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Is a retrospective RPE appropriate in soccer? Response shift and recall bias

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ABSTRACT

This study examined the acceptability of a retrospective rating of perceived exertion in soccer. Two attributes were investigated: response shift and recall bias. Response shift refers to a change in perception due to changes in internal standards and recall bias can influence the response shift assessment. Ratings were collected with the Borg-CR100® scale. Study 1: during competitive season 58 players (age 22 ± 5 years, height 178 ± 6 cm, body mass 72 ± 6 kg) were asked their rating following cessation of the matches and again at48 h post match. Response shift (first part of the season) was investigated by difference between the two ratings and recall bias (second part of the season) asking players whether they remembered exactly the rating given 48 h before. No response shift or recall bias were found. Study 2: 21 players (age 25 ± 5 years, height 176 ± 6 cm, body mass 71 ± 7 kg) were asked ratings at the end and 48 h following a field session, equated for internal and external loads. The same session was repeated after 10 days in a randomized crossover design. No significant differences ($P > 0.05$) between conditions were found. Retrospective rating was appropriate, however, the inconsistency of some ratings (i.e., after training) suggested it should be used only under special circumstances.

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Rating of perceived exertion (RPE); association football; training load; GPS; Borg CR100 scale; session-RPE

Introduction

The rating of perceived exertion (RPE) is widely used in soccer for quantifying workload (WL) from matches and training sessions (Akubat et al. 2012; Scott et al. 2013a; Wrigley et al. 2012). This method, called session-RPE, is calculated by multiplying session duration and RPE after the activity (Foster et al. 2001). The session-RPE is considered a valid indicator of internal-WL as defined by the actual physiological stress imposed on the athlete (Impellizzeri et al. 2005) and its construct validity in soccer has been demonstrated by assessing correlation with other indicators of the reference construct (i.e., relative physiological stress) such as heart rate (HR) (Akubat et al. 2012; Casamichana et al. 2013; Impellizzeri et al. 2004; Scott et al. 2013a) and lactate (Coutts et al. 2009). In addition, the monitoring of WL has been suggested as a potential injury prevention strategy in team sport (Drew & Finch 2016).

The WL imposed by the match has been reported to be higher than the mean weekly from training sessions only and as such should be considered an essential addition to the workload monitoring strategy. This will allow a greater understanding of the entire training and match process (Impellizzeri et al. 2004; Akubat et al. 2012). Following a soccer match, the performance outcomes within the match itself can affect the subjective perceived exertion (Brito et al. 2016). For example, the failure of a player to cope with the match demands, tactical tasks or the emotional response after a match can influence the RPE, under- or over-estimating the rating. In general, the athletes are exposed to high levels of stress during the competitions compared to training sessions and this can produce anxiety, psychological stress and tension (Haneishi et al. 2007; Elloumi et al. 2008; Moreira et al. 2012). Furthermore, based on the results of the match, especially after a loss, players may be not cooperative and may refuse to provide an accurate rating. In a preliminary data collection (unpublished results), a mismatch of ratings (difference between expected and collected) was observed in two different professional teams (Italian and Switzerland second league level) after official matches and training sessions. In addition, ~10% of the RPE values were not able to be obtained immediately following matches while none were missed after training. The effect of inaccurate and/or missed session-RPE data are very important from a practical standpoint and can affect the veracity of WL datasets with compromising the ability to assess and control training based on these data.

Due to the inability to always collect RPE data immediately after matches, technical staff often collect these data in the following 48 h. A retrospective rating can also be collected from players when RPE values are not collected after training (i.e., when a player leaves the training facility before giving his rating). However, due to the difference in timing of collecting data, they are often concerned about the consistency and validity of a retrospective rating of session-RPE (e.g., collected 48 h following matches).

