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Title: Validity of Session-Rating of Perceived Exertion for measuring training load in youth team handball players

Brief running head: Validity of Session-Rating of Perceived Exertion in team handball

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ABSTRACT

Session rating of perceived exertion (sRPE) is a subjective self-reported measure of training load and is a popular method in several different team sports. This study aimed to investigate the validity of sRPE, by correlating sRPE-load (sRPE x minutes of training) and heart rate (HR) expressed as Edwards Summated Heart Rate Zones (SHRZ) and PlayerLoad™ amongst Danish youth team handball players. Secondly, the study aimed to investigate sRPE-load's ability to descriptively differentiate between a low and a high training load category. A comparative cross-sectional study was conducted in the in-season period. 14 training sessions were measured from 6 teams, in which PlayerLoad™, Edwards SHRZ, and sRPE-load were measured for the training session and collected from 47 participants (23 male, 24 female). Pearson's product-moment correlation coefficients were calculated between sRPE-load and Edwards SHRZ and PlayerLoad™. Furthermore, a high and a low load category were made from PlayerLoad™ or Edwards SHRZ to investigate sRPE-load`s ability to discriminate between high and low objective load. Large correlations between sRPE-load and Edwards SHRZ (0.52 [95% CI 0.27:0.70]) and between sRPE-load and PlayerLoad™ (0.67 [95% CI 0.47:0.80]) were observed. Our findings further indicate that sRPE-load can differentiate between a high and a low training load category in both Edwards SHRZ and PlayerLoad™. Our results show that sRPE-load reflects both internal and external load during team handball training sessions and appears to discriminate between high and low-intensity training sessions. These results support the validity of sRPE-load for measuring training load in young team handball players.

Key Words: Team sport, Youth sport, Training load, Session-Rating of Perceived Exertion, Validity

INTRODUCTION

Training load management for young athletes is fundamental to promote a long sporting career and engagement in sporting environments (33), as it may help develop or maintain fitness, mitigate injury risk (6, 14, 34, 43), and enhance performance in athletes (13, 42). Training load encompasses external and internal dimensions, with external training loads representing the physical work performed during the training session or match, while internal training load reflects the physiological and biomechanical responses to the external load and encompasses contextual factors such as training status, individual characteristics, environment. (23, 31).

Session rating of perceived exertion (sRPE) (17) and sRPE training load (sRPE-load) are easy, low-cost methods sand have become popular methods for measuring internal load (16, 20). Several studies have investigated training load using sRPE-load in different team sports, including team handball (2, 8, 12, 16, 24). However, to serve as a tool for practitioners and coaches, the validity and reliability of sRPE-load is imperative. Associations between objective and subjective measures of internal and external load can provide evidence for the validity and sensitivity of internal load measures, which is essential in the absence of any "gold standard criterion measure" (31). Several studies have investigated such relationships in team sports for several different variables (16, 20, 31). A meta-analysis found high correlations between sRPE-load and total distance covered (r = 0.79) and accelerometer derived load variables that include PlayerLoad™ (r = 0.63) in team sports (31). In addition, high correlations between sRPE-load and heart rate (HR) are also reported (29). A limited number of studies have been performed in youth athletes. These studies have reported slightly lower correlations between sRPE-load and HR in youth field hockey, rugby, and football than in senior athletes (r=0.60-0.72) (39).

Training mode is shown to be an important factor for the relationship between sRPE-load and external load parameters (31). This implies that the relationship in one sport cannot be directly transferred to other sports. To our knowledge, information on the relationship between sRPE-load and HR or external load parameters in the youth team handball context is lacking. To be able to confidently use sRPE-load as a training load measurement in team handball, more information concerning the validity of this method is needed. Given the paucity of research on the relationship between sRPE-load and external load parameters in youth sport in general, and in team handball particularly, we aimed to investigate the convergent validity through the correlation between sRPE-load and objectively obtained training load measures (HR and PlayerLoad™) amongst Danish youth team handball players. Secondly, we aimed to investigate sRPE-load's ability to descriptively differentiate between a low and a high training load category created separately from objective measurements.

