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ARTICLE

Quantifying internal workload during training drills in handball players: comparison between heart rate and perceived exertion based methods

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Abstract – Aim: Monitoring internal workload is widely used in team sports. The association between the rating of perceived exertion-based (s-RPE) and heart rate (HR)-based methods needs further investigations regarding exercise modalities in handball. This study compared sRPE and HR-based responses during commonly used handball-training drills. **Methods:** Twelve professional male players were monitored in 6 separate occasions during two small-sided games (SSGs), two match-play periods (MPs) and two interval runs (IRs). The s-RPE and two HR-based methods were used to quantify workload. Pearson correlations were applied to determine relationships between quantification methods, and one-way ANOVA was used to compare workloads between exercise modalities for each method. **Results:** Nearly perfect correlation was observed ($p < 0.0001$, $r = 0.93$–0.99) between both HR-based methods for each exercise modality. Relationships between s-RPE and HR-based methods revealed trivial to small correlations. The perception of effort reported in response to SSGs and MPs sequences were much lower than IRs. **Conclusion:** s-RPE and HR-based methods do not seem to be interchangeable. They should be considered as complementary to understand psychophysiological workload. The s-RPE quantification of training drills might help coaches to better design their training session particularly during intense periods.

Keywords: training load, fatigue, small-sided game, ball game, interval running

Résumé – Quantification de la charge de travail interne lors d'exercices d'entraînement chez des joueurs de handball : comparaison des méthodes basées sur la fréquence cardiaque et la perception d'effort. Objectif : Le suivi de la charge de travail interne est largement utilisé en sports collectifs. La relation entre les méthodes basées sur l'évaluation de la perception de l'effort (s-RPE) et celles basées sur la fréquence cardiaque (FC) nécessite davantage d'études au regard des diverses modalités d'exercices en handball. Cette étude compare les réponses s-RPE et celles dérivées de la FC au cours d'exercices d'entraînement couramment utilisés en handball. **Méthodes :** Douze joueurs professionnels de handball ont été suivis durant 6 séquences : 2 jeux à effectifs réduits (SSGs), 2 périodes de match (MPs) et 2 exercices de course intermittente (IRs). La méthode s-RPE et deux méthodes basées sur la FC ont été utilisées pour quantifier la charge de travail. Les relations entre les méthodes ont été déterminées en utilisant un test de Pearson. Les charges de travail de chaque exercice d'entraînement ont été comparées pour chaque méthode à partir d'une ANOVA à un facteur. **Résultats :** Des corrélations significatives ont été observées ($p < 0{,}0001$; $r = 0{,}93$–$0{,}99$) entre les méthodes basées sur la FC pour chacune des modalités d'exercice. Il ne semble pas y avoir de corrélation entre les méthodes s-RPE et FC. La perception d'effort observée en réponse aux séquences SSGs et MPs était nettement inférieure à celle observée lors des IRs. **Conclusion :** Les méthodes s-RPE et celles basées sur la FC ne sont pas interchangeables. Elles doivent être considérées comme complémentaires pour comprendre la charge de travail sous l'angle psychophysiologique. La quantification des exercices d'entraînement par la méthode s-RPE peut aider les entraîneurs à mieux construire leurs entraînements au cours de périodes intenses.

Mots clés : charge d'entraînement, fatigue, jeu à effectif réduit, sport collectif, course intermittente

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1 Introduction

Handball is a popular team sport defined as an intermittent exercise alternating moderate (*e.g.*, walking, running) and high-intensity activities comprising jumping, sprinting, changing of directions, and tackling (Michalsik, Aagaard, & Madsen, 2013; Póvoas *et al.*, 2012). During match play the physiological demands imply contributions of both aerobic and anaerobic energetic pathways (Póvoas *et al.*, 2012). Coaches implement training sessions aiming to improve team performance, players' physical potential and technical skills. Hence, handball training comprised various exercise modalities as ball games (*e.g.*, periods of match play, repetitions of back checking and counter-attack), traditional interval running and fitness games (Iacono, Eliakim, & Meckel, 2015; Ravier, Hassenfratz, Bouzigon, & Groslambert, 2019). During the last decade, fitness games and more specifically small-sided game (SSG) became very popular in team sports to improve match-specific energetic demands by involving technical skills of players whilst maintaining motivation (Buchheit *et al.*, 2009; Iacono *et al.*, 2015). With elite team handball players who are involved in a daily or twice-daily training regimen, the challenge for coaches is to modulate intensity, duration and/or content of the training sessions. Modulation of training workload seems an important factor that contribute to maintaining motivation and performance while preventing non-functional overreaching and avoiding injuries and illnesses (Bresciani *et al.*, 2010).

