

ASSOCIATION BETWEEN SESSION RPE AND EDWARDS' TRIMP AS INDICATORS OF INTERNAL LOAD IN ELITE MALE BASKETBALL PLAYERS

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Abstract: Accurate monitoring of internal training load is essential for optimizing performance and minimizing injury risk in elite athletes. Session rating of perceived exertion training load (sRPE-TL) and Edwards' training impulse (TRIMP) are commonly used methods for quantifying internal training load, yet their relationship in elite basketball remains underexplored. This study examined the association between sRPE-TL and Edwards TRIMP among elite male basketball players during pre-season practice sessions to provide evidence for the convergent validity of sRPE-TL. The sRPE-TL was calculated using session duration and RPE, and Edwards TRIMP was derived from time spent in heart rate zones multiplied by a weighting factor. A strong, statistically significant correlation was found between the variables ($r = 0.86$, 95% CI [0.82, 0.89], $p < .001$). Regression analysis indicated that sRPE-TL accounted for 74.2% of the variance in TRIMP ($R^2 = 0.742$). Both the slope ($p < .001$) and intercept ($p < .001$) of the regression model were statistically significant. Sensitivity analysis using Spearman's rank correlation confirmed the robustness of the association ($\rho = 0.81$, 95% CI [0.75, 0.85], $p < .001$). These findings indicate that sRPE is a convergently valid tool for monitoring internal training load during practices in the pre-season training period in elite basketball, particularly when resource or logistical constraints are present.

Keywords: Training Load, sRPE, TRIMP, Basketball, Elite Athletes

INTRODUCTION

The underlying concept of the training process is that an athlete's performance potential can be enhanced by overloading their biological systems, prompting adaptive responses (Suchomel et al., 2016). However, if the body's systems are subjected to chronic stress that exceeds their biological capacity to adapt, the performance potential may decrease, and the risk of injury may increase (Meeusen et al., 2013). This underscores the importance of measuring and managing training loads and their related responses.

Training load can be divided into external and internal components (Impellizzeri et al., 2019). External load refers to the objective work completed, such as the distance covered or the number of repetitions performed (Ide et al., 2023). In contrast, internal load reflects the physiological and psychological responses to that work, acting as a trigger for training-induced adaptations (Ide et al., 2023). Both components are essential for understanding athlete adaptation, but neither can be directly measured; thus, reliable and valid proxy measures are required (Impellizzeri et al., 2019, Ide et al., 2023).

Basketball is a high-intensity, intermittent sport characterized by frequent accelerations, decelerations, jumps, and physical contact (Ben Abdelkrim et al., 2010). In recent years, basketball players have faced increased workloads (Russell et al., 2021). Consequently, it is essential to understand how these athletes internally respond to the external demands they encounter, enabling more informed training decisions.

Two of the most widely used methods for quantifying internal load are the session rating of perceived exertion (sRPE) and exercise heart rate (HRex) (Dudley et al., 2023). sRPE is a subjective measure typically collected post-session, representing the athlete's perceived effort (Foster et al., 2001). Though the impact of exercise duration on sRPE is still unclear, sRPE can be multiplied by exercise volume (duration) to express internal load as a single impulse-type metric (sRPE-TL) (Foster et al., 2001). Summing sRPE-TL over time provides a global measure of how athletes perceived and tolerated cumulative training and competition demands (Foster et al., 2001).

Exercise heart rate (HRex) has become a popular, objective measure for quantifying internal load in both individual and team sports, primarily because it is relatively easy to measure (Dudley et al., 2023). HRex can be used

to estimate training load through two main factors: volume and intensity. One of the most well-known methods for calculating training load using HRex is the TRIMP method, developed by Banister in 1991 (Banister, 1991). While there are various adaptations of TRIMP, none have emerged as the gold standard.

Among the most commonly used methods is the zone-based approach by Edwards, which calculates TRIMP by multiplying the time spent in different heart rate zones by specific weighting factors (Edwards, 1993). The validity of this method has been well established compared to more physiologically sound methods for calculating TRIMP (Manzi et al., 2010).

While heart rate serves as an objective measure of internal load, it has several limitations, the most significant being its tendency to underestimate internal load during short, intense activities (Gardner et al., 2023). Additionally, heart rate monitors can be prohibitively expensive for many players and organizations. Consequently, sRPE is increasingly preferred over heart rate monitoring for quantifying internal load (Falk Neto et al., 2020). However, establishing the validity of any internal load metric is crucial for making informed decisions regarding training load management. Although there is no universally accepted gold standard for measuring internal load, the convergent validity of sRPE-TL is typically evaluated against various TRIMP calculations derived from HRex (Halson, 2014). This is due to the challenges of obtaining other measures of internal exercise load in practical settings.

Research has shown that sRPE-TL is strongly associated with TRIMP in various sports, including soccer, Australian and Canadian football, rugby league, cycling, swimming, rowing, gymnastics, and Taekwondo (Impellizzeri et al., 2005; Haddad et al., 2017). This association has also been observed in basketball (Haddad et al., 2017). However, examining the precise strength of this association is challenging due to differences in methodology concerning data collection and result interpretation, variations in population demographics such as age, gender, and competitive levels, and differences in the timing of the competitive season.