METHODS

Experimental approach to the problem

A comparative cross-sectional design was used to examine the construct validity of sRPE-load in youth team handball players. The convergent validity was investigated with the correlation of sRPE-load to HR expressed as Edwards Summated Heart Rate Zones (SHRZ) and accelerometer derived load (PlayerLoad™). sRPE-loads' ability to differentiate between a low and a high training load category was assessed by comparing sRPE-loads in two different training load categories created from Edwards SHRZ and PlayerLoad™, separately. For this, we strived to collect three different training sessions for each athlete with different intensities during the in-season period (January-March 2020) in which PlayerLoad™ and HR were monitored, and sRPE-load was collected for all participants. All sessions were observed under their normal training environment, in an indoor sports hall, and planned by their coach. The training session duration ranged from 60 to 120 minutes, with a median of 90 minutes, and with 75% of the data ranging from 90-120 minutes.

Subjects

By invitation to relevant team handball clubs in Denmark, we conveniently recruited 47 young team handball players (age: 17.0±0.9 (mean±SD) years (range 16-20 years), team handball playing experience: 10.3±2.1 years). 23 males (height 186±5.2 cm, weight 82±8.6 kg, BMI 23.5±2.1 kg/m/m), and 24 females (height 171±6.2 cm, weight 68±7.0 kg, BMI 23.1±1.8 kg/m/m) from U17 (16-17 years old) or U19 (18-19 years old) teams who trained a minimum of three team sessions a week. Fifty-five percent of included participants were back players, 30% were wing players and 15% were line players. Goalkeepers and subjects who did not participate fully in the observed training session due to injury or other reasons were excluded. Figure 1 illustrates the inclusion and exclusion flow of the teams and participants. In total, 14 training sessions were measured, resulting in 93 individual data points. All 47 subjects were measured once, while thirty of the subjects were measured twice and 16 subjects were measured three times.

This study was exempted from ethical review (20202000-10) due to the study design according to the Danish Act on Research Ethics Review of Health Research Projects. Southern University Research and Innovation Office granted permission for the study (notification number 10.925). All players provided written consent. Guardian consent was obtained in cases where the subject was under 18 years old.

*** INSERT FIGURE 1 AROUND HERE ***

Procedures

All players were equipped with an inertial measurement unit (IMU; ClearSky T6, Catapult Sports, Melbourne, Australia, firmware version: 5.6) and an HR unit (Polar Team2, Polar Electric, Kempele, Finland) for measuring of PlayerLoad™ and HR during training. The IMU was located in a padded pouch on the upper back in a custom-made vest (Catapult Sports, Melbourne, Australia). The vest was placed tight, directly on the skin. Sports tape was utilized to tighten the west, especially in the IMU's placement area, if the vest was not completely tight. Participants wore the same unit and size of the west for all observations. The HR unit was placed at the solar plexus with the help of an adjustable strap. Data from the HR unit was automatically synced with the IMU data through the Catapult Software (OpenField, version 1.22, Catapult Sports, Melbourne, Australia). To ensure that only active training time was included in the analyses, the data collection was monitored live via the Catapult Software.

After each training session, each player reported sRPE via a mobile app (Athlete Monitoring, FITSTATS Inc, New Brunswick, Canada), using the modified Borg category ratio-scale (CR-10) with integers and verbal anchors (17). sRPE-load was calculated by multiplying the sRPE by the session duration in minutes, defined by the start and stop from the IMU recordings. Players were instructed to report sRPE in a 30-minute window after the training. A reminder via Athlete Monitoring message system was sent 10 minutes after the training session. If they did not report after the first reminder, they were individually contacted again over the message system in Athlete Monitoring two hours after the first reminder. After the second reminder, if they still haven't reported, they were contacted personally via SMS a final time four hours after the training session. Previous studies have found sRPE being temporally robust, and reporting is valid even several days after completion of a particular training session (16, 35).

To assure that participants were familiar with Athlete Monitoring and sRPE, they were introduced to Athlete Monitoring and educated in sRPE at least one week, and in most cases, two weeks before observations. The education in sRPE was completed as instructed by the study of Foster et al. 2001 (17). The mean number of registrations before the first observed training session included in the analysis was 3.6±2.5 sRPE registrations.

