Using differential ratings of perceived exertion to assess agreement between coach and player perceptions of soccer training intensity: An exploratory investigation

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Full title Using differential ratings of perceived exertion to explore agreement between coach and player perceptions of soccer training intensity: an exploratory investigation

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Abstract

We aimed to assess coach-player agreement of subjective soccer training loads via differential ratings of perceived exertion (dRPE). The coach initially underwent quantifiable familiarisation (blackness test) with the Borg CR100 scale. Data were collected from 16 semi-professional soccer players across seven consecutive training sessions. For the measurement of subjective training load, the coach and players provided dRPE (CR100) for legs (RPE-L), breathlessness (RPE-B) and technical exertion (RPE-T). Coach prescribed dRPE were recorded prior to training, with coach observed and player reported dRPE collected post training. Statistical equivalence bounds for agreement between coach (prescribed and observed) and player reported dRPE scores were 4 arbitrary units on the CR100 and we used a probability outcome of likely (≥75%) to infer realistic equivalence. Following three familiarisation sessions, the coach improved their blackness test score from 39% to 83%. Coach observed and player reported RPE-T scores were likely equivalent, with all other comparisons not realistically equivalent. Since training prescription is coach led, our data highlight the importance of accurate internal load measurement and feedback in soccer. The improved accuracy and precision of coach intensity estimation after three attempts at the blackness test suggests that this method could be worthwhile to researchers and practitioners employing dRPE.

Keywords: *Ratings of perceived exertion; soccer; training monitoring; internal load; training prescription; equivalence testing.*

Introduction

In soccer, time constraints between competitive fixtures can lead to technical and tactical training often being prioritised over physical training (Morgans et al., 2014). Coaches must be able to accurately prescribe training loads in the context of the desired outcomes as incongruence between coach prescribed and player reported loads could expose players to training maladaptation (Scantlebury et al., 2018). Research investigating differences between coach prescribed and player reported internal training loads, as reported by a session ratings of perceived exertion (sRPE), is equivocal as coaches both underestimate and overestimate sRPE during team sport training (Brink et al., 2014; Kraft et al., 2018; Doeven et al., 2017; Scantlebury et al., 2018). Such differences are important as consistent coach underestimation of player internal training load could result in negative consequences of training such as overreaching, illness or injury; whereas, coach overestimation of player internal training load could result in the under preparation of players for the demands of match-play (Brink and Frencken, 2018).

In previous work (Brink et al., 2014; Kraft et al., 2018; Doeven et al., 2017; Scantlebury et al., 2018), training load was represented by the sRPE score which may not be sensitive to the stochastic demands of soccer training (Weston, 2013). Alternatively, differential ratings of perceived exertion (dRPE) - separate exertional scores for breathlessness (RPE-B), legs (RPE-L) and technical (RPE-T) - provide a more detailed quantification of player internal training load (Weston et al., 2015; McLaren et al., 2017; Barrett et al., 2018) and therefore have potential to advance our understanding of agreement between coach prescribed and player reported training loads. For example, RPE-L may better quantify the greater peripheral load imposed on players during small-sided games due to increased frequency of high-intensity accelerations and decelerations (Olthof et al., 2018). Conversely, RPE-B would quantify the greater central loading imposed during large sided games that are frequently used in training to elicit greater high speed running distances and more closely replicate match demands (Clemente et al., 2018). Ratings of perceived technical exertion could also add value to coaches during technical and tactical sessions by permitting the quantification of task difficulty (Barrett et al., 2018; Coyne et al., 2018). As such, dRPE have potential to inform on distinct physiological, neuromuscular/ musculoskeletal and cognitive loading pathways that will enable a more detailed understanding of internal training load than the use of a global sRPE score. Therefore, an examination of whether dRPE enhance our understanding of the agreement between coach prescribed and player reported training loads during soccer training is justifiable.