The use of perceptual measures in sport science can often present some methodological issues, sometimes generating

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erroneous interpretation or conceptual mistakes (Impellizzeri et al. 2011). Response shift and recall bias are two issues that may influence the rating in longitudinal assessment of perceptual constructs (Barclay-Goddard et al. 2009). These two methodological issues are also practically important as they can give insights into how and when the rating can be collected. The response shift refers to a change in the internal standard of measurement and consequently in the way patients perceive and interpret their health status (Schwartz & Sprangers 1999). Sprangers and Schwartz (1999) defined the response shift as a modified meaning of self-evaluation of a target construct due to re-conceptualization (redefinition of the target construct), re-prioritization (changes in the priorities, i.e., change in the importance of the components of the target construct) and scale recalibration (changes in a internal standard of measurement) after a period of time. The recall bias concerns the ability to recall previous events, changes in health status or symptoms (Blome & Augustin 2015). Therefore, the retrospective assessment of the perceived exertion may not be accurate due to the recall bias effect. Williams et al. (2012) found that 48 h after a match players were able to recall episodic events such as number of crosses, tackles and passing success rates. However, it is not yet known if players are able to remember exactly the exercise intensity or exertion of an activity performed 48 h prior. Therefore, the response shift phenomenon should be investigated controlling for the influence of the recall. Accordingly, the aims of the study were to investigate the response shift and recall bias in session-RPE after official matches and training sessions to verify the acceptability of a retrospective (48 h) rating.

Methods

The present investigation consisted of two studies involving a total of 81 male players (flow chart is presented in Figure 1). Study 1 was carried out with two data collections in different periods, in the first period response shift was analysed after matches whereas in the second period recall bias and response shift were assessed following matches and training sessions. Study 2 was designed to verify the results of study 1 with a different approach and was carried out during a Christmas break. Response shift (Figure 1) was examined with three different methods (i) then-test, (ii) then-test controlled for recall bias, (iii) cross-over design. Therefore, a standard descriptive method (frequently adopted in the clinical setting for rating scales and questionnaires) and an experimental approach were used in the two studies. The studies were approved by the Local Ethics Committee of the University of Verona.

Rating of perceived exertion

The RPE was collected using the Borg CR100® Scale that is a category ratio scale (as the previous CR10®) with verbal anchors and numbers between 0 and 100 arbitrary units (AU) (Borg & Borg 2002). The CR100® and CR10® scales have shown similar psychophysics properties (similar exponent in the power function), but with the CR100® showing a lower tendency to provide ratings clustered on the verbal anchors compared to CR10® (25% vs. 37%, respectively), thus suggesting more accurate training load data (Borg & Kaijser 2006; Fanchini et al. 2015). The session-RPE calculated with the CR100® scale has been showed to be a valid measure of internal-WL in soccer and in Australian Football (Fanchini et al. 2015; Scott et al. 2013b). Before commencing the studies, players were familiarized with the Borg CR100® scale. The fitness coaches of each team collected the ratings by showing the scale to the players in a confidential interview with players blinded to the ratings of their teammates to avoid external influences.

Participants and design

Study 1

Fifty-eight soccer players (age 22 ± 5 years, height 178 ± 6 cm, body mass 72 ± 6 kg) from three Italian teams (one semi-professional and two youth professional teams) participated in the study. The RPE was collected at the end (RPE0) and 48 h (RPE48) after matches and training sessions. Between the two assessments players were not allowed to train. A time frame of 48 h was used as it is typical that the day following matches are usually programmed as rest days and players are not required to participate in any training duties. Therefore, to achieve ecological validity, response shift and recall bias were investigated at 48 h after matches and training.

The "then test" is the most commonly used method to assess response shift in longitudinal clinical research (Barclay-Goddard et al. 2009), and it was therefore considered to be appropriate for the present study (Schwartz & Sprangers 2010; Sprangers et al. 1999; Visser et al. 2005). However, the "then

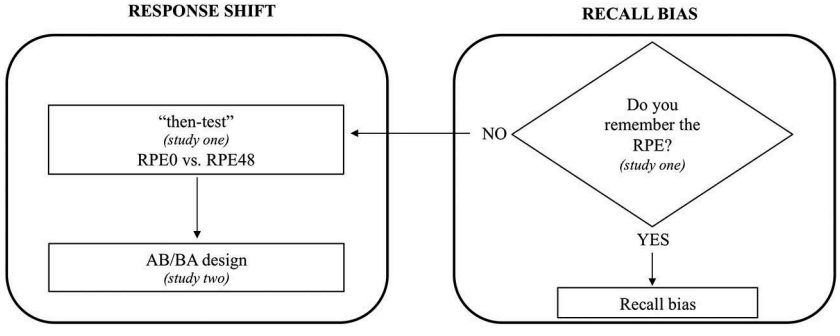

Figure 1. Flowchart used to investigate response shift and recall bias in soccer in the two studies.