Data processing

Data were extracted from the IMU and HR units after each session using the Catapult Software. PlayerLoad™ was chosen to provide a representation of an objective external load and have shown to be valid and reliable (11, 27). PlayerLoad™ is a vector magnitude expressed in arbitrary units as the square root of the sum of the squared instantaneous rate of change in acceleration in 3 dimensions, described comprehensively by Boyd et al. (7). For measuring HR, Edwards SHRZ was utilized and chosen as a representation of internal load that have been shown to be valid and reliable (26, 29, 40). Edwards SHRZ determines internal load by multiplying the accumulated training duration in five discrete HR zones (50–59.9% = zone 1, 60–69.9% = zone 2, 70–79.9% = zone 3, 80–89.9% = zone 4, 90–100% = zone 5) relative to HR_{peak} by a coefficient relative to each zone and summating the results (15). HR_{peak} was assessed using the Yo-Yo intermittent recovery level 1, which has been shown to be as effective to elicit HR_{peak} as an incremental treadmill test (37). The test consists of 20m repeated shuttle runs back and forth, with a 10-second break between each interval (25). One of the following criteria had to be achieved to use the measured HR_{peak}:1) the participant had performed a Yo-Yo test and scored an sRPE of 8 or above, or 2) the participant has registered HR_{peak} ≥200 in the Yo-Yo test. Of the 47 participants, 24 measured an HR_{peak}. For the remaining 23 participants, the Fox formula (220-age) was used to estimate HR_{peak} (18).

Statistical analyses

Data were imported to STATA 16.1 (StataCorp. 2019) for statistical analysis. Descriptive statistics were used to analyse the population characteristics and measurement variables including Edwards SHRZ, PlayerLoad™, sRPE, and sRPE-load. Continuous variables were described by mean ± SD, and range (minimum-maximum). Quantile plot, histogram, and Shapiro Wilk test were used to test normal distribution. For testing the linearity, a scatter plot was utilized. sRPE-load, Edwards SHRZ and PlayerLoad™ were normally distributed.

For the primary aim, the convergent validity was assessed with the correlation between the measurements with Pearson's product-moment correlation coefficients between subjects' single measure with all 47 subjects and separately for both sexes with 95% confidence intervals. In this analysis, we used the first training the subjects attended. The size of the correlation was interpreted as following: r = <0.1 trivial, r = 0.1-0.3 low, r = 0.3-0.5 moderate, r = 0.5-0.7 large, r = 0.7-0.9 very large, r = >0.9 nearly perfect, r = 1 perfect (21). To investigate sRPE-load's ability to differentiate between low and high training loads, we first calculated and created low and high training load categories based on the median of either PlayerLoad™ or Edwards SHRZ of all 14 training sessions including 93 individual player training sessions. Measures below the median were categorized as a low training load (Edwards 170-220, PlayerLoad™, 190-415), while measures above the median were categorized as a high training load (Edwards 221-395, PlayerLoad™, 416-737). For all individual training sessions included in each of the two categories, we included the corresponding individual sRPE and sRPE-load measures. In situations, where a subject was involved more than once in the same training load category, the first attended training session was chosen, and other training sessions were excluded. The mean of Edwards SHRZ, PlayerLoad™, sRPE, and sRPE-load in each training load category was then calculated and descriptively described. A box plot was used to illustrate the spread of data.

RESULTS

A large correlation between sRPE-load and Edwards SHRZ and between sRPE-load and PlayerLoad™ was found (Table 1). A large correlation was also found separately for men and women. The correlation analysis plot can be seen in Figure 2.

*** INSERT TABLE 1 AROUND HERE ***

*** INSERT FIGURE 2 AROUND HERE ***

The individual measures finally included for the Edwards SHRZ training load categories were: Low training load (n=27), High training load (n=31), and for PlayerLoad™: Low training load (n=31) High training load (n=25). Table 2 presents a low and a high training load category based on the median of measurements from Edwards SHRZ and PlayerLoad™ and shows the related mean sRPE, mean sRPE-load, mean Edwards SHRZ, and mean PlayerLoad™ in each training load category. Figure 3 shows the spread of the data and illustrates when the objective method measures a low or high training load, the related sRPE-load also measures low or high. This indicates an ability to differentiate from a low to a high training load. There were no missing sRPE-load values.

*** INSERT TABLE 2 AROUND HERE ***

*** INSERT FIGURE 3 AROUND HERE ***

DISCUSSION

This is to our knowledge the first study, to investigate the construct validity of sRPE-load in youth team handball players. A large correlation between sRPE-load and Edwards SHRZ as a measure of internal load as well as between sRPE-load and PlayerLoad™ as a measure of external load was observed. A large correlation was also observed separately for men and women. sRPE-load appears to be able to descriptively discriminate between low and high training load categories.