Methodological limitations have hindered the internal validity of previous literature investigating agreement between coach prescribed and player reported internal training load. Previous work (Brink et al., 2014; Kraft et al., 2018; Doeven et al., 2017; Scantlebury et al., 2018) did not quantify the extent of player and coach familiarisation with RPE scoring. Although this problem has long been acknowledged in sports science research (Winter, 2005), recent work within psychology has provided a robust framework for undertaking and quantifying RPE familiarisation (Borg, 2013; Borg and Love, 2017). Additionally, tests of standardised mean differences between coach and player RPE scores are commonly used, yet equivalence testing holds potential for advancing measurement research as it provides evidence of equivalence, rather than no evidence of difference (Dixon et al. 2018). Here, the confidence interval for the mean difference is assessed against a pre-determined 'region of equivalence' and if the confidence interval excludes the lower and upper equivalence bounds, equivalence is assumed (Lakens et al., 2018). Therefore, we performed an exploratory investigation to assess agreement, via equivalence testing, of coach prescribed and coach observed dRPE with player reported dRPE during regular soccer training. A secondary aim was to quantify familiarisation when introducing the coach to exertional measurement procedures.

Methods

Participants

Sixteen semi-professional soccer players (age: 23.7 ± 4.5 years; stature: 1.79 ± 0.11 m; body mass: 82.7 ± 7.2 kg; Yo-Yo Intermittent Recovery Test Level 1 distance: 1715 ± 337 m) from one soccer team completed seven consecutive training sessions during a six-week in-season period at the end of the 2017-2018 season. The teams coach also participated in this study. The coach had over 20 years' experience in professional and semi-professional soccer, holding a UEFA A license for five years. All participants completed written informed consent and appropriate ethical approval was granted from the ethics committee of the School of Social Sciences, Humanities and Law at Teesside University prior to data collection in accordance with the Declaration of Helsinki.

Design

Using an observational research design, data were collected during seven on-field training sessions over a six-week in-season training period. The coach was instructed to carry out training planning as normal, with no interference from the researchers. The soccer team typically completed 1-2 training sessions per week, structured around 2-3 competitive fixtures per week due to a fixture back-log. Throughout the observational period, the coach provided prescribed dRPE before training. Up to 30 minutes after training (Foster, 2001a), the coach and players provided their observed and reported dRPE, respectively. During dRPE collection, players and the coach provided exertion scores for RPE-L, RPE-B and RPE-T using the Borg CR100 scale (Borg and Kaijser, 2006) . Training data was only analysed for players completing the whole session; however, all training outside of squad training was monitored through individual training diaries with consistency of players' habitual training patterns observed.

Procedures

Familiarisation with dRPE

Despite the players using the CR100 scale as part of their internal training load monitoring procedures for four full seasons, they still underwent a tutorial presentation on the CR100 which explained each of the verbal descriptors (verbal anchors), the numbers and sensations each represented. The coach also attended this tutorial. Further, a blackness test was provided to the coach as a learning tool for the CR100 scale (Borg, 2013; Borg and Love, 2017). Here, the coach completed the blackness test on three occasions with two days between each test. The test consisted of nine pictures with filled squares differing in blackness using the nine different grey pre-set colours in Microsoft PowerPoint (5%, 15%, 25%, 35%, 50%, 65%, 75%, 85%, 95% blackness). Each image was centred and presented twice in a randomised order with blanks between each picture. Each picture was shown for 10 seconds. The levels of blackness are closely linked to the verbal anchors on the CR100 scale so the coach was asked to estimate how strong they experienced blackness on each image according to the CR100 (e.g. the 50% blackness square would represent the 'Strong' verbal anchor on the CR100). Each answer was scored for accuracy (i.e., correct/ incorrect) and level of precision (i.e., how many arbitrary units [au] away from the correct verbal anchor).

Training Sessions

Prior to each training session, the coach was asked to provide their training plan and then subsequently prescribe session intensity using dRPE. A specifically designed data collection sheet, complete with a numerically blinded CR100 scale, afforded the coach the option to report anticipated positional differences in prescribed load, although none were reported. Playing positions were categorised as central defenders, wide defenders, central midfielders, wide midfielders and strikers (Barrett et al., 2018). After training, the coach provided their observed dRPE scores on the aforementioned data collection sheet, based on their observation of the players during training. The coach was told to provide their scores from the observed training session only and not to re-evaluate their prescribed scores. Players who took part in all of the training session evaluated session intensity via dRPE as per their normal training procedures. Player dRPE for each training session were recorded via a bespoke computer application running on a 7" tablet (Iconia One 8, Taipei, Taiwan: Acer Inc.). Ratings were provided independently and confidentially. As a means of anonymising the data, each participant was required to log into the application via a unique identification number. After logging in, the applications interface presented players with a numerically blinded version of the CR100 scale, labelled only with the idiomatic English verbal anchors. Once players recorded their scores using the touch-screen interface, the application software uploaded each score as a number value to a cloud-based spreadsheet.