test" is not able to discern between reconceptualization, reprioritization or recalibration, it is assumed to measure recalibration (Barclay-Goddard et al. 2009; Blome & Augustin 2015). To evaluate the response shift after matches, players were asked to report the RPE referring to the entire match within a time frame of 48 h (i.e., RPE0 and RPE48) during the first period of the competitive season (from October to February). When RPE48 was collected, players were asked to think about the perceived exertion experienced and not the rating already given 48 h before (i.e., the RPE0). The difference between the RPE48 and RPE0 was used as the main outcome to investigate response shift (i.e., "then test").

The "then test" results may be influenced by recall bias. Players may be not able to precisely recall the intensity perceived during exercise completed 48 h prior, but they may be able to remember the numeric rating given which can influence the "then test". During the second part of the competitive season (from February to May), recall bias was investigated by asking players whether or not they remembered the exact RPE0 given after the matches and training sessions. For players declaring that they did not remember the RPE0, a new rating was requested and this was considered an additional evaluation of response shift. When the players could recall their RPE0, they were asked to provide the same rating and the difference between the two values was considered as outcome for the occurrence of recall bias. Recall bias and response shift were investigated both in training sessions (Rec-B-TRN and Res-S-TRN, respectively) and matches (Res-S-MTC and Rec-B-MTC, respectively).

Study 2

Twenty-one amateur soccer players (age 25 ± 5 years, height 176 ± 6 cm, body mass 71 ± 7 kg) participated in the study. A randomized crossover design was used to investigate response shift after training sessions. Players were involved in three field sessions and blinded to the aim of the study. In the first session, players completed a Yo-Yo Intermittent Recovery Test level 1 in order to evaluate their physical ability and peak heart rate (HRpeak). The Yo-Yo Test is a widespread incremental maximal shuttle running test and its description has been reported elsewhere (Krustrup et al. 2003). Next, the players were matched for distance covered in the test and randomly allocated in two groups using a computer-generated sequence of numbers. In sessions 2 and 3, the same training (equated for internal-WL) was provided to the players before and after a washout period of 10 days in an AB/BA design (2 periods, 2 treatments: condition-0 and condition-48). Players in the condition-0 were asked to provide an RPE at the end of the session, while players allocated in the condition-48 were asked to provide an RPE at 48 h following the session. The same session structure and intensity was provided after 10 days and RPE collected inverting the conditions.

Training session

The training session consisted of a warm-up, interval training exercises and cool-down. A 20-min modified (exercises 7–10 were not performed due to cold environmental temperature) version of the FIFA 11+ injury prevention programme was used as a warm-up (Soligard et al. 2008). The interval training running consisted of 3 bouts of 4-min spaced by 3-min of passive recovery followed by 3 bouts of 2-min with 1-min of passive recovery. Interval running bouts were performed at the intensity of 90% HRpeak. A standardized 15-min cool-down was performed after the interval training consisting of 3 blocks of 5-min duration of static stretching, jogging and dynamic stretching for lower limbs.

Internal-WL

HRs were measured using a telemetric system (Polar Electo Oy, Kempele, Finland) and checked with Polar RS 400 SD. After every training session, HR data were downloaded on a portable personal computer using the specific software (Polar Pro-trainer Software, Polar Electo, Oy, Kempele, Finland) and analysed using the Excel software program (Microsoft Corporation, USA). The average session HR and two HR-based training load methods (Edwards's method and Banister TRIMP) (Banister 1991; Edwards 1992) were calculated to assess and compare the exercise intensity and load of the two conditions. The Edwards' method determines internal-WL by measuring the product of the accumulated training duration (minutes) of 5 HR zones by a coefficient relative to each zone (50–60% of HRpeak = 1, 60–70% of HRpeak = 2, 70–80% of HRpeak = 3, 80–90% of HRpeak = 4, 90–100% of HRpeak = 5) and then summating the results. The Banister training impulse (TRIMP) was determined with the following formula:

$$\text{Time duration} \cdot \text{HR reserve} \cdot 0.64 \cdot e^{1.92 \cdot \text{HR reserve}}$$

