The relationship between adductor squeeze strength, subjective markers of recovery and training load, in elite Rugby players

Caoimhe Tiernan, Mark Lyons, Tom Comyns, Alan M Nevill, Giles Warrington

ABSTRACT

The adductor squeeze strength test has become a popular training monitoring marker, particularly in team sports. The aim of this study was to investigate the relationship between adductor squeeze strength scores, subjective markers of recovery and training load in elite Rugby Union players, due to limited research in this area. Nineteen elite male Academy Rugby Union players completed daily monitoring markers (adductor squeeze strength and 5 selected subjective markers of recovery), over a 10-week pre-season training period. Rate of Perceived Exertion (RPE) was collected to determine training load (sRPE; RPE x session duration) and to calculate weekly training load. Spearman correlation was used to analyze the relationship between adductor squeeze strength scores, subjective markers of recovery and weekly training load. The results found that where adductor squeeze scores decreased, both perceived fatigue levels ($r=-0.335$, R^2 =11.2%, $p<0.001$) and muscle soreness ($r=-0.277$, R^2=7.7%, $p<0.001$) increased. A weak correlation was found between Monday adductor squeeze strength scores and the previous week's training load ($r=-0.235$, R^2= 5.5%, $p<0.001$) and Friday adductor squeeze strength scores and the same week's training load ($r=-0.211$, R^2= 4.5%, $p<0.05$). These results show that adductor squeeze strength may provide coaches with a time-efficient, low-cost objective player monitoring marker. Additionally, the combination of adductor squeeze, with subjective markers, perceived fatigue and muscle soreness, and appropriately planned training load may help coaches to optimize training adaptations by determining a player's training status.

Keywords: Monitoring Markers, On-feet Training Load, Optimizing Performance, Training Status

INTRODUCTION

To maximize a player's performance, coaches need to appropriately plan training, incorporating adequate periods of recovery to allow for positive physiological adaptations to occur, which in turn will minimize the risk of overtraining and injury (4). It can be a challenge for coaches to prescribe individualized programs ensuring the correct balance between training load and recovery (4). However, the use of objective and subjective monitoring markers may assist the coach and support staff to make informed decisions on the players training status and reduce the risk of performance decrements (16).

The adductor squeeze strength test is widely used as a marker to inform training prescription to help reduce the risk of groin injuries in Rugby Union (6), Australian Rules (7) and Gaelic games (9). It is time-efficient, low-cost and easily implemented as part of a normal training schedule (26). Research has also found that adductor squeeze may be used as a marker of recovery following Rugby Union matches (26). Roe et al. (26) found that adductor squeeze strength scores decreased 24-hours post-match (Effect Size (ES)= -0.06 ± 0.25) and increased slightly 48-hours post-match (ES= 0.32 ± 0.16), compared to baseline data. Additionally, players that covered greater sprinting distances during a match exhibited a greater decline in adductor squeeze scores 48-hours post-match. These results may help coaches identify players that potentially need additional recovery, if adductor squeeze scores do not return to baseline after 48-hours following a match. Distance covered during a match may be classified as a component of on-feet training load (5). Buchheit et al. (3) collected adductor squeeze strength scores prior to an Australian Rules Football (AFL) match and for the subsequent 4-day period following the match. It was found that an AFL match induced an 18% decrease in adductor squeeze scores, and players' adductor squeeze scores did not recover to baseline levels until 4-days post-match. These results indicated that adductor squeeze strength scores may be used as an objective marker of adductor strength, which can highlight players that may not have fully recovered from an AFL match. However, these previous studies only analyzed the distance covered during a match (3, 26), further research is needed to explore all on-feet training load as a component of training load. Another study by Buchheit et al. (2) investigated adductor squeeze strength scores immediately post-conditioning sessions compared to pre-conditioning sessions, in soccer players. The results found that adductor squeeze strength scores decreased after a conditioning session, which the author deemed as adductor muscle fatigue. A limitation to these studies (2, 3, 26) were the acute nature of the studies, both Buchheit et al. (3) and Roe et al. (26) studies were only conducted over a 4-day period with one match, and Buchheit et al. (2) study was only conducted over a 2-week period. Further research is needed to explore adductor squeeze strength scores over a longer training period that includes multiple training sessions and matches in Rugby Union players.