Statistical Analysis

The present study adopted a two-step approach involving estimation and agreement assessment analyses, with the summary effects for the coach and players perceptions during the examined period presented as mean ± standard deviation (SD). Data from Weston et al., (2015) informed the realistic difference value deemed of practical relevance for estimation and agreement assessment analyses, respectively (Cook et al., 2018). Specifically, the magnitude of differences were interpreted against a threshold of 10% of the dRPE scores (4 arbitrary units [au] for all dRPE) for estimation analyses, whereas the equivalence region ranged from +2 au to -2 au (i.e., 4 au) to determine agreement. Using an alternative-frequentist method to guide interpretations, the probability of any substantial difference or realistic equivalence relative to the predefined target values was interpreted using the following scale: <0.5%, most unlikely; 0.5–5%, very unlikely; 5–25%, unlikely; 25–75%, possibly; 75–95%, likely; 95-99.5%, very likely; >99.5%, most likely (Batterham and Hopkins, 2006). Paired t-tests quantified differences between coach dRPE scores (prescribed and observed). Mixed linear modelling estimated differences between player reported dRPE scores (RPE-B, RPE-L, RPE-T), with the final models including dRPE type as a fixed effect, player identity as a random effect, plus a random intercept to account for the repeated training sessions within players. Two one-sided tests (TOST) determined agreement between coach (prescribed, observed) and player reported dRPE scores as per recommendations from Dixon et al. (2018). Data were analysed using the dependent samples (equivalence bounds based on raw scores) and one sample (equivalence bounds based on raw scores) spreadsheets (Lakens, 2017) for coach prescribed and observed dRPE agreement, and coach prescribed and observed dRPE and player reported dRPE, respectively. The coach mean dRPE score across the seven training sessions represented the value to test against, with the players mean dRPE scores derived from the mixed linear model used for the comparison and the total number of training sessions (n=81) minus 1 representing our degrees of freedom (Bakdash and Marusich, 2017). While visual inspection is the criterion used to determine statistical equivalence based on whether the magnitude of uncertainty around the mean effect does not exceed the lower and upper equivalence bounds (Lakens et al., 2018), we assessed equivalence on a continuous scale to avoid test interpretation via the dichotomy of null hypothesis significance testing (Rothman, 2016). This was achieved via conversion of t-statistics for both one-sided tests to a probability (via the t-distribution) and then interpreted using the aforementioned scale, with equivalence indicated by the lower probability (Dixon et al., 2018; Kyprianou et al., 2019). Uncertainty in the point estimates for the mean effects is presented as 90% confidence intervals. Statistical analyses were performed using Microsoft Excel (Microsoft Corporation, USA) and IBM Statistical Package for the Social Sciences (SPSS) Statistics v.24 (IBM Corp, New York, USA).

Results

RPE Familiarisation

On the initial blackness test, the coach answered 39% questions correctly with a level precision (mean ± SD) of 6.9 ± 6.9 au. In subsequent sessions, the coach answered 78% and 83% correctly with a level of precision of 2.8 ± 5.5 au and 1.4 ± 3.3 au in sessions two and three, respectively.

Coach and Player dRPE scores

The dRPE scores from each training session for the players and the coach are presented in Table 1. Pairwise comparisons of the coach prescribed and observed dRPE showed substantially higher prescribed RPE-T than prescribed RPE-B (11 au; 90% confidence interval 1 to 22 au) and higher observed RPE-L compared to observed RPE-B (8 au; 0 to 15 au). All other comparisons were not substantial. Mixed linear modelling of the players' reported dRPE revealed no substantial differences between scores, with differences ranging from -2.5 au (-8.1 to 3.1 au) to -0.3 au (-5.6 to 5.0 au).