The HR reserve was calculated with the following formula:

$$[(\text{mean HR} - \text{HR at rest})/(\text{HRpeak} - -\text{HR at rest})].$$

External-WL

Although the RPE is a valid measure of internal-WL (individual exercise intensity), the external-WL was also assessed to compare between the two conditions. The training activities were measured in a sub-group of randomly selected players (n = 11) with a GPS System, (SPI-Pro X, unit mass: 76 g, size: 48 × 20 × 87 mm, GPSport, Canberra, Australia) sampling at 15 Hz with a 100 Hz accelerometer inside. The GPS system is considered a valid and reliable method to monitoring activities during team sports (Coutts & Duffield 2010; Duffield et al. 2010; Gray et al. 2010; Jennings et al. 2010; Aughey 2011). All GPS units were activated outdoor 20 min before the start of the activity to detect signal from satellites, and then placed in a back pocket positioned between shoulder blades of the player. The average of eight satellites was found to transmit data of positioning during all sessions. All data were downloaded and analysed on a personal computer with SPI Ezy software and Team AMS software (R2 2102, GPSport, Canberra, Australia). Total distance and high-

intensity running distance (distance covered at speeds >15 km · h^{-1}) (Bangsbo et al. 2008) were used for the comparison of the external-WL of the sessions.

Statistical analysis

Data are presented as mean ± standard deviation (mean ± SD).

Study 1

The individual data of each player collected in the various training sessions were averaged for the analysis. From these values, the mean value and the mean difference between RPE0 and RPE48 with the corresponding 90% confidence intervals (90% CI) were calculated. The Bland & Altman plot and 95% limits of agreement (95% LOA, as the mean difference ± 1.96 SD of the differences) was used to compare RPE0 and RPE48 to evaluate response shift and recall bias. In addition, a plot of identity was used to represent the theoretical relationship of equality between the two variables. For a better interpretation of the results, the mean difference between RPE0 and RPE48 was compared to the smallest worthwhile change (SWC). The SWC was calculated using a distribution-based method, that is as a proportion of the effect size, which represents the magnitude of change in a variable as a function of the between-subjects standard deviation of the investigated population (i.e., 0.2 times the between-subject SD) (de Vet et al. 2006). Cohen's effect sizes (ES) were calculated as the mean difference between RPE48 and RPE0 divided by the pooled SD and 90% CIs calculated using the spreadsheet provided by Hopkins (www.sportsci.org). The following criteria was used to interpret the degree of effect size: trivial, <0.2; small, 0.2–0.6; moderate, 0.6–1.2; or large, >1.2. SigmaPlot™ 12 software (SigmaPlot™, Systat Software Inc., California, USA) was used to create Bland & Altman Plot.

Study 2

The main differences and 90% CIs and paired *T*-test were used to compared the RPE, Edward's method, Banister TRIMP, total distance and high intensity distance between the two conditions (condition-0 and condition-48). Cohen's effect sizes (ES) with corresponding 90% CIs were calculated and interpreted as in study 1. The level of statistical significance was set at $P < 0.05$. Statistical analysis was performed with the software package SPSS 19 (IBM SPSS Statistics for Windows, Version 19.0. Armonk, NY: IBM Corp.).