Training load has been defined as "the cumulative amount of stress placed on an individual from multiple training sessions and games over a period of time, expressed in terms of either the external workloads performed or the internal response to that workload" (p. 992) (Gabbett, Whyte, Hartwig, Wescombe, & Naughton, 2014). Exercise workload may be assessed from external and internal quantifying methods. External load provides indications about physical demands using microtechnology as Global Position System (outdoors sports), inertial measurement units (as accelerations) or video analysis. The internal workload represents the psychophysiological response elicited during exercise. When coaches and scientists need to control the psychophysiological stress applied to the athlete the use of internal workload methods is suggested (Impellizzeri, Marcora, & Coutts, 2019).

To quantify internal workload, Banister (1991) has developed the concept of "training impulse" by integrating the heart rate (HR) response during endurance exercise. Score derived from HR at rest, during exercise, and the calculation of the HR reserve. Then, Edwards (1993) developed a modification of this HR-based method by integrating the time spent in intensity HR zones. Both HR-based methods still remain widely used in team sports to monitor the adequate training load which is required to induce physiological adaptations (Fox, Stanton, Sargent, Wintour, & Scanlan, 2018). Foster *et al.* (2001) proposed to assess internal exercise load subjectively using the session rating of perceived exertion method (s-RPE). To do so, players are required to rate the intensity of each exercise session after their completion using the category ratio scale (CR-10) by answering the question: "How intense was your exercise?". Then, the workload is calculated by multiplying the session CR-10 value by the exercise time in minutes. To date, the s-RPE method shows broad applicability in quantifying training sessions and remains one of the most common means for assessing internal workload in team sports (Fox *et al.*, 2018). In handball, most of the studies (Corvino, Tessitore, Minganti, & Sibila, 2014; Dello Iacono *et al.*, 2018; Iacono *et al.*, 2015; Póvoas *et al.*, 2012; Ravier *et al.*, 2019) aimed at investigating the physiological demands of various training drills analyzed the HR response. Usually, the HR is monitored during the whole training session using HR chest belts and recorded data are subsequently downloaded to be analyzed after the end of the training session. Data are expressed as percentage of the peak HR which was previously determined from an incremental maximal running test. Finally, the physiological demand of the training session is determined from the mean HR and time spent in HR intensity zones (percentage of peak HR). However, in field conditions coaches have not used the HR-based method over long periods to monitor training load. The main reasons are that wearing watch monitor is prohibited by the official playing rules and may be hazardous due to contacts in offense and defense phases. Moreover, due to the large number of players in the handball team, the data analysis would be time consuming for coaches. Owing to technological advances, exercise HR is now transferred to the computer by using wireless transmission which avoids wearing watch monitor. For instance, the Advanced Network Tools (ANT) protocol allows collecting more than twenty sensors simultaneously. The ANT is an open access multicast wireless sensor network technology defining a wireless communications protocol stack. It is conceptually like Bluetooth low energy but orienting towards use with sensors. The main interest of that technology is that ANT-powered nodes are capable of acting as transmitters and receivers to route traffic to other nodes and so avoiding interference. In addition, software calculates physiological variables automatically (*i.e.*, mean HR or time spent in selected HR zones) which are needed to quantify internal workload. Consequently, the HR is available in real time and workload may be quantified with ultra-short-term delay after the end of the training session.

The first study testing the relationship between s-RPE and HR-based methods in different forms of exercise-investigated steady state and interval cycling exercises, and basketball sessions (Foster *et al.*, 2001). Basing from regression lines, authors reported that the pattern of differences between s-RPE and HR-based methods were consistent among these exercises. However to date, few studies assessed the relationships between s-RPE and HR-based methods by using the product-moment correlation in team sports (Campos-Vazquez *et al.*, 2015; Impellizzeri, Rampinini, Coutts, Sassi, & Marcora, 2004; Iturricastillo,

Table 1. Weekly working structure and experimental setup of training sessions.