Coach and Player dRPE agreement

Results of the equivalence tests between coach prescribed and observed dRPE scores with those scores reported by the players are presented in Figure 1. Evidence for agreement, as indicated by a threshold of likely equivalent, was observed only between coach observed and player reported RPE-T scores. All other coach and player dRPE comparisons were deemed not realistically equivalent. Equivalence testing of the coach prescribed and observed dRPE showed unlikely agreement for RPE-B (mean difference 5 au; 90% confidence interval -15 to 5 au) and RPE-L (2 au; -12 to 8 au), and very unlikely agreement for RPE-T (-12 au; -21 to -2 au).

Discussion

Prior research investigating differences between coach and player perception of session intensity is equivocal. However, training load was represented by sRPE, which may lack sensitivity. Differential ratings of perceived exertion (dRPE) can provide a more sensitive appraisal of player subjective training loads and may therefore advance our understanding of coach-player agreement. Using dRPE as the measure of training load, the main finding of our exploratory investigation was evidence for realistic agreement only between coach observed and player reported RPE-T scores. Such differentiation is not possible using sRPE and therefore suggests dRPE could be a valuable addition to training load prescription and monitoring procedures in soccer. Additionally, the present study provides novel information relating to RPE familiarisation, with results showing the coach to have a better understanding of intensity estimation after three educational sessions. This finding highlights the importance of a quantifiable familiarisation period when using exertional scoring.

This is the first study to provide some evidence for equivalence between coach observed and player reported technical exertion in soccer training. In the context of training load prescription and monitoring, this is an important finding since having a greater understanding of a soccer player's response to training can help coaches and practitioners prescribe appropriate subsequent training sessions (Barrett et al., 2018). Notwithstanding the findings emerging from the analyses of technical exertion scores, coach observed and player reported physical exertion (RPE-B, RPE-L) scores were unlikely to be realistically equivalent. Likewise, this was apparent both for coach prescribed and observed scores. As coaches are mostly responsible for planning soccer training (Weston, 2018), differences in the amount of load they prescribed and observe with what the players actually report could have substantial practical implications. For example, consistent coach overestimation or underestimation could place players at risk of the negative consequences of training that could result in either absence (e.g., illness, injury) or being underprepared. In the context of dRPE, these negative training consequences could be overreaching and illness (RPE-B), mechanical overload (RPE-L) or psychological stress/ anxiety (RPE-T).

Our findings suggest the coach was able to interpret player technical and tactical external cues (e.g., skill execution or tactical positioning) better than physical cues (e.g., sweating and body language) (Robertson and Noble, 1997). Indeed, Kraft and colleagues (2018) suggested that coaches find it difficult to interpret external cues to evaluate sRPE of players during team sport training whereas the players had internal and external cues to draw upon. This highlights the potential usefulness of dRPE in training load prescription and monitoring procedures as it provides coaches and players with the opportunity to focus on specific aspects of exertion (e.g., physiological, biomechanical, technical).

Disagreement between coach prescribed and player reported dRPE may be unsurprising as we were evaluating two different cognitive function paradigms, estimation (evaluation) and production (prescription) (Groslambert and Mahon, 2006). These paradigms place different demands upon the three effort continua (perceptual/psychological, physiological and performance/situational) (Easton and Parfitt, 2006) with memory of exercise experience most relevant for production and interpretation of current stimulation most relevant for estimation (Groslambert and Mahon, 2006). We believe our findings support this hypothesis as probability for equivalence of coach-player dRPE scores was higher (unlikely to likely) for the estimation paradigm than for the production paradigm (most unlikely to possibly). It is also plausible that disagreements between coach prescribed and player reported dRPE can be explained by psychological mechanisms such as changes in teloanticipation or the RPE template (Abbiss et al., 2015; St Clair Gibson et al., 2006).