Therefore, the aim of this study was to investigate the association between sRPE-TL and Edwards TRIMP among elite male basketball players during practices in the pre-season training period.

By further evaluating the relationship between these two widely used internal load measures in a high-performance environment, we aim to provide practitioners with evidence regarding the convergent validity of sRPE in elite basketball.

METHODS

Participants

This study included ten elite male basketball players from Hapoel Galil Elyon (Israel). The players had a mean age of 25.5 ± 4.2 years, a mean height of 195.8 ± 5.9 cm, and a mean body mass of 91.3 ± 8.2 kg. All participants had at least five years of experience in professional competitive basketball. The inclusion criteria required that the players be injury-free at the beginning of the study and medically cleared for full participation by the team's sports medicine staff. All participants were informed about the study, its processes, and aims, and they provided consent to participate.

Measures

Internal training load was assessed using sRPE-TL and Edwards' TRIMP. Athletes were asked to provide their Rating of Perceived Exertion (RPE) using the Borg CR-10 scale, 10 minutes after each training session. This timing was selected to minimize the impact of acute fatigue bias. The scale was thoroughly explained to the athletes prior to the start of the study, and two training sessions were conducted for familiarization. The session RPE-training load (sRPE-TL) was calculated using the following formula:

$$\text{sRPE-TL} = \text{RPE} \times \text{session duration (minutes)}$$

Heart rate (HR) data were continuously recorded during all sessions using a Polar H10 chest strap monitor. Individual maximal heart rate (HRmax) was determined prior to the training period using the Yo-Yo Intermittent Recovery Test Level 1. Edwards' TRIMP was computed by categorizing heart rate data into five zones based on the percentage of HRmax, with each zone assigned a weighting factor:

- 50–60% HRmax = 1
- 60–70% HRmax = 2
- 70–80% HRmax = 3
- 80–90% HRmax = 4
- 90–100% HRmax = 5

The TRIMP score for each session was calculated as:

$$\text{TRIMP} = \sum (\text{Time in Zone} \times \text{Zone Weighting Factor})$$

Design and Procedures

Data collection occurred over a four-week pre-season period during August and September of the 2023–2024 season. A total of 24 structured team training sessions were monitored, each taking place at 18:00 local time on the same indoor basketball court. All sessions were planned by the team’s head coach and strength and conditioning staff, reflecting typical pre-season training activities. Each session began with a standardized 15-minute warm-up that included light running, dynamic stretching, and ball-handling drills. This warm-up was followed by a combination of small-sided games and technical and tactical drills. Data were analyzed only from athletes who completed each session in its entirety.

Statistical Analysis

The data obtained in the research were analyzed using SPSS (Statistical Package for the Social Sciences). In the evaluation of the data, maximum value, minimum value, arithmetic mean, and standard deviation were used as descriptive statistics. The data were tested for normal distribution using the Shapiro–Wilk test. The relationship between sRPE-TL and TRIMP was assessed using Pearson’s correlation coefficient (r) and further examined using univariate linear regression analysis. Spearman’s rank correlation coefficient (ρ) was calculated as a sensitivity analysis to assess the robustness of the association. The significance level was set a priori at $p \leq 0.05$.

RESULTS

Participants had a mean age of 25.5 ± 4.2 years, an average body weight of 91.3 ± 8.2 kg, and an average height of 195.8 ± 5.9 cm. The demographic characteristics of the participants are presented in Table 1.

Table 1. Demographic Characteristics of the Participants

Variables	n	Mean	SD
Age (years)	10	25.5	4.2
Body Mass (kg)	10	91.3	8.2
Body Height (cm)	10	195.8	5.9

The average session Rate of Perceived Exertion Training Load (sRPE-TL) of the participants was 529.7 ± 189.6 arbitrary units (AU), with a minimum value of 135 AU and a maximum value of 1085 AU. The average Edwards’ TRIMP score was 210.1 ± 72.6 AU, ranging from 60 to 446 AU. Descriptive statistics for sRPE-TL and Edwards’ TRIMP are demonstrated in Table 2.

Table 2. sRPE-TL and Edwards’ TRIMP values

Variables	Mean	SD	Minimum	Maximum
sRPE-TL	529.7	189.6	135	1085
TRIMP	210.1	72.6	60	446

Pearson correlation analysis revealed a strong, positive, statistically significant correlation between sRPE-TL and Edwards’ TRIMP ($r = 0.86$, 95% CI [0.82, 0.89], $p < .001$). Linear regression demonstrated a significant association between sRPE-TL and TRIMP ($F = 676.1$, $p < .001$), with sRPE-TL accounting for 74.2% of the variance in TRIMP scores ($R^2 = 0.742$). The regression equation formulated was: $\text{TRIMP} = 0.33 \times \text{sRPE-TL} + 35.45$, where both the slope ($p < .001$) and intercept ($p < .001$) were statistically significant. Sensitivity analysis using Spearman’s rank correlation confirmed the robustness of the association ($\rho = 0.81$, 95% CI [0.75, 0.85], $p < .001$). Figure 1 illustrates the relationship between TRIMP and sRPE-TL.