		Monday	Tuesday	Wednesday	Thursday	Friday
Week 1	*Morning*	Strength	Handball			
	Afternoon	Handball	Strength	Handball	Handball	Intermittent Fitness Test
Weeks 2/3/4	*Morning*	Strength	Handball	Handball		
	Afternoon	*SSG/MP/IR	*IR/SSG/MP	Handball	Handball	Handball or Match play

*SSG was performed during the 2nd and 3rd week, IR was performed during 2nd and 4th week, and MP was performed during the 3rd and 4th week.

Granados, Los Arcos, & Yanci, 2017; Manzi *et al.*, 2010; Scanlan, Wen, Tucker, Borges, & Dalbo, 2014). Overall, the s-RPE method might be considered a good indicator of internal loads during training sessions by most authors in soccer (Impellizzeri *et al.*, 2004) and basketball players (Manzi *et al.*, 2010; Scanlan *et al.*, 2014). Despite the fact that large magnitude correlation has been reported between s-RPE and HR-based methods during periods of the competitive season, relationships might be training forms dependent (Iturricastillo *et al.*, 2017; Scanlan *et al.*, 2014). Moreover, the magnitude of relationships was reported to be influenced by the training drills implemented during training sessions (Campos-Vazquez *et al.*, 2015; Iturricastillo *et al.*, 2017). Thus, in professional soccer players, large relationships were observed between HR-based methods and s-RPE during training session defined as "mixte" mode (*i.e.*, comprising association of metabolic, skills and tactical sequences) while unclear correlations were reported with SSG or tactical exercise when analyzed separately (Campos-Vazquez *et al.*, 2015).

In handball, there is a lack of information regarding the association between s-RPE-based and HR-based methods during various exercise modalities. However, monitoring internal workload seems important in understanding fatigue and maintaining performance in handball players. Moreover, knowledge of the workload related to various training drills can provide relevant information that might help coaches in prescribing training sessions. The present study aimed to determine whether the s-RPE-based and HR-based methods influenced the internal workload response during small-sided games, interval running sessions and periods of match play in handball players.

2 Methods

2.1 Participants

Twelve elite male handball players (mean ± SD: age 23.1 ± 3.5 years; body mass 84.3 ± 8.0 kg; body height 188.7 ± 6.5 cm) from the same team volunteered to participate in this study. In addition, two goalkeepers provided their contribution in performing exercise sessions when appropriate without being monitored. All players were involved in the professional French National Handball League and received the same training volume (on average, seven times a week) and competed on weekends. Each participant was medically screened in accordance with the requirements of the medical board of the National Handball League (including the guidelines of the European Society of Cardiology) and did not have medical or orthopaedic problems at the time of the study. Participants were informed of the procedures, benefits and risks of the investigation, as well as the right to terminate participation at will. The experiment was carried out during the regular season, and data arose as a usual condition of elite player monitoring. This study was conducted in accordance with the 1964 Declaration of Helsinki and its later amendments.

2.2 Experimental design

The study used an observational within subject repeated-measure design. The reliability and sensitivity of three quantifying training load methods were tested by determining internal workload of six sequences performed on separate occasions. Experimental sessions carried on during the regular handball training of the team over four consecutive weeks at the same time of the day (5:00 p.m.) (Tab. 1). First, participants completed the maximal incremental Intermittent Fitness Test (Buchheit, 2008) to determine their maximal running velocity and their maximal HR (HRmax). Then, six exercise sessions comprising three different training drills were monitored in separate occasions (on Monday and Tuesday): a small-sided game (SSG), an intermittent shuttle running (IR), and a match play (MP). Each of these training drills was repeated once during a separate training session one week apart (SSG1, SSG2, IR1, IR2, MP1, MP2). At the beginning of each handball training, players were required to wear a HR monitor and rested passively in sitting position for 5 min in a quiet locker room without speaking to obtain their resting HR (HRrest) (*i.e.*, mean of the last two minutes). Then, a usual warm up was completed followed by one of the three exercise modalities lasting two 10 min periods separated by 2 min of passive recovery (allowing hydration ad libitum for athletes).