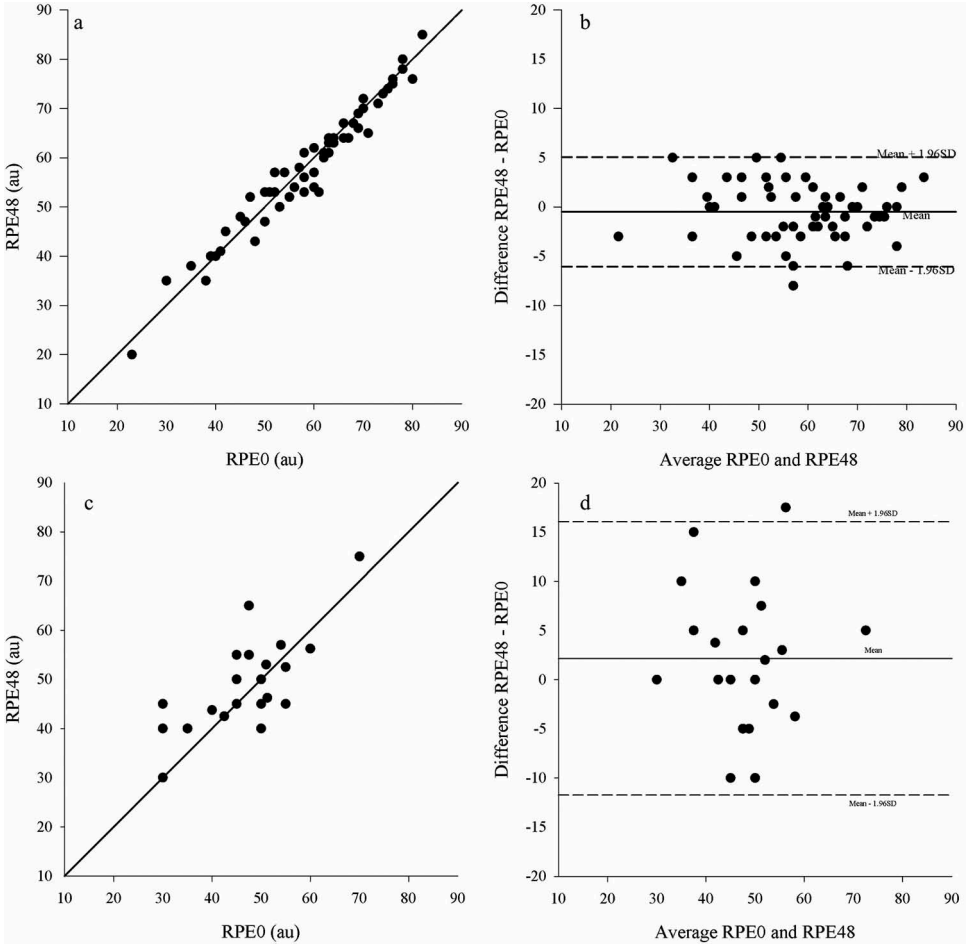

Figure 2. Response shift after matches: (a) identity plot and (b) Bland & Altman plot. Response shift after training sessions: (c) identity plot and (d) Bland & Altman plot.

Table 1. Study 1.

Variable (cases-participants)	RPE0	RPE48	Mean difference	95% LOA	ES	Descriptor
R-Shift-M (n = 457–58)	59.2 ± 13.2	58.7 ± 12.9	−0.5 (−1.1 to 0.1)	−6.0 to 5.1	−0.05 (−0.10 to 0.00)	Trivial
R-Bias-T (n = 177–51)	46.0 ± 11.6	47.1 ± 12.8	1.1 (0.5–1.8)	−4.4 to 6.6	0.09 (0.03–0.15)	Trivial
R-Shift-T (n = 42–22)	46.8 ± 9.8	48.9 ± 9.5	2.2 (−0.4 to 4.8)	−11.7 to 16.1	0.23 (−0.05 to 0.51)	Small
R-Bias-M (n = 82–34)	55.7 ± 17.7	57.1 ± 18.5	1.4 (0.2–2.6)	−6.9 to 9.7	0.08 (0.01–0.15)	Trivial

Response shift (R-Shift) and recall bias (R-Bias) after matches (M) and training sessions (T). R-Shift-M, response shift after matches, R-Bias-T, recall bias after training, R-Shift-T, response shift after training; R-Bias-M, recall bias after matches; RPE0, rating of perceived exertion measured at the end of the session; RPE48, rating of perceived exertion measured after 48 h; mean differences (bias) between RPE0 vs. RPE48 and 90% confidence intervals (90% CI); 95% LOA, 95% limits of agreement; ES, effect size and 90% CI.