While previous studies have reported dRPE scores quantify the distinct sensory inputs in team sports (Weston et al., 2015; McLaren et al., 2017), we were unable to report any substantial differences between the players' dRPE (e.g., RPE-B vs RPE-L vs RPE-T) despite between-session differences. This could be due to two reasons. Firstly, given the exploratory nature of our study, the sample of training sessions was not large nor diverse enough to robustly define this effect, thereby rendering the width of the uncertainty around the estimated mean differences prone to sampling error. Or, secondly, given the mixture of physical, technical and tactical training sessions our data reflect of the absence of a dominant sensory input (e.g., no dedicated physical training sessions, as per McLaren et al., 2017). Comparing our data to previous literature is difficult due to the different methodological approaches, yet previous research (Brink et al., 2014; Kraft et al., 2018; Doeven et al., 2017; Scantlebury et al., 2018) has shown that coach prescribed and observed sRPE scores differ from player reported sRPE; however, by differentiating ratings of perceived exertion our study found some evidence for agreement between coach observed and player reported technical exertion. That aside, our data were in line with previous research showing the agreement between coaches' and players' perception of training intensity in team sports to be weaker than in individual sports (Foster et al., 2001b; Wallace et al., 2009). This might be due to team sport training being carried out in groups rather than individually, making it extremely difficult for coaches to plan and control exercise intensity (Brink et al., 2014).

Recently, the poor education of players has been acknowledged as a limiting factor when using subjective load monitoring procedures (Coyne et al., 2018). Our study therefore represents a timely investigation into the impact of a thorough familiarisation process on an individual's ability to understand intensity estimation, achieved via the 'blackness test'. Not only did the coach improve the percentage of questions answered correctly, but their precision improved from session one to session three. Such improvements in a short period of time highlight the importance of a quantifiable familiarisation period when using exertional scoring. Given the practicality of the 'blackness test', we urge researchers to go beyond the usual statement of "participants were familiarised with the procedures" (Winter, 2005) and provide information and, ideally data to support the familiarisation process.

Our investigation is not without its limitations; most notably this was an exploratory study and given the small sample of training sessions there is substantial uncertainty in our estimates of coach and player agreement and also our comparisons between the separate dRPE scores. Nonetheless, even with a low number of training sessions we are able to report some evidence for realistic agreement between coach observed and player reported RPE-T.

Therefore, our exploratory investigation advances knowledge in this area. It is important to acknowledge, however, that we declared effects relevant if the outcome probability emerged as likely (≥ 75%) and this has recently been described as weak evidence (Sainani et al., 2019). While our confidence interval for the difference between coach observed and player reported RPE-T contains more coverage for equivalence than non-equivalence, this finding may need to be interpreted cautiously. Indeed, research using a larger sample of players and training sessions is needed to replicate this finding, examine whether coach-player physical dRPE disagreement holds, and provide a meaningful examination of the effect of session type (e.g., physical, technical, tactical) on coach-player intensity agreement. Due to a low number of training sessions, we did not differentiate our analysis by playing position; however, this limitation is countered by the absence of any clear coach planned between-positions differences in prescribed training load. We also acknowledge that the blackness test for RPE familiarisation should have been applied to the players but, unfortunately, this was not possible due to the club's time constraints. While we are unable to provide data to support the players familiarisation, we have provided detail of our procedures (i.e., a tutorial presentation) which is the exception rather than norm in the applied sports science literature. Finally, as the players were semi-professional, the team employed only one coach. In professional soccer, multiple coaches are likely to be involved in the prescription of player training loads, although it may still be common for one coach to have the final say for overall load prescription.

Conclusions

As training prescription in soccer is largely a coach determined practice, it is important to understand the extent to which the players' reported internal training load corresponds to that planned by the coach. Our exploratory investigation shows for the first time, albeit in a group of semi-professional soccer across a small number of training sessions, that some evidence for realistic agreement between coach and players was only seen for the post-training evaluation of technical exertion. Results of coach familiarisation with intensity estimation procedures show that familiarisation cannot be assumed without training. Future research should advance the current study by replicating our research design over a longer period and on a larger scale.

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Table 1. Coach and player differential ratings of perceived exertion scores during the seven training sessions (mean ± SD).