2.3 Measures

The subjective workload quantification method (s-RPE in arbitrary units, AU) developed by Foster (Foster *et al.*, 2001) consists of multiplying the RPE and the exercise duration (in minutes). The field players were required to provide their RPE within the 15 min after the end of each exercise. The present time delay was reduced from that recommended (*i.e.*, 30 min) because our experimental exercise comprised a single drill sequence and modality. RPE was determined by using Borg's category-ratio scale (CR-10) comprising 11 statements ranging from 0 ("nothing") to 10 ("maximum"). Both RPE and exercise duration were collected using a custom-design web-based application (https://training-sense.fr) available in free access, which was previously downloaded on the player's smartphone. This procedure was usual for players since adopted over the course of the season.

Two heart rate-based workload quantification methods implied monitoring heart during IR and both ball drills (SSG, MP). The heart rate was continuously recorded at 2 s intervals and analyzed from the beginning to the end of each of two 10-min exercise periods. Data was collected using a HR monitor (HR1 chest belt, Matsport, Saint Ismier, France) with ANT+ wireless transmission. Participants were recorded all together at the same time by means of the Mooky Center software (Matsport, Saint Ismier, France) which is made to collect more than twenty signals simultaneously. This technology did not require wearing an individual watch monitor.

The HR data were subsequently analysed to quantify internal training load. Edwards's method (T-Zone, AU) calculates the products of the time accumulated for five training intensity HR zones multiplying by a coefficient related to each zone (50–59% of HRmax = 1; 60–69% of HRmax = 2; 70–79% of HRmax = 3; 80–89% of HRmax = 4; 90–100% of HRmax = 5). The T-Zone workload (Edwards, 1993) corresponded to the sum of the amount of time spent in each arbitrary zone multiplied by their corresponding coefficient.

The method of Banister (TRIMP, AU) calculated the workload from the following equation (Banister, 1991): TRIMP = completion time × x × 0.64 $e^{1.92x}$, where 1.92 is a generic constant for males, and time duration was expressed in minutes. The x corresponds to the following formula:

$$\frac{(mean\,exercise\,HR - HRrest)}{HR\max - HRrest}.$$

2.4 Exercise modalities

Both ball drills and the interval running session were completed on a regular indoor handball court (20 m × 40 m). The SSG consisted of two 10 min sequences of match play performed in intermittent regimen (30 s–30 s) with passive recovery, opposing 3-a-side field players plus goalkeepers. Playing rules has been thoroughly described (Ravier *et al.*, 2019). Adaptations aimed to prevent time off. For instance, each team consisted of six field players with 3 of them playing the match while others watching. This role was reversed immediately after the whistle of the timekeeper: before leaving, the ball carrier passed the ball to one of his teammates entering the court. By using this rule, the interruption of the game has been avoided.

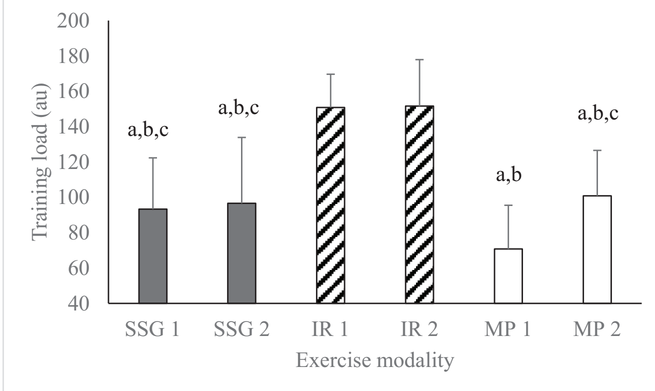

Fig. 1. Perceived-based training load method during small-sided game, intermittent running and match play. Values are means ± SD. SSG: small-sided game completed; IR: intermittent shuttle running bout; MP: match play; a: specific significant difference with IR1 ($p < 0.0001$); b: specific significant difference with IR2 ($p < 0.0001$); c: specific significant difference with MP1 (between $p < 0.01$ and $p = 0.050$).

The MP consisted of two periods of continuous match play opposing two teams (6-a-side field players plus goalkeepers) respecting the official rules of the International Handball Federation. The IR consisted of shuttle running (40 m) in intermittent regimen (30 s–30 s) with passive recovery at running intensity set at 95% of the individual maximal velocity which was previously determined from the Intermittent Fitness Test.