Table 2. Study 2.

	Condition-0	Condition-48	T-test (P-level)	Mean difference (90% CI)	ES (90% CI)	Descriptor
Internal WL (no. 21)						
RPE (au)	53 ± 15	54 ± 12	0.72	0.6 (−2.2 to 3.3)	0.04 (−0.2 to 0.2)	Trivial
Heart rate mean (%)	71 ± 3	72 ± 3	0.36	−0.3 (−0.3 to 1.0)	0.12 (−0.1 to 0.3)	Trivial
Edward's WL (au)	151 ± 20	154 ± 11	0.36	2.6 (−2.3 to 7.6)	0.16 (−0.1 to 0.5)	Trivial
Bannister WL (au)	67 ± 13	68 ± 12	0.46	1.1 (−1.4 to 3.5)	0.09 (−0.1 to 0.3)	Trivial
External WL (no. 11)						
Total distance (m)	6091 ± 409	6044 ± 217	0.70	−47 (−261 to 168)	−0.15 (−0.8 to 0.5)	Trivial
High intensity distance (m)	691 ± 446	795 ± 372	0.15	104 (−17 to 224)	0.26 (0.0–0.6)	Small

Internal and external training loads in condition-0 and condition-48.
TL: training load; RPE: rating of perceived exertion; condition-0, RPE measured after the training; condition-48, RPE measured after 48 h; paired T-test; mean differences and 90% CI, 90% confidence intervals; ES, effect size and 90% CI.

Results

Study 1

Identity plots and Bland & Altman plots for Res-S-MTC, Res-S-TRN are presented in Figure 2. In the first part of the season a total of 457 cases of paired RPE (RPE0 and RPE48) from 58 players were collected to examine Res-S-MTC from 8 ± 4 official individual matches. In the second part of season, 304 cases from individual paired data (RPE0 and RPE48) were collected to examine the recall bias and response shift. In the second part of the season, the number and proportion of times (expressed as percentage) the players remembered the previous RPE values were 259 (85%) and 45 (15%) for correct and incorrect recall, respectively. Among the 259 cases in which players correctly recalled the previous RPE, 177 cases from 51 players corresponded to training sessions (Rec-B-TRN) and 82 cases from 34 players corresponded to matches (Rec-B-MTC). Among the 45 cases in which players were not able to recall the previous RPE, 42 cases from 22 players were from training sessions (Res-S-TRN) and only 3 from 3 players corresponded to matches.

The mean RPE0, RPE48, mean difference (90% CI) and 95% LOA, ES (90% CI) and their descriptor for Res-S-MTC, Rec-B-TRN, Res-S-TRN ad Rec-B-MTC are presented in Table 1. Rec-B-TRN and Rec-B-MTC showed significant mean difference between RPE0 and RPE48 but trivial effect sizes. The SWC from the overall RPE collected in the study was ±3.8 AU which was greater than the mean differences in all the variables.

Study 2

The mean internal- and external-WL values found in condition-0 and condition-48, mean difference (90% CI), ES (90% CI) and descriptors are presented in Table 2. No significant differences ($P > 0.05$) and trivial effects sizes were found for both internal- and external-WL indicators.

Discussion

The present studies showed that the RPE can be collected after 48 h to calculate the session-RPE without being affected by either response shift or recall bias. Specifically, we did not find response shift after both matches and training sessions. We found a recall bias with trivial effects size and lower values compared to the SWC, suggesting the players in general are able to remember the RPE given (or with irrelevant difference) when asked within 48 h. Therefore, recall bias should not have influenced the response shift assessment.

Given that after the match players often have a day without training or team commitments, the RPE can effectively be asked 48 h after the match. However, we cannot confirm that players would be able to recall the rating if left for longer periods or if a shorter period (i.e., 24 h) would influence the retrospective rating as these periods were not examined in the present study.