The large correlations between sRPE-load and PlayerLoad (r=0.67) and between sRPE-load and Edwards SHRZ (r=0.52) provide evidence of the construct validity of sRPE-load in team sports, and in team handball specifically. Compared to previous studies, the observed correlation between sRPE-load and PlayerLoad™ in the present study is like, or slightly higher than observed in youth rugby players (r=0.64), youth field hockey players (r=0.55) (38), and youth football players (r=0.64) (30), but lower than in semiprofessional adult football players (r=0.76) (9) and male Australian football (r=0.83) (41). Our observed correlation between sRPE-load and Edwards SHRZ is lower than observed in a number of studies showing a very large association (r=0.84-0.85) in endurance-trained athletes (5), female football players (1), and elite male basketball players (29) but similar to a study on male semiprofessional football players (9). In one study by Scantlebury and colleagues (39) on youth athletes, slightly higher correlation coefficients of 0.60, 0.68, and 0.72 are seen between sRPE-load and Edwards SHRZ for field hockey, rugby, and soccer respectively. The differences between our and previously reported results may be explained by methodological differences. While previous studies mostly have focused on within-subject designs (9, 29, 30, 38, 39, 41), our study is a between-subject correlation analysis. By only allowing each participant to contribute to the dataset with one observation, a larger variance is expected than if the same player is measured multiple times and thereby possibly decreases the correlation (4). Previous research has shown that there are individual responses in sRPE-load to external load (44), further underlining that the between-subject design is expected to demonstrate lower correlations. The differences may also be explained by the disparity in movement patterns that variates between sports, as well as the fact that we do not include measurements of match play (1). Finally, we measured sRPE-load via a mobile app. In other studies, sRPE-load was reported directly to the observer (29, 30, 38, 39, 41). The difference in the reporting context, where the player reports through a phone could influence the players´ rating by decreasing the awareness or the seriousness when compared to directly reporting to the observer, hereby affecting the sRPE rating (13). It has also been suggested that younger players could have more immense difficulties self-assessing their perception of load and effort (6, 39), which in turn could decrease the correlation to objective measures. This should be acknowledged and handled by proper education and guidance.

Our results demonstrate a larger correlation between sRPE-load and the external load measured by PlayerLoad™ (r=0.67) than between sRPE-load and internal load measured using Edwards SHRZ (r=0.52). This finding is in accordance with a study on semi-professional football players (9) also showing a larger correlation between sRPE-load and PlayerLoad™ (r=0.74) than sRPE-load and Edwards SHRZ (r=0.57). The higher correlation found between sRPE-load and PlayerLoad™ may partly be explained by the statistical advantage of PlayerLoad™ compared to Edwards SHRZ. PlayerLoad™ has a broader range than Edwards SHRZ, which increases the possible correlation compared to a smaller range (3). In addition, HR has shown to be closely related to oxygen consumption in continuous exercise, whereas the association is weaker during intermittent exercise as in team sports, and HR has been shown to be limited in predicting aerobic load on an individual level in team sport (10). In contrast, PlayerLoad™ has been shown to be related to the total distance covered, changes of direction, high-speed running distance, and the number of collisions (9, 19, 22, 36). These measures reflect the intermittent nature of movements in team handball, which involves repeated changes in direction, accelerations, and decelerations, jumps, and tackles interspersed with lower intensity action (28).

Previous studies have solely assessed the convergent validity with a correlation coefficient (20, 31). The present study strived to additionally investigate sRPE-load's ability to differentiate between a low and a high training load category created from the objective measures separately. The results showed indications of sRPE-load having the ability to descriptively differentiate between a high and a low training load. This adds to the notion that sRPE-load can be used as a valid method for measuring training load in team handball. However, we planned to measure all teams through three training sessions and with different intensities to complete this assessment. Unfortunately, due to practical considerations (figure 1), we could not measure all participants three times. The ability of sRPE-load to differentiate between different loads should therefore be interpreted with caution because of the low statistical power. Additionally, we created the training load categories based on the median of our limited data and not on validated or planned training load categories. It is uncertain if these training load categories are an adequate representation of a high or low training load. A priori, we planned to have a low, medium and high training load category. Unfortunately, there was not enough data observations for a medium training load category due to the Covid-19 lockdown (Figure 1). The limited number of observations decreased the spread of data, which complicated creation of three categories. When only utilizing a low and high training load category there is a wide range in the categories, which is especially seen in the high training load category.