In addition to the dearth of longitudinal data, there is an absence of research examining the relationship between training load and adductor squeeze strength in Rugby Union players (11, 26). Monitoring training load may help inform training recommendation, which may lead to better training outcomes, such as maximizing training adaptations, reducing the risk of injuries and overtraining (4). RPE has been found to be a valid measure to identify a player's exercise intensity, it has been compared to heart rate metrics such as the Edwards' method in soccer players (17) and youth basketball players (20). A study by Esmaeili et al. (11) investigated the relationship between internal training load and adductor squeeze strength scores, over a 10-month AFL season. Adductor squeeze strength scores were collected once a week either on a Monday (pre-season) or on a Tuesday (in-season). The study found no relationship between internal training load (session RPE, sRPE= RPE x session duration) and adductor squeeze strength scores 2 or 3 days following intense training (pre-season) or matches (in-season). A limitation to this study (11) was adductor squeeze scores were only collected weekly. A higher frequency of data collection may provide further information on fluctuations in adductor squeeze scores in response to training load. Roe et al. (26) study collected internal training load through sRPE but did not conduct any statistical analysis examining the association between training load and adductor squeeze strength scores. Further research is therefore needed to determine if there is a relationship between training load and adductor squeeze strength scores in elite Rugby Union players.

Previous research has investigated subjective markers (e.g. perceived fatigue, muscles soreness) as markers of a players' recovery (4, 13, 14). It was identified that subjective markers of recovery are sensitive to the players' recovery status and may be used by coaches to understand the players training needs to help optimize training (4, 13, 14, 27). The inclusion of both subjective and objective markers (e.g. adductor squeeze strength) provides the coach with a holistic view of the player, to help make evidence-based decision on the players' training status (24). In addition, objective markers provide data that are more difficult to alter, as subjective markers are more easily manipulated to provide a desired outcome (30). However, to the author's knowledge, no study has been conducted investigating the relationship between adductor squeeze strength scores and subjective markers of recovery.

In summary, adductor squeeze strength has been found to be an objective marker of recovery post-match (3, 26) and has been shown to have a relationship with groin injuries (6, 7, 9). There is limited research investigating the associations between adductor squeeze strength and training load, and no research has investigated the association between adductor squeeze strength and subjective markers of recovery. The purpose of this study therefore was to investigate if there was a relationship between adductor squeeze strength scores, subjective markers of recovery and weekly training load, in elite Rugby Union players. Additionally, the study sought to investigate the weekly variations of adductor squeeze strength across the 10-week training period.

METHODS

Experimental Approach to the Problem

Over a 10-week pre-season training period, players provided both selected subjective markers of recovery and adductor squeeze strength scores, before commencing their normal training. RPE was taken after every session to calculate weekly training load from sRPE. Players were familiar with all testing protocols due to previous years of monitoring (3-5 years). All testing took place in the training facilities of the club to ensure minimal disruption to the players' normal training schedule. One of the researchers (CT) was present at every training session and supervised all data collection to ensure players performed the tests correctly. Baseline data collection was completed during week 1 of pre-season and a download (recovery week, where lower training loads were prescribed) was completed in week 3.

Subjects

Nineteen elite male Rugby Union players, volunteered to take part in the study (age 19.7 ±1.1 years, height 184.5 ±7.7 cm, body mass 96.2 ± 12.5 kg). All players were Academy contracted and trained full-time with Academy or senior squad. Training was typically 4-5 days a week, with multiple sessions a day. Sessions included, Rugby pitch based sessions (e.g. skills, conditioned games), gym/resistance sessions, conditioning sessions and matches (Figure 1, provides the match schedule). All players were informed of the study requirements and provided written informed consent. The study was approved by the University Research Ethics Committee and all procedures were in accordance with the Declaration of Helsinki.