Study 1

Response shift is a change in the meaning of a self-evaluation of the construct of interest in longitudinal assessments (Schwartz & Sprangers 1999; A. Sprangers & Schwartz 1999). This change can be influenced by the same intervention evaluated in the context of soccer, such as the match or the training. For example, during the day after a match players may reflect on their performance and the resulting interpretation (emotional or technical) may affect the retrospective RPE value. However, the results of the study 1 showed that RPE given either immediately and 48 h after a match or a training session were not significantly different. More importantly, the magnitude of these changes were not practically meaningful, as they were lower than the SWC. Indeed, the identity plot (Figure 2(a)) showed that the RPE0 vs. RPE48 were very close to the line of equality. Similarly, the Bland & Altman plot (Figure 2(b)) also showed a good agreement between two measurements.

In the second part of study 1, some players answered that they remember their previous rating, however, when the two values were compared we found significant mean differences but trivial effect size. Therefore, players could have reported similar rating in the first part of study 1 just because they remembered it and this might be considered as a flaw in the "then-test" and a limit in the study 1. However, other than being an established method (Barclay-Goddard et al. 2009), the instructions should have limited this issue as the players (coming from three different teams) were specifically asked to report the RPE they experienced without considering the value previously given (in case they remembered it). To further control for residual effects of the previously given value, we also asked the players whether they remembered, the previous RPE. The response shift was then examined in the samples where the players could not recall their initial rating. However, we found no response shift (Figure 2(c,d)) with very small mean differences between ratings that were less than the SWC (i.e., 2.2 on a 100 point scale with a SWC of 3.8 AU).

Interestingly, the Bland and Altman plot corresponding to the matches showed lower LOA compared to the training sessions. This may be due to the high (supposed) level of emotional stress experienced by athletes during competitions (Polman et al. 2007; Nédélec et al. 2015) and the importance of the event resulting in strong anchoring of perception, which may improve the recall accuracy.

Recall bias can occur whenever self-report retrospective information are required from participants (Raphael 1987). This can be due to either memory failure or simply because of inaccurate recollection. In this study, the recall bias was considered as an inaccurate recollection of the prior rating, which would manifest in a RPE value recalled to be higher or lower than 48 h earlier. However, while the present results showed significant differences in the recalled RPE values with those taken following the match, the magnitude of the difference between these values were trivial and therefore excluded the presence of recall bias in this setting.

Study 2

Despite result of study 1, we could not exclude a residual effect of the previous RPE value (i.e., RPE0) and for this reason we also designed the second study (i.e., study 2) to further examine the response shift using an experimental approach. Indeed, another group of players were randomized to the two conditions using a crossover design to control for any possible effect of previous RPE memory. In addition, since a relationship between internal-WLs and RPE in soccer activity has been shown in various studies (Impellizzeri et al. 2004; Coutts et al. 2009), we also imposed on the athletes the same load using two standardized training sessions, which were developed in order to induce a similar internal-WL. However, we did not observe a response shift providing additional support for the results observed in study 1.

Limitations

A moderate rating accuracy can influence the individual calculation of session-RPE. Based on the analysis of the Bland & Altman plot, for some players, the inaccuracy or inconsistency of the rating may give slightly different values. For example, in some players we found differences of ~10 points in the RPE0 compare to RPE48 after training sessions. This potential risk should be taken into consideration when asking the rating after 48 h especially after training sessions. In addition, response shift was examined 48 h after a single session however sometimes players are submitted to multiple session daily and this may cause a greater difficulty in the retrospective assessment.

Conclusions

To the best of our knowledge, this is the first study investigating response shift and recall bias in RPE in soccer players. We have demonstrated that there is no systematic response shift and trivial recall bias for both match and training. Therefore, the results of the present study suggest that the collection of RPE 48 h after soccer activity is acceptable (especially after matches).

Practical applications

The present findings show that a delayed recall of session-RPE value can be used when single or groups of players do not want to give the rating after the match (e.g., players are not cooperative due to substitution or negative score of the match, etc.) or if the data are lost. However, we do not suggest that players are asked to provide a RPE 48 h after the matches or training as standard practice. Rather, we recommended that this approach is only used in specific situations, when it is impractical to record session-RPE soon after matches of training.

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Disclosure statement

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