | -22.5%, ±15.9%; ↓*** |
| T:C | H-L | -21.0%, ±29.5% | -2.9%, ±21.8% | 5.7%, ±21.3% | 18.9%, ±22.9%; ↑** |

Values are presented as % change in mean, ± 90% CI; direction of response: positive ↑ and negative↓. Symbols denote: * possibly, ** likely, *** very likely and **** most likely chance of the true effect exceeding a small (0.2) effect size. m: meters; [μg.dL$^{-1}$]: micrograms per deciliter; [pg.mL$^{-1}$]: pictogram per milliliter. M-L: medium compared to low match load, H-M: high compared to medium match load, H-L: high compared to low match load.