Insert Figure 1 here

Procedures

Both adductor squeeze strength scores and subjective markers of recovery were recorded in the morning prior to the first training session on a mobile phone app, installed on the players' phones. The players inputted the data into the app, which was immediately sent to a database and subsequently checked by the coach and lead researcher (CT), to ensure data were inputted correctly. These variables, adductor squeeze scores and subjective markers of recovery, were collected on a Monday, Tuesday, Thursday and Friday, as these were in accordance with the players' typical training days.

Adductor squeeze strength test

During testing, players lay supine on the ground with hips kept in a neutral position, knees flexed at 90° and hips flexed at 45° (Figure 2) (10, 18). Hip flexion at 45 degrees has been found to be the optimal position for maximal adductor activation and force (10, 18). The sphygmomanometer (Welch Allyn, Durashock DS-65, New York USA) was pre-inflated to 10 mmHg (23). The cuff of the sphygmomanometer was placed between the player's knees with the middle third of the cuff located at the most prominent point of the medial femoral condyles (Figure 2). These positions were verified visually by the lead researcher (CT) for each player, following previously published protocols (10, 18). The players were instructed to gradually squeeze the cuff as hard as they could and hold for 2-3-seconds and the highest reading was recorded under the supervision of researcher CT (10). One maximal adductor squeeze test was performed, due to time constraints. However, players had experience and knowledge of performing these monitoring tests throughout their Academy years.

The adductor squeeze has been found to be a valid and reliable tool for assessing adductor strength scores in team sports (3, 10, 26). The sphygmomanometer has been validated (r = 0.77 to 0.91) against a handheld dynamometer (HHD). It has also been found to be a reliable measure (ICC = 0.80 to 0.92) (29).

Insert Figure 2 here

Subjective markers of recovery

The subjective markers of recovery included perceived fatigue, muscle soreness, energy levels, physical recovery and stress levels. These were completed on a Likert scale 1-10 (15, 22). For muscle soreness, fatigue and stress levels, 1= not sore/stressed/fatigued and 10= very sore/stressed/fatigued. For physical recovery and energy, 1= full of energy/recovered and 10= no energy/not recovered. Subjective markers have been found to be reliable (22) and valid (13) as markers of recovery.

Training load

RPE was recorded after every training session or match to subjectively measure the player's perceived exercise intensity (19) using the modified Borg's 0-10 scale (1). RPE has been found to be a valid and reliable monitoring marker of training or exercise intensity (19). Training load for each session was calculated by RPE x duration of session (minutes), sRPE (12). Each sessions training load was added together to provide a total weekly training load data. Total training load included all sessions completed by the player, whether it was on-feet or off-feet.

On-feet training load

On-feet training load is a sub category of training load, and includes the following training components: running, skills, pitch based sessions, speed and plyometric sessions. Gym and off-feet conditioning sessions (e.g. bike, swim and rowing) were not included in the on-feet training load sessions but still included in total weekly training load (8). On-feet training load–was chosen in the current study, as previous research has found that players with a greater running distance (a component of on-feet training load) covered during a match had a greater decline in adductor squeeze strength scores (3, 26).

Statistical analysis

Descriptive statistics were calculated using SPSS software (Version 22), for all variables. Non-parametric analysis was used, as data were not normally distributed. Normality of data was analyzed using the Shapiro-Wilk test. Spearman correlation was used to investigate if there was a relationship between adductor squeeze strength scores, subjective markers of recovery and weekly training load. Monday adductor squeeze strength scores were compared to the previous weeks training load and Friday adductor squeeze strength scores were compared to the same weeks training load. The strength of the interpretation for Spearman correlation was, 0-0.3=weak correlation, 0.3-0.7=moderate correlation and 0.7-1.0=strong correlation (25). Significance was set at $p \leq 0.05$.