Several factors need to be considered when interpreting the results. One of the strengths of this study is the application of a study design measuring between-subjects correlation, including a large number of different participants from three clubs and six different teams with different coaches and equal gender representation among the players. Other studies typically have significantly fewer athletes included, ranging from 6-32 and more often in the lower, than the high end (20). The broad and diverse population included in our study strengthens the generalizability of our results. Another strength of this study is the comparison with two different objective measurement methods with both internal and external training load, which provides further clarity of the results.

In this study, we had no missing data in the reporting of the sRPE which supports the use of self-reporting via a mobile app being a part of a successful sRPE-load implementation in this population. However, this method of reporting sRPE limits our control of possible influence of teammates or others on the players' reporting e.g., by discussing their sRPE before reporting. In addition, the short adaptation period with sRPE before study start could be a limiting factor in this study. The players had a mean of 3.6 sRPE registrations as familiarization before data being registered for this study. Registering sRPE may therefore still be relatively new to the players, which could influence the ratings and thus the correlations. The sRPE rating in our study was an overall estimation of the whole training session where different intensities and activities within the same training session were assessed in one rating. It is not clear if the results would be different if a differential sRPE assessment was used, where the training session is split into several sRPE registrations (13, 31, 32) e.g., splitting into specific parts of the training session such as technical drills, tactical sessions, and small-sided games. It has also been suggested that separate sRPE scores for breathing, upper body, and lower body/leg exertion may be relevant to make sRPE even more specific for monitoring different components of load (13, 32).

This study adds to the understanding of the relationship between sRPE-load and external and internal load variables in team sports and is to our knowledge the first study to investigate this in team handball. Large correlations between sRPE-load and Edwards SHRZ and PlayerLoad™ were found in this study. Furthermore, we found indications of sRPE-load having a descriptive ability to discriminate between a high and a low training load category created from the objective measurement methods. However, this finding should be interpreted with caution due to low statistical power. Our findings support that sRPE-load is a feasible and valid method for measuring youth male and female team handball players' training load.

PRACTICAL APPLICATIONS

Our results show that sRPE-load have a high correlation with both internal and external load variables during team handball training sessions and appears to be able to discriminate between high and low-intensity training sessions. Therefore, sRPE-load can be viewed as a valid and feasible low-cost method to measure training load in youth male and female team handball players. Indeed, the simplistic and non-invasive nature of sRPE measurements make such measurements favorable for implementation. In addition, no missing data in the sRPE reporting via Athlete Monitoring indicates a successful implementation, which is key to proper and usable monitoring.

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Figure and table legends:

Figure 1. Flow chart of inclusion and exclusion of teams, subjects and training sessions

Table 1. Pearson's product-moment correlation between sRPE-load and Edwards SHRZ, and between sRPE-load and PlayerLoad™.

Figure 2. Pearson's product-moment correlation between A) Session-Rating of Perceived Exertion training load (sRPE-load) and Edwards Summated Heart Rate Zones (SHRZ) and B) between sRPE-load and PlayerLoad™.

Table 2. Mean±SD and (minimum-maximum) of Edwards SHRZ, PlayerLoad™, sRPE, and sRPE-load (arbitrary units) in two different load categories: Low training load and High training load.

Figure 3. Box plot of session rating of perceived exertion training load (sRPE-load) in two different load categories compared with the training load from A) Edwards Summated Heart Rate Zones (SHRZ) and B) PlayerLoad™. The Box shows quartile 1-3, and the marker in the box illustrates the median.