2.5 Statistical analysis

Statistical analysis was carried out using XLSTAT statistical software. Data are reported as mean ± SD. The normality was checked using the Shapiro–Wilk's test. A one-way ANOVA for repeated measures was used to determine the significant mean effects between exercise modalities (SSG1, SSG2, IR1, IR2, MP1, and MP2). Each quantifying method (s-RPE, TRIMP and T-Zone) was analysed separately. Pairwise comparisons were tested using the *post-hoc* Tukey's test. Furthermore, relationships between training load methods were determined by using Pearson's correlation for the whole group and individually. The magnitude of the correlation was determined from the correlation coefficient (r) as: < 0.1 trivial, 0.1–0.3 low, 0.3–0.5 moderate, 0.5–0.7 large, 0.7–0.9 very large and > 0.9 nearly perfect (Hopkins, 2007). The $p \leq 0.05$ criterion was used for establishing statistical significance.

3 Results

A significant exercise modality effect was observed for s-RPE ($p < 0.0001$), TRIMP ($p < 0.0001$), and T-Zone ($p = 0.005$) methods. *Post-hoc* differences between exercise modalities are shown for s-RPE (Fig. 1), TRIMP (Fig. 2) and T-Zone (Fig. 3) methods. The s-RPE was the quantifying method showing the most differences between exercise modalities.

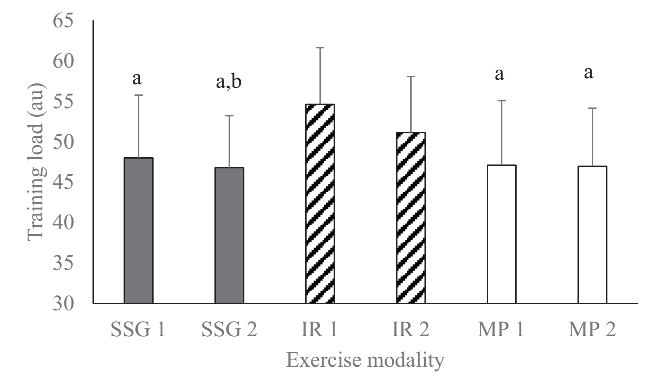

Fig. 2. Heart rate-based training load method of Banister during small-sided game, intermittent running and match play. Values are means ± SD. SSG: small-sided game completed; IR: intermittent shuttle running bout; MP: match play; a: specific significant difference with IR1 (between $p < 0.001$ and $p = 0.004$); b: specific significant difference with IR2 ($p = 0.050$).

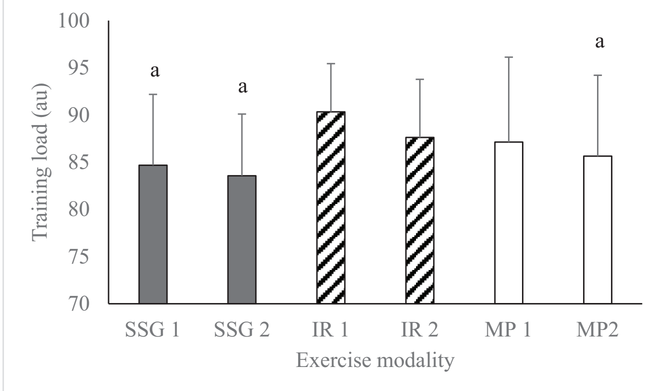

Fig. 3. Heart rate-based training load method of Edward during small-sided game, intermittent running and match play. Values are means ± SD. SSG: small-sided game completed; IR: intermittent shuttle running bout; MP: match play; a: specific significant difference with IR1 (between $p = 0.003$ and $p = 0.03$).

Correlations between quantifying methods were tested individually regardless the exercise modality: four players showed significant correlations between the three quantifying methods while any significant result was observed for three players. More specifically, nine players showed significant correlation between T-Zone and TRIMP (comprised between $r = 0.913$ and $r = 0.998$ for these 9 players), six displayed significant correlation between TRIMP and s-RPE (comprised between $r = 0.816$ and $r = 0.941$ for these 6 players), and five presented significant correlation between T-Zone and s-RPE (comprised between $r = 0.816$ and $r = 0.902$ for these 5 players).

Table 2 displays correlations between quantifying methods for the whole group for each modality analyzed separately.

4 Discussion

This study aimed to assess whether s-RPE and HR-based methods might reveal differences between three types of exercises, and to identify which exercise session generated the greatest internal workload. Moreover, relationships between internal loads associated with exercise modalities were tested. The s-RPE method was the one revealing most differences between exercise modalities.