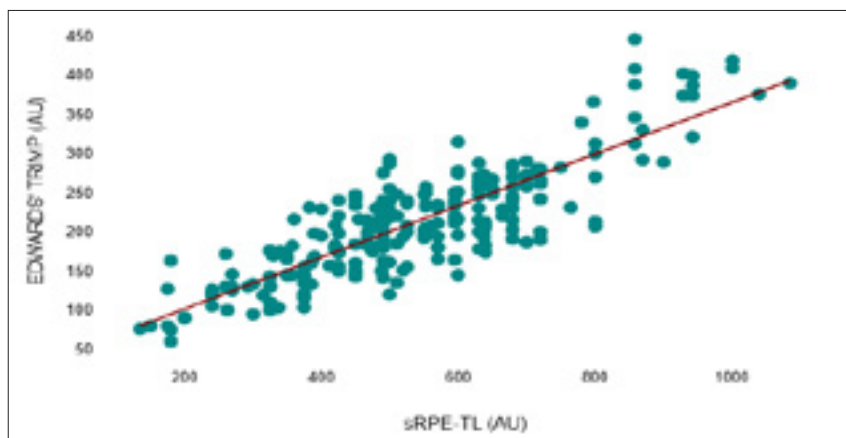


Figure 1. Relationship Between TRIMP and sRPE-TL

Figure 1 abbreviations: AU, arbitrary units; sRPE-TL, session rating of perceived exertion training load; TRIMP, training impulse.

DISCUSSION

This study investigated the association between sRPE-TL and Edwards TRIMP among elite male basketball players during pre-season practice sessions. The results revealed a strong positive correlation between sRPE-TL and Edwards' TRIMP ($r = 0.86$), indicating that higher heart rate-derived load corresponded with higher perceived training load. Regression analysis showed that sRPE-TL explained a substantial proportion of the variance in TRIMP ($R^2 = 0.742$), suggesting that both measures reflect related aspects of internal load despite being derived from different inputs. Sensitivity analysis using Spearman's rank correlation showed that the relationship was robust to underlying data statistical assumptions. These findings support the convergent validity of sRPE-TL as an indicator of internal training load in this setting.

Our results are consistent with previous research in various sports, including soccer, rugby, Australian football, and swimming, where strong associations between sRPE-TL and TRIMP have been reported (Haddad et al., 2017). In the context of basketball, Scanlan et al. (2014) found moderate to high correlations ($r = 0.64\text{--}0.82$) between sRPE-TL and Edwards' TRIMP in semi-professional basketball players. Similarly, Manzi et al. (2010) reported a strong correlation ($r = 0.80$) in professional male basketball setting. Although our results align with those of other studies conducted in basketball, the strength of the association identified in this study is at the upper end of the range previously reported for the sport. One possible explanation is that our research focused exclusively on team basketball practices during the pre-season, unlike other studies that examined various stages of the season or included different training modalities. Additionally, our sample consisted solely of elite male basketball players, making it a homogeneous population group.

While TRIMP offers an objective and widely accepted measure of internal load, it has limitations in intermittent, high-intensity sports like basketball (Scanlan et al., 2018). Heart rate responses can lag behind short-duration efforts such as sprints, jumps, and rapid directional changes, potentially leading to an underestimation of internal load (Scanlan et al., 2018). To address these limitations of TRIMP, the strong association between sRPE-TL and TRIMP found in this study supports the continued use of sRPE-TL in elite basketball settings, especially when logistical or financial constraints limit the feasibility of continuous heart rate monitoring.

While this study benefits from the inclusion of elite athletes, standardized monitoring tools, and a clearly defined training phase, several limitations should be noted. The research focused exclusively on elite male players and assessed only in pre-season practices. This limits the generalizability of the findings to other populations, competitive matches, and different training phases. The study also relied solely on Edwards' TRIMP model, which, although practical, restricts comparison with other TRIMP variations. Future research should compare multiple TRIMP models and investigate whether the relationship between sRPE-TL and TRIMP differs across training contexts, competition levels, or sex-specific groups.

CONCLUSION

This study found a strong and significant relationship between sRPE-TL and Edwards' TRIMP in elite male basketball players during practices in the pre-season training period. These results support the use of sRPE-TL as

a convergently valid tool for monitoring internal training load during practices in the pre-season training period in elite basketball, particularly when resource or logistical constraints are present. Our findings are constrained by the use of a single TRIMP model, a homogeneous sample, exclusive focus on practice sessions, and a specific training phase. Future research should examine various TRIMP models and diverse populations, and include competition and additional seasonal phases, to assess the generalizability of these results.

Data Availability Statement

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request

Author Contributions

Conceptualization, methodology, software, validation, formal analysis, data curation, visualization, supervision, and project administration were performed by K.S. Investigation and resources were provided by K.S. and D.A. Writing—original draft preparation was performed by K.S., and writing—review and editing was carried out by K.S. and D.A. All authors have read and agreed to the published version of the manuscript.

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