	Coach Prescribed dRPE			Coach Observed dRPE			Players' Reported dRPE		
Session	RPE-B	RPE-L	RPE-T	RPE-B	RPE-L	RPE-T	RPE-B	RPE-L	RPE-T
1. Physical and technical (small sided games)	35	50	50	50	70	35	58 ± 10	57 ± 10	56 ± 11
2. Tactical and technical (defensive shape and small sided games)	35	50	50	35	50	50	53 ± 13	58 ± 14	52.2 ± 6.3
3. Tactical and technical (offensive plays and passing drills)	50	50	70	50	50	50	23 ± 11	22.0 ± 6.9	45 ± 10
4. Tactical only (set piece drills)	35	35	50	13	13	25	26.5 ± 5.9	25.7 ± 8.3	33.3 ± 3.7
5. Tactical only (role play)	25	25	50	13	13	25	14.9 ± 4.5	15.1 ± 4.3	27.4 ± 4.9
6. Physical and technical/tactical (medium sided games)	45	50	55	50	50	60	45 ± 11	41.6 ± 6.5	41 ± 10
7. Physical and technical/tactical (medium sided games)	70	70	50	50	70	50	57 ± 25	60 ± 17	43 ± 10
Mean	42 ± 15	47 ± 14	53.6 ± 7.5*	37 ± 17	45 ± 24#	42 ± 14	40 ± 21	41 ± 20	43 ± 12

Abbreviations: SD – standard deviation; dRPE – differential ratings of perceived exertion; RPE-B – ratings of perceived exertion on breathlessness; RPE-L – ratings of perceived exertion on legs; RPE-T – ratings of perceived exertion on technical tasks.
** indicates coach prescribed RPE-T to be substantially higher than coach prescribed RPE-B; # indicates coach observed RPE-L to be substantially higher than coach observed RPE-B.*

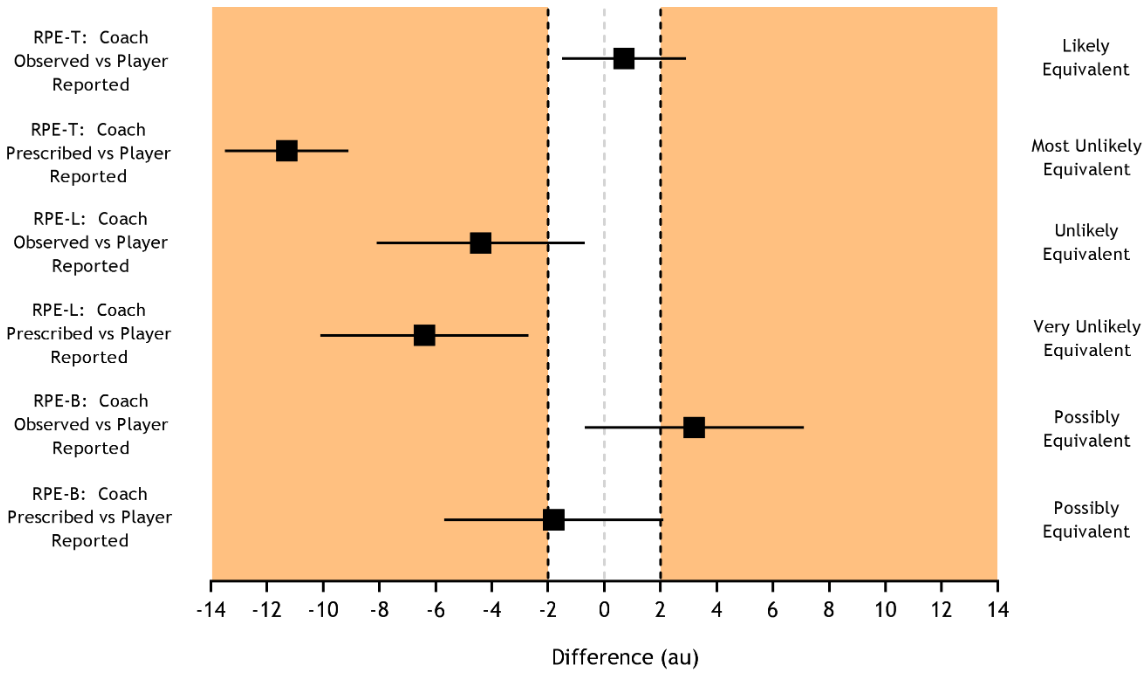

Figure 1. Mean difference (au) and uncertainty for the difference (90% confidence interval) between coach (prescribed and observed) and player reported differential RPE scores. The unshaded area represents our statistical equivalence region of 4 au (-2 au to 2 au). RPE-B (breathlessness); RPE-L (legs); RPE-T (technical).