The greatest internal workload was observed for IR1 with the three different methods of quantification. The possible link between perception of effort and HR response is supported by the "afferent feedback" model (Pageaux, 2016). This model considers that feedback from skeletal muscle and cardiorespiratory strain experienced during exercise (from nociceptors and mediated by group III and IV muscle afferents) constitutes the main sensory signal involved in the generation of RPE. Previous studies reported that the perception of effort was influenced by muscular fatigue state (Marcora, Bosio, & de Morree, 2008), and cardiorespiratory stress (as dyspnea) (Iandelli *et al.*, 2002). Nevertheless, SSGs and MPs sequences showed clear-cut lower s-RPE than IRs (Fig. 1) whereas HR-based workload showed similar values between IR2 and both SSG and MP (Figs. 2 and 3). The first explanation of the present data might be the greater enjoyment resulting from the manipulation of the ball and performing handball specific skills during MP and SSG in comparison with IR. It is well accepted that perception of effort results from the neural process (including the sensory cortex) of sensory signals that can be influenced by many psychological factors (mood state, pleasure and mental fatigue) (Marcora, 2009; Noble & Robertson, 1996). Previous studies reported that RPE was lower in response to soccer SSGs compared to intermittent runs of similar mean HR response in young and adult players (Hill-Haas, Coutts, Rowsell, & Dawson, 2009; Los Arcos *et al.*, 2015). In handball, one previous study comparing psychophysiological response during SSG and traditional intermittent running, reported similar mean HR whereas SSG showed lower RPE and affective balance (*i.e.*, difference between RPE and pleasure) and higher pleasure (Ravier *et al.*, 2019). It is worth noting that the influence of pleasure in the s-RPE internal workload should not be considered negatively. Feeling is also influenced by individual performance and may reveal inter-individual differences. For instance, scoring goals is important during ball game (*i.e.*, MP) and achievement of fatigue seems determinant during fitness game (*i.e.*, SSG). Indeed, physical fatigue provides satisfaction "getting a job done". The workload derived from s-RPE reflects more than the acute physiological response generated by physical activity (*i.e.*, running intensity, number of sprints, jumps and so on) during the training session. Thus, psychological strain (comprising attention requested during exercise, pleasure, motivation and mood state) would largely influence the exercise constraint felt by players (Freitas, Nakamura, Miloski, Samulski, & Bara-Filho, 2014; Hill-Haas *et al.*, 2009; Los Arcos *et al.*, 2015; Ravier *et al.*, 2019). Because

Table 2. Correlations for the whole group between heart rate-based and perceived exertion based training load methods during small-sided game, intermittent running and match play.

	T-Zone–s-RPE	T-Zone–TRIMP	TRIMP–s-RPE
MP1	$p = 0.44$ $r = 0.25$, moderate	$p < 0.0001$ $r = 0.94$, nearly perfect	$p = 0.15$ $r = 0.44$, large
MP2	$p = 0.94$ $r = 0.03$, low	$p < 0.0001$ $r = 0.95$, nearly perfect	$p = 0.42$ $r = 0.26$, moderate
MP	$p = 0.75$ $r = 0.07$, low	$p < 0.0001$ $r = 0.94$, nearly perfect	$p = 0.16$ $r = 0.29$, moderate
IR1	$p = 0.20$ $r = 0.40$, large	$p < 0.0001$ $r = 0.94$, nearly perfect	$p = 0.36$ $r = 0.29$, moderate
IR2	$p = 0.64$ $r = 0.15$, moderate	$p < 0.0001$ $r = 0.93$, nearly perfect	$p = 0.51$ $r = 0.21$, moderate
IR	$p = 0.28$ $r = 0.23$, moderate	$p < 0.0001$ $r = 0.93$, nearly perfect	$p = 0.28$ $r = 0.23$, moderate
SSG1	$p = 0.80$ $r = 0.08$, low	$p < 0.0001$ $r = 0.99$, nearly perfect	$p = 0.68$ $r = 0.13$, moderate
SSG2	$p = 0.58$ $r = 0.18$, moderate	$p < 0.0001$ $r = 0.98$, nearly perfect	$p = 0.39$ $r = 0.27$, moderate
SSG	$p = 0.56$ $r = 0.12$, moderate	$p < 0.0001$ $r = 0.98$, nearly perfect	$p = 0.36$ $r = 0.19$, moderate

r: Pearson's correlation coefficient with the magnitude of the correlation.
MP1, MP2, MP: first, second and both together match play, respectively; IR1, IR2, IR: first, second and both together intermittent running, respectively; SSG1, SSG2, SSG: first, second and both together small-sided game, respectively. T-Zone: heart rate-based training load method of Edward; s-RPE: perceived-based training load method; TRIMP: heart rate-based training load method of Banister.