MLwin (Version 2.36) was used to analyze the weekly variance of adductor squeeze scores, subjective markers of recovery and training load data, compared to baseline (week 1). A two-level model was conducted accounting for training weeks (level 1) and players (level 2).

RESULTS

Subjective markers of recovery

A moderate negative relationship was found between adductor squeeze strength scores and the subjective markers of perceived fatigue (r=-0.335, R^2 =11.2%, p<0.001) and a weak negative relationship was found with muscle soreness (r=-0.277, R^2=7.7%, p<0.001) (Table 1).

Insert Table 1 Here

Training Load

A weak negative correlation was found between Monday adductor squeeze strength scores and the previous weeks training load (r=-0.235, R^2= 5.5%, p<0.05) and Friday adductor squeeze strength scores and the same weeks training load (r=-0.211, R^2= 4.5%, p<0.05). Additionally, a weak negative correlation was found between Monday adductor squeeze strength scores and on-feet training load of the previous weeks training (r=-0.224, R^2= 5%, p<0.001), and Friday adductor squeeze strength scores and the same weeks on-feet training load (r=-0.271, R^2= 7.3%, p<0.001) (Table 2).

Insert Table 2 Here

Figure 3 and 4 show the weekly analysis of adductor squeeze strength scores, muscle soreness and perceived fatigue. Training load and on-feet training load are shown in Figure 5. All weekly results were compared to week 1 (baseline), which was the first week of pre-season training.

Insert Figure 3 here

Insert Figure 4 and 5 here

DISCUSSION

This is the first study of its kind to track adductor squeeze strength over a pre-season training period and investigate its association to subjective markers of recovery and weekly training load, in elite Rugby Union players. The results found that as weekly training load and on-feet training load increased, both Monday and Friday adductor squeeze scores decreased. Monday adductor squeeze strength scores were compared to the previous weeks training and Friday adductor squeeze strength scores were compared to the same weeks training. Additionally, it was found as players' perceived fatigue and muscles soreness increased, adductor squeeze strength scores decreased. However, due to the weak correlation results must be interpreted with caution.

The results indicated that there was an association between adductor squeeze strength scores and weekly training load, i.e. where training load increased, adductor squeeze scores decreased. To the authors knowledge, only one previous study has explored the relationship between training load and adductor squeeze strength (11). It was found that adductor squeeze scores did not correlate with internal training load, which contradicts the findings in the current study. A possible explanation for the difference in findings may be the higher frequency of data collection in the current study compared to only one day of data collection a week in the study by Esmaeili et al. (11). The benefit of multiple testing times points during a week may provide a better representation of variability across weekly sessions, whereas weekly scores only captures one day of the training week. The weak correlation found in the current study must be highlighted, and a potential reason for this may be that the data from the current study was provided to the coaches. This meant the coaches could use the results, if they felt necessary, to understand the players training status, alter training load, which in turn may have helped to ensure sufficient recovery and optimize training adaptations. Additionally, another reason for the weak correlation may be that there were a number of other factors that could have contributed to the change in adductor squeeze scores, such as age, decreased range of motion and past injury history (18).

Adductor squeeze strength scores were also found to decrease with an increase in on-feet training load. This is also depicted in the weekly analysis (Figure 3 and 5), where on-feet training load significantly increases in weeks 2, 5-10, compared to baseline and adductor squeeze strength also significantly decreased. Roe et al. (26) found that a greater decrease in adductor squeeze strength scores post-match occurred when a greater distance was covered during a Rugby match. As on-feet training load includes running and pitch based sessions (8), this implies that a greater running distance may mean a greater on-feet training load (5). Similarly, Buchheit et al. (3) also indicated that the larger decrease in adductor squeeze scores post AFL match, was due to the greater running demands. However, it is difficult to compare across studies as neither study (3, 26) calculated on-feet training load. The results from the current study may provide coaches with an objective marker that is associated to the change in on-feet training load.

