

**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 ( $\geq 75\%$ ) 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.*

## 1 Introduction

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

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

35 Methodological limitations have hindered the internal validity of previous literature  
36 investigating agreement between coach prescribed and player reported internal training load.  
37 Previous work (Brink et al., 2014; Kraft et al., 2018; Doeven et al., 2017; Scantlebury et al.,  
38 2018) did not quantify the extent of player and coach familiarisation with RPE scoring.  
39 Although this problem has long been acknowledged in sports science research (Winter,  
40 2005), recent work within psychology has provided a robust framework for undertaking and  
41 quantifying RPE familiarisation (Borg, 2013; Borg and Love, 2017). Additionally, tests of  
42 standardised mean differences between coach and player RPE scores are commonly used, yet  
43 equivalence testing holds potential for advancing measurement research as it provides

44 evidence of equivalence, rather than no evidence of difference (Dixon et al. 2018). Here, the  
45 confidence interval for the mean difference is assessed against a pre-determined 'region of  
46 equivalence' and if the confidence interval excludes the lower and upper equivalence bounds,  
47 equivalence is assumed (Lakens et al., 2018). Therefore, we performed an exploratory  
48 investigation to assess agreement, via equivalence testing, of coach prescribed and coach  
49 observed dRPE with player reported dRPE during regular soccer training. A secondary aim  
50 was to quantify familiarisation when introducing the coach to exertional measurement  
51 procedures.

## 52 **Methods**

### 53 **Participants**

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

### 63 **Design**

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

### 76 **Procedures**

#### 77 **Familiarisation with dRPE**

78 Despite the players using the CR100 scale as part of their internal training load monitoring  
79 procedures for four full seasons, they still underwent a tutorial presentation on the CR100  
80 which explained each of the verbal descriptors (verbal anchors), the numbers and sensations  
81 each represented. The coach also attended this tutorial. Further, a blackness test was provided  
82 to the coach as a learning tool for the CR100 scale (Borg, 2013; Borg and Love, 2017). Here,  
83 the coach completed the blackness test on three occasions with two days between each test.  
84 The test consisted of nine pictures with filled squares differing in blackness using the nine

85 different grey pre-set colours in Microsoft PowerPoint (5%, 15%, 25%, 35%, 50%, 65%,  
86 75%, 85%, 95% blackness). Each image was centred and presented twice in a randomised  
87 order with blanks between each picture. Each picture was shown for 10 seconds. The levels  
88 of blackness are closely linked to the verbal anchors on the CR100 scale so the coach was  
89 asked to estimate how strong they experienced blackness on each image according to the  
90 CR100 (e.g. the 50% blackness square would represent the ‘Strong’ verbal anchor on the  
91 CR100). Each answer was scored for accuracy (i.e., correct/ incorrect) and level of precision  
92 (i.e., how many arbitrary units [au] away from the correct verbal anchor).

### 93 Training Sessions

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

### 112 Statistical Analysis

113 The present study adopted a two-step approach involving estimation and agreement  
114 assessment analyses, with the summary effects for the coach and players perceptions during  
115 the examined period presented as mean  $\pm$  standard deviation (SD). Data from Weston et al.,  
116 (2015) informed the realistic difference value deemed of practical relevance for estimation  
117 and agreement assessment analyses, respectively (Cook et al., 2018). Specifically, the  
118 magnitude of differences were interpreted against a threshold of 10% of the dRPE scores (4  
119 arbitrary units [au] for all dRPE) for estimation analyses, whereas the equivalence region  
120 ranged from +2 au to -2 au (i.e., 4 au) to determine agreement. Using an alternative-  
121 frequentist method to guide interpretations, the probability of any substantial difference or  
122 realistic equivalence relative to the predefined target values was interpreted using the  
123 following scale: <0.5%, most unlikely; 0.5–5%, very unlikely; 5–25%, unlikely; 25–75%,  
124 possibly; 75–95%, likely; 95–99.5%, very likely; >99.5%, most likely (Batterham and  
125 Hopkins, 2006). Paired t-tests quantified differences between coach dRPE scores (prescribed  
126 and observed). Mixed linear modelling estimated differences between player reported dRPE  
127 scores (RPE-B, RPE-L, RPE-T), with the final models including dRPE type as a fixed effect,