workload monitoring is widely used for the assessment of fatigue and in screening for overreaching state, it seems important to determine the whole amount of stress placed on players expressed in terms of psychophysiological response (Freitas *et al.*, 2014). Our results confirm the interest of SSG and MP to reduce s-RPE compared with traditional IR. The s-RPE method might be encouraged to quantify internal workload in elite handball players who perform different training drills.

In the present study, individual correlations between s-RPE and T-Zone and between s-RPE and TRIMP methods for exercise modalities analyzed all together (IR1, IR2, SSG1, SSG2, MP1 and MP2) revealed wide inter-individual differences. This result was previously reported in professional soccer players (Campos-Vazquez *et al.*, 2015) as the magnitude of relationships depended on training drills. In our study, when considering the whole group of participants (Tab. 2) low to large correlations were observed between T-Zone and s-RPE and moderate to large correlations were observed between TRIMP and s-RPE. The present results not support the large relationships between s-RPE and HR-based workload methods previously reported in response to entire training sessions in team sports (Impellizzeri *et al.*, 2004). More broadly, both T-Zone and TRIMP have been correlated to s-RPE when monitored weekly training load and during crucial parts of the competitive season (Manzi *et al.*, 2010; Scanlan *et al.*, 2014). Nevertheless, when analyzing training drills separately, relationships between perceived-based and HR-based methods were reported to be exercising mode dependent. For instance, in professional soccer players (Campos-Vazquez *et al.*, 2015) large relationships were observed between T-zone and s-RPE during mixed session of ball game and tactical exercise ($r = 0.73$ to 0.87) while unclear correlations were reported for SSG or tactical exercise analyzed separately.

Our results might be explained by individual differences in training status and individual sensitivity to perceive HR intensity. Thus, the quantification of energetic demands implies that players would have developed their capability to perceive slight variations in physiological markers as heart rate, breathing frequency, and muscle fatigue. Moreover, the capability to sustain strength-based or endurance-based exercise might influence the RPE during experimental exercises (SSG, MP and IR). Because of these individual characteristics, the

RPE has been extended further by including respiratory and muscular scores in response to wheelchair basketball SSGs (Iturricastillo *et al.*, 2017) and soccer training sessions (Arcos, Yanci, Mendiguchia, & Gorostiaga, 2014). This methodology may be prescribed when exercise modalities involves strength fatigue and/or central adaptations and for players with greater sensibility to either strength or respiratory strain.

Finally, near perfect correlations were observed (Tab. 2) between T-Zone and TRIMP. This result support the data previously reported in soccer players (Campos-Vazquez *et al.*, 2015) between both HR-based methods ($r = 0.92$ to 0.98). The HR response is widely recorded in team sports (Buchheit *et al.*, 2009; Iacono *et al.*, 2015; Ravier *et al.*, 2019) for determining the physiological demand during training session. For instance, a total duration of 10 min per training session spent in the HR zone lower than 90% of the maximum HR was shown to provide an appropriate stimulus for large changes in aerobic fitness (Impellizzeri *et al.*, 2006). Although HR-based methods present nearly perfect correlations, Banister's method is the only one to reveal differences between SG2 and IR2 and between MP1 and IR1 (Figs. 2 and 3).

5 Conclusion

In conclusion, the s-RPE method was the one revealing most differences between exercise modalities. MP and SSG revealed lower workload in comparison with IR sessions. Monitoring training load is predominately a chronic (periodization) decision-making tool. Nevertheless, the workload quantification of various exercise modalities might help coaches to better design their training session during crucial periods (congestive training sessions and match). Regarding the wide magnitude of correlations between s-RPE and HR-based methods, these internal training load methods do not seem to be interchangeable and should be considered as complementary to understand psychophysiological fatigue.

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