This is the first study to find a relationship between adductor squeeze strength scores and the subjective markers, perceived fatigue and muscle soreness. This meant that if a player felt sore or fatigued, adductor squeeze strength scores were found to be lower. Previous research has principally investigated subjective markers of recovery (4, 13, 14, 27) or adductor squeeze as a marker of recovery (3, 26) but not the relationship between them. The previous research found that subjective markers of recovery could be used to help coaches make informed decisions on a players training ability and to optimize their training adaptations (4, 13, 14, 27, 28). Additionally, previous work has shown that adductor squeeze could be used as a marker of match recovery in AFL (3) and Rugby Union (26). Perceived fatigue and muscle soreness in the current study correlated with adductor squeeze strength scores but energy levels, physical recovery and stress levels did not. It must be highlighted that perception of effort (21) may have been a reason for the association between the reduction in adductor squeeze strength scores and increased perceived fatigue. As adductor squeeze strength is an effort-based test, a player that perceives themselves to be more fatigue may put less effort into the test. However, as this was the first study to investigate the relationship between subjective markers of recovery and adductor squeeze strength scores, further research is required to explore this relationship and the perception of effort.

A limitation to the study was data were only collected for pre-season and not during in-season. In addition, no external load data, such as Global Positioning System (GPS), were collected which may provide further external load metrics (such as distance covered each session). Therefore, further research is needed over an entire Rugby season, with a larger sample size, to further investigate the relationship between adductor squeeze strength, subjective markers of recovery, training load and on-feet training load.

In conclusion, the results may indicate that adductor squeeze strength scores are associated to changes in training load, while also correlating with the subjective markers perceived fatigue and muscle soreness. These results highlight the importance that coaches should use a variety of monitoring markers, objective (adductor squeeze) and selected subjective markers of recovery, in combination with training load to optimize training adaptations and to ensure sufficient recovery.

PRACTICAL APPLICATIONS

The results may potentially help coaches to make informed decisions on a player's training status, to help optimize training, recovery and performance. However, the results from the current study must be interpreted with a degree of caution due to the weak correlations. With this caution in mind, the coach may use the selected subjective markers of recovery (perceived fatigue and muscle soreness) in combination with adductor squeeze to provide a global picture of the player's response to training to help appropriately plan training load.

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FIGURES CAPTIONS

Table 1. Relationship between adductor squeeze scores and subjective markers of recovery. *$p<0.05$= significant, ** $p<0.001$= highly significant.

Table 2. Relationship between adductor squeeze scores and training load indices
*$p<0.05$= significant, ** $p<0.001$= highly significant.

Figure 1. Training and match schedule over the 10-week pre-season period.

Figure 2. Adductor squeeze test, supine on the ground with knees flexed at 90° and 45° of hip flexion.

Figure 3. Adductor squeeze scores (weekly mean ± SD), over the pre-season training period. *$p<0.05$ – significant difference to baseline (week 1), ** $p<0.001$ - highly significant difference to baseline (week 1).

Figure 4. Perceived fatigue and muscle soreness (weekly mean ± SD), over the 10-week pre-season training period. *$p<0.05$ - significant difference to baseline (week 1), ** $p<0.001$ - highly significant difference to baseline (week 1).

Figure 5. Weekly means ±SD for (a) Training load and (b) on-feet training load, over the pre-season training period. ** $p<0.001$ – highly significant difference to baseline (week 1).

TABLES

Table 1. Relationship between adductor squeeze scores and subjective markers of recovery

	Perceived fatigue	Muscle soreness	Energy Levels	Physical recovery	Stress levels
Spearman correlation (R-value)	-0.335**	-0.277**	0.097*	-0.072	0.048
R^2	11.2%	7.7%	0.9%	0.5%	0.2%
Significance (p-value)	0.000	0.000	0.039	0.130	0.310

*p<0.05= significant
** p<0.001= highly significant

TABLES

Table 2. Relationship between adductor squeeze scores and training load indices

	Monday to previous weeks training load	Friday to same weeks training load	Monday to previous weeks on-feet training load	Friday to same weeks on-feet training load
Spearman correlation (R-value)	-0.235**	-0.211*	-0.224**	-0.271**
R^2	5.5%	4.5%	5%	7.3%
Significance (p-value)	0.002	0.012	0.004	0.001

*p<0.05= significant
** p<0.001= highly significant

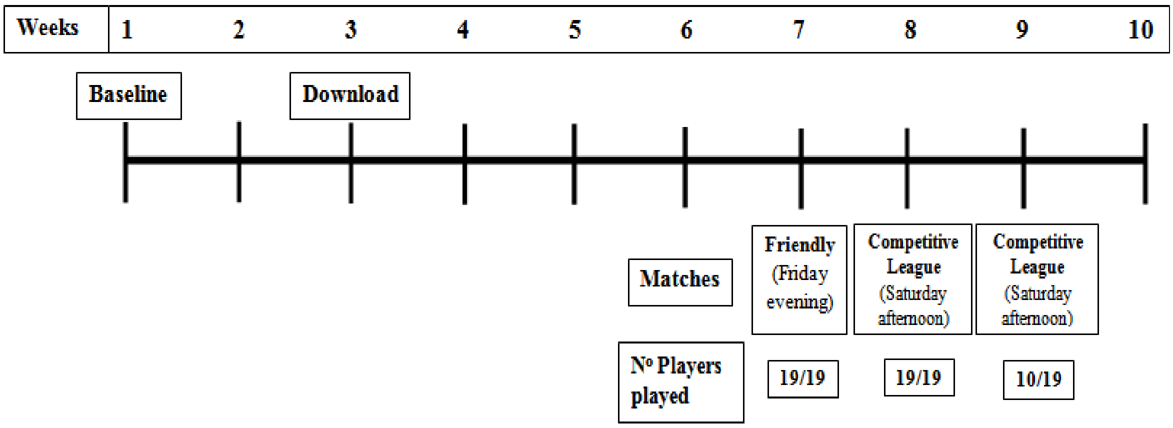

Figure 1. Training and match schedule over the 10-week pre-season period.

Figure 2. Adductor squeeze test, supine on the ground with knees flexed at 90 and 45˚ of hip flexion.