128 player identity as a random effect, plus a random intercept to account for the repeated training  
129 sessions within players. Two one-sided tests (TOST) determined agreement between coach  
130 (prescribed, observed) and player reported dRPE scores as per recommendations from Dixon  
131 et al. (2018). Data were analysed using the dependent samples (equivalence bounds based on  
132 raw scores) and one sample (equivalence bounds based on raw scores) spreadsheets (Lakens,  
133 2017) for coach prescribed and observed dRPE agreement, and coach prescribed and  
134 observed dRPE and player reported dRPE, respectively. The coach mean dRPE score across  
135 the seven training sessions represented the value to test against, with the players mean dRPE  
136 scores derived from the mixed linear model used for the comparison and the total number of  
137 training sessions ( $n=81$ ) minus 1 representing our degrees of freedom (Bakdash and  
138 Marusich, 2017). While visual inspection is the criterion used to determine statistical  
139 equivalence based on whether the magnitude of uncertainty around the mean effect does not  
140 exceed the lower and upper equivalence bounds (Lakens et al., 2018), we assessed  
141 equivalence on a continuous scale to avoid test interpretation via the dichotomy of null  
142 hypothesis significance testing (Rothman, 2016). This was achieved via conversion of t-  
143 statistics for both one-sided tests to a probability (via the t-distribution) and then interpreted  
144 using the aforementioned scale, with equivalence indicated by the lower probability (Dixon et  
145 al., 2018; Kyprianou et al., 2019). Uncertainty in the point estimates for the mean effects is  
146 presented as 90% confidence intervals. Statistical analyses were performed using Microsoft  
147 Excel (Microsoft Corporation, USA) and IBM Statistical Package for the Social Sciences  
148 (SPSS) Statistics v.24 (IBM Corp, New York, USA).

## 149 **Results**

### 150 RPE Familiarisation

151 On the initial blackness test, the coach answered 39% questions correctly with a level  
152 precision (mean  $\pm$  SD) of  $6.9 \pm 6.9$  au. In subsequent sessions, the coach answered 78% and  
153 83% correctly with a level of precision of  $2.8 \pm 5.5$  au and  $1.4 \pm 3.3$  au in sessions two and  
154 three, respectively.

### 155 Coach and Player dRPE scores

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

### 163 Coach and Player dRPE agreement

164 Results of the equivalence tests between coach prescribed and observed dRPE scores with  
165 those scores reported by the players are presented in Figure 1. Evidence for agreement, as  
166 indicated by a threshold of likely equivalent, was observed only between coach observed and  
167 player reported RPE-T scores. All other coach and player dRPE comparisons were deemed  
168 not realistically equivalent. Equivalence testing of the coach prescribed and observed dRPE

169 showed unlikely agreement for RPE-B (mean difference 5 au; 90% confidence interval -15 to  
170 5 au) and RPE-L (2 au; -12 to 8 au), and very unlikely agreement for RPE-T (-12 au; -21 to -2  
171 au).

## 172 **Discussion**

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

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

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

208 Disagreement between coach prescribed and player reported dRPE may be unsurprising as we  
209 were evaluating two different cognitive function paradigms, estimation (evaluation) and  
210 production (prescription) (Gros Lambert and Mahon, 2006). These paradigms place different



211 demands upon the three effort continua (perceptual/psychological, physiological and  
212 performance/situational) (Easton and Parfitt, 2006) with memory of exercise experience most  
213 relevant for production and interpretation of current stimulation most relevant for estimation  
214 (Gros Lambert and Mahon, 2006). We believe our findings support this hypothesis as  
215 probability for equivalence of coach-player dRPE scores was higher (unlikely to likely) for  
216 the estimation paradigm than for the production paradigm (most unlikely to possibly). It is  
217 also plausible that disagreements between coach prescribed and player reported dRPE can be  
218 explained by psychological mechanisms such as changes in teloanticipation or the RPE  
219 template (Abbiss et al., 2015; St Clair Gibson et al., 2006).

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

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

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

254 Therefore, our exploratory investigation advances knowledge in this area. It is important to  
255 acknowledge, however, that we declared effects relevant if the outcome probability emerged  
256 as likely ( $\geq 75\%$ ) and this has recently been described as weak evidence (Sainani et al.,  
257 2019). While our confidence interval for the difference between coach observed and player  
258 reported RPE-T contains more coverage for equivalence than non-equivalence, this finding  
259 may need to be interpreted cautiously. Indeed, research using a larger sample of players and  
260 training sessions is needed to replicate this finding, examine whether coach-player physical  
261 dRPE disagreement holds, and provide a meaningful examination of the effect of session type  
262 (e.g., physical, technical, tactical) on coach-player intensity agreement. Due to a low number  
263 of training sessions, we did not differentiate our analysis by playing position; however, this  
264 limitation is countered by the absence of any clear coach planned between-positions  
265 differences in prescribed training load. We also acknowledge that the blackness test for RPE  
266 familiarisation should have been applied to the players but, unfortunately, this was not  
267 possible due to the club's time constraints. While we are unable to provide data to support the  
268 players familiarisation, we have provided detail of our procedures (i.e., a tutorial  
269 presentation) which is the exception rather than norm in the applied sports science literature.  
270 Finally, as the players were semi-professional, the team employed only one coach. In  
271 professional soccer, multiple coaches are likely to be involved in the prescription of player  
272 training loads, although it may still be common for one coach to have the final say for overall  
273 load prescription.

## 274 **Conclusions**

275 As training prescription in soccer is largely a coach determined practice, it is important to  
276 understand the extent to which the players' reported internal training load corresponds to that  
277 planned by the coach. Our exploratory investigation shows for the first time