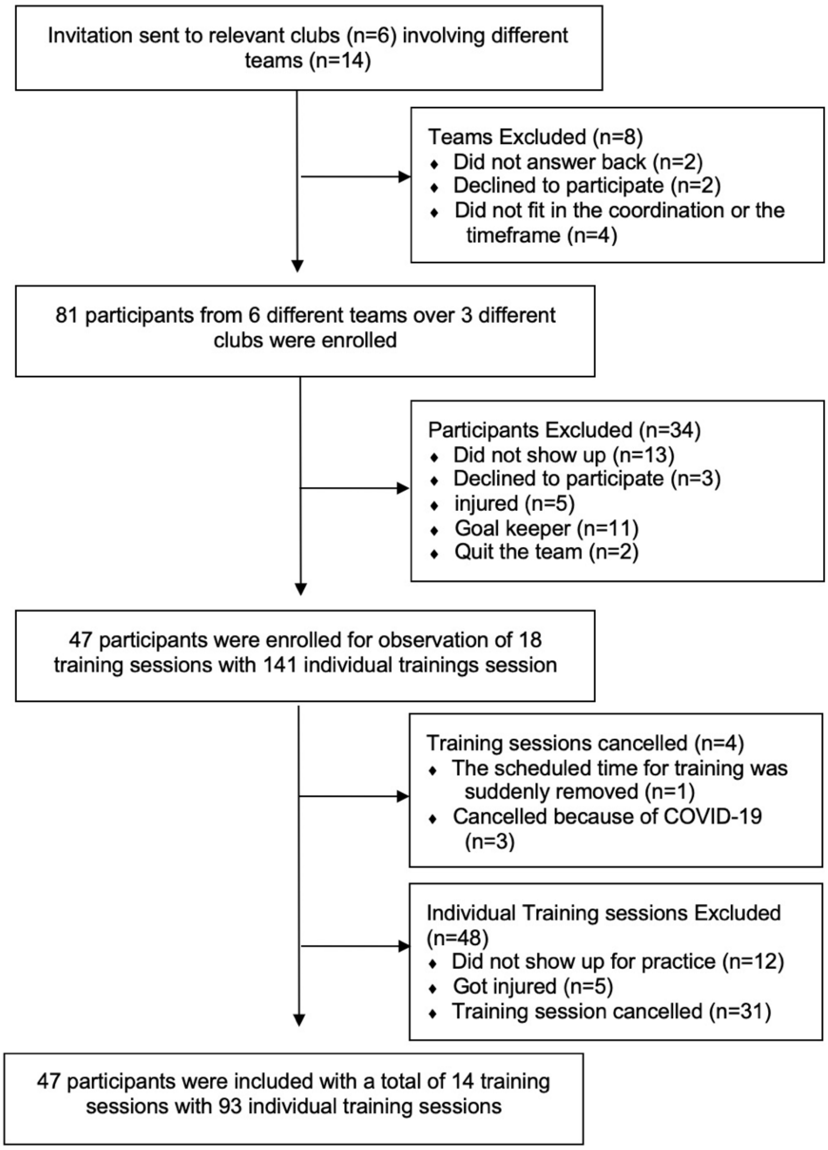

Figure 1. Flow chart of inclusion and exclusion of teams, subjects and training sessions

Table 1. Pearson's product-moment correlation between sRPE-load and Edwards SHRZ, and between sRPE-load and PlayerLoad™.

	Edwards SHRZ Mean±SD (min-max)	PlayerLoad™ Mean±SD (min-max)	sRPE Mean±SD (min-max)	sRPE-Load Mean±SD (min-max)	Correlation (95% CI) Edwards and sRPE-Load	Correlation (95% CI) PlayerLoad™ and sRPE-Load
Overall (n=47)	251±75 (125-395)	461±113 (190-737)	5.0±1.6 (2-8)	498±199 (150-960)	0.52 (0.27:0.70)	0.67 (0.47:0.80)
Male (n=23)	221±69 (125-365)	499±133 (333-737)	5.3±1.8 (2-8)	509±225 (150-960)	0.63 (0.30:0.83)	0.69 (0.39:0.86)
Female (n=24)	280±70 (145-395)	425±102 (190-682)	4.8±1.3 (2-7)	488±174 (180-720)	0.54 (0.18:0.78)	0.69 (0.40:0.86)

SHRZ (Summated Heart Rate Zones), sRPE-load (Session-Rating of Perceived Exertion training load), CI (Confidence Intervals)