FIGURES

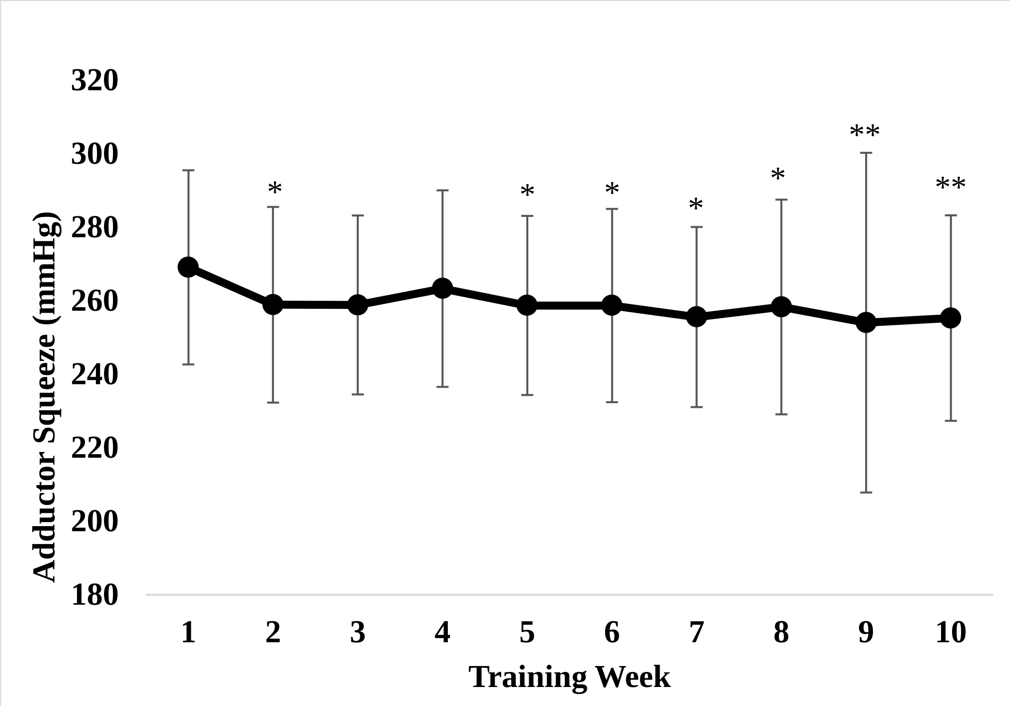

Figure 3. Adductor squeeze scores (weekly mean ± SD), over the pre-season training period

*p<0.05 – significant difference to baseline (week 1)
** p<0.001 - highly significant difference to baseline (week 1).

FIGURES

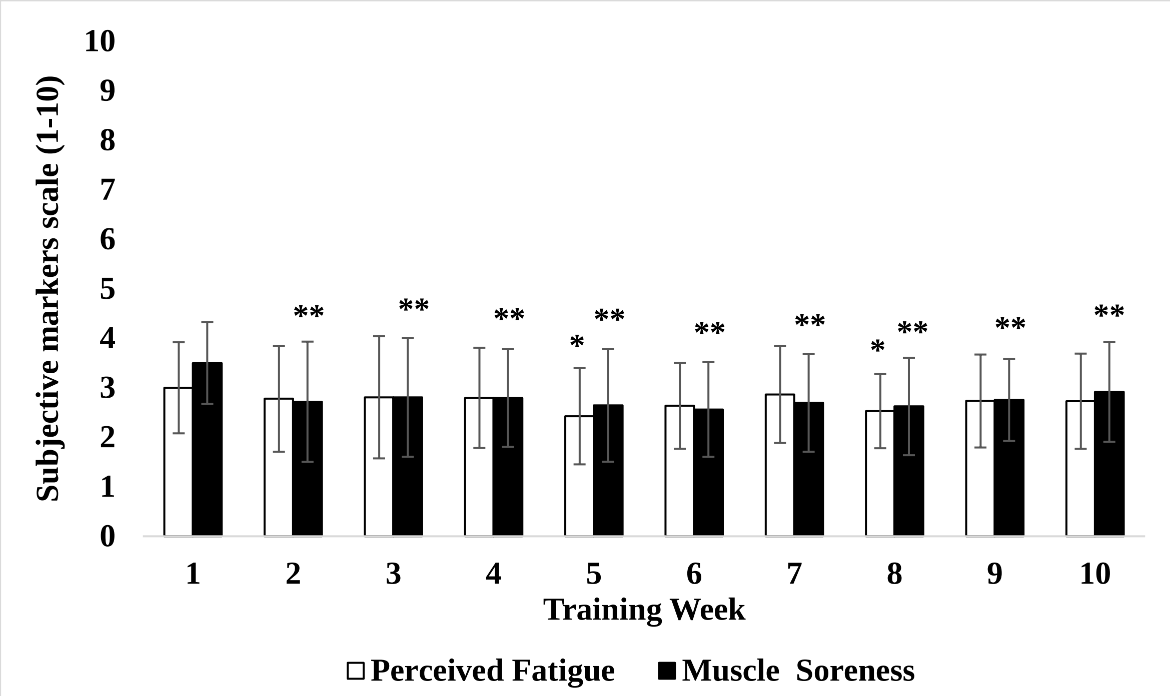

Figure 4. Perceived fatigue and muscle soreness (weekly mean ± SD), over the 10-week pre-season training period.

*p<0.05 - significant difference to baseline (week 1)
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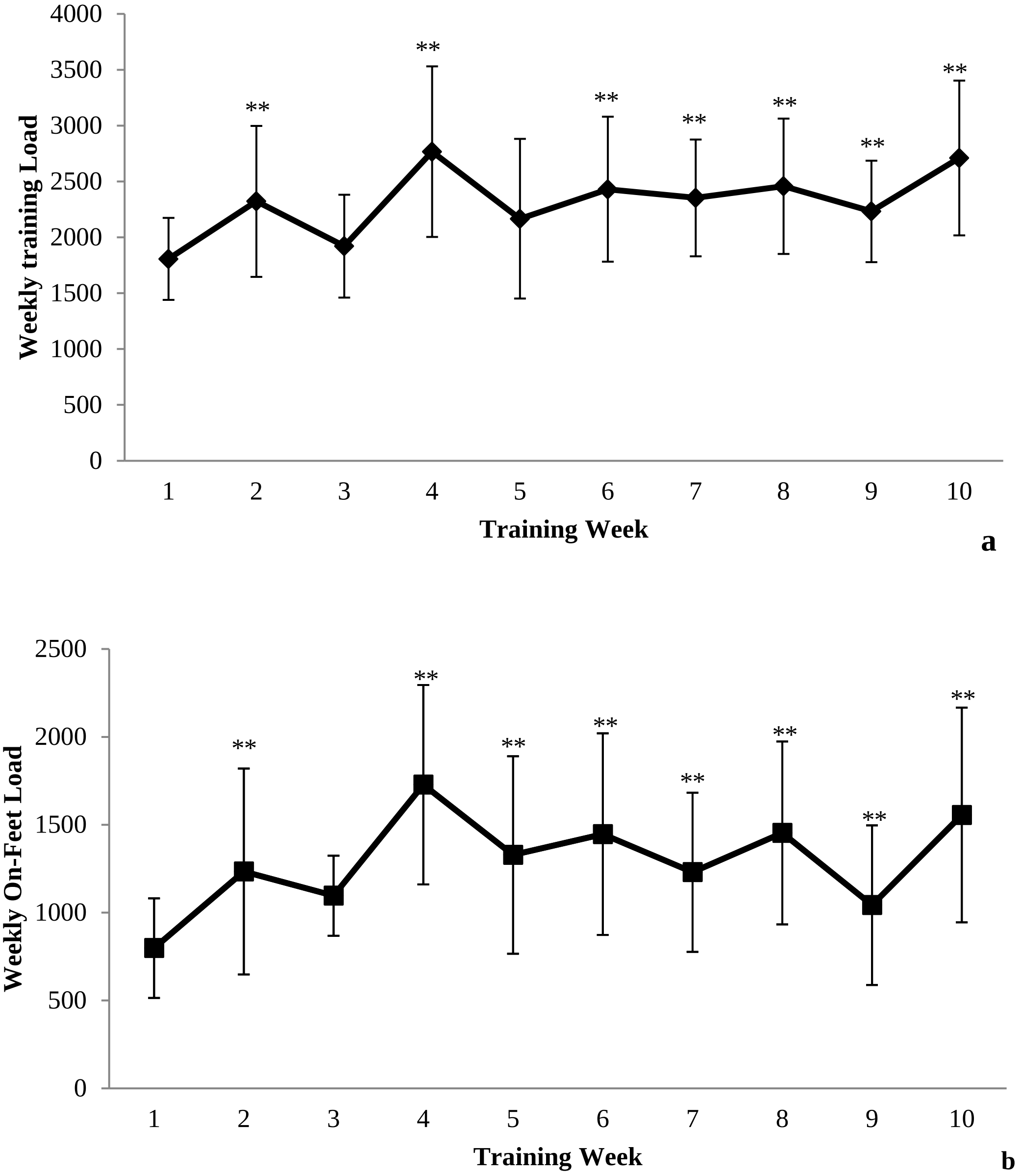

Figure 5. Weekly means ±SD for (a) Training load and (b) on-feet training load, over the pre-season training period. ** p<0.001 – highly significant difference to baseline (week 1).