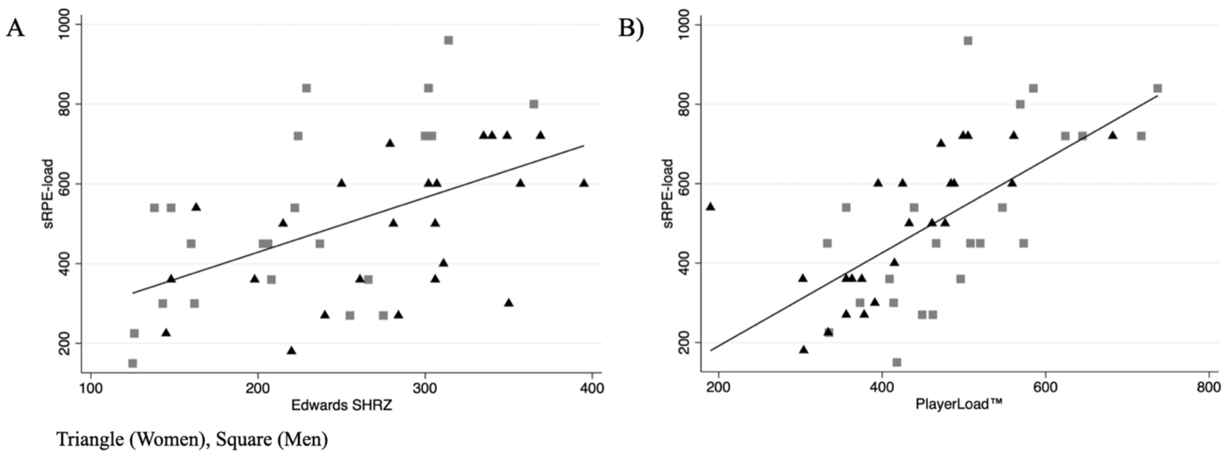

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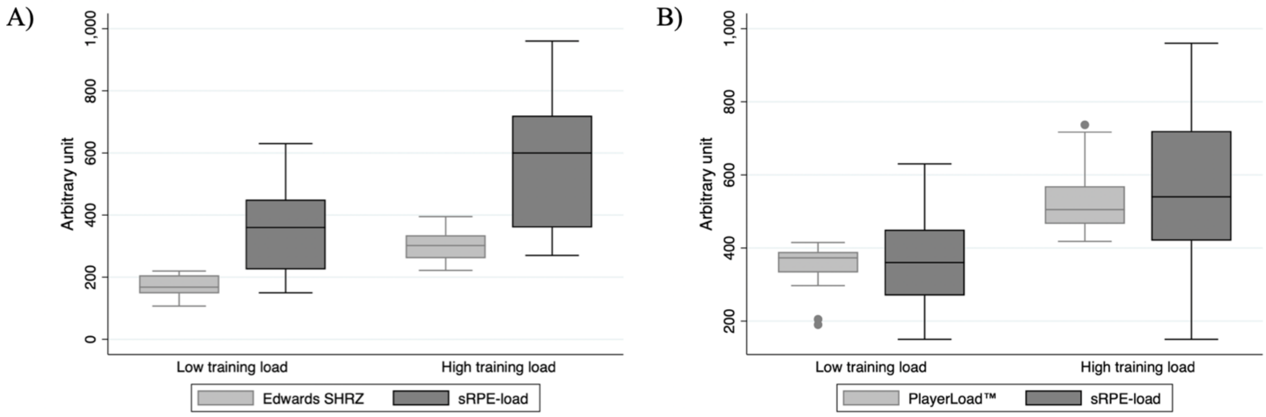
Table 2. Mean±SD and (minimum-maximum) of Edwards SHRZ, PlayerLoad™, sRPE, and sRPE-load (arbitrary units) in two different load categories: Low training load and High training load.

Edwards SHRZ load categories	Edwards SHRZ Mean±SD (min-max)	sRPE Mean±SD (min-max)	sRPE-load Mean±SD (min-max)
Low training load (n=27)	173±32 (107-220)	4.1±1.5 (2-7)	343±147 (150-630)
High training load (n=31)	297±46 (222-395)	5.5±1.6 (3-8)	569±197 (270-960)

PlayerLoad™ load categories	PlayerLoad™ Mean±SD (min-max)	sRPE Mean±SD (min-max)	sRPE-load Mean±SD (min-max)
Low training load (n=31)	354±54 (190-415)	4.0±1.4 (2-7)	341±128 (150-630)
High training load (n=25)	525±82 (418-737)	5.4±1.6 (2-8)	551±197 (150-960)

sRPE (session Rating of Perceived Exertion), sRPE-load (Session Rating of Perceived Exertion training load), SHRZ (Summated Heart Rate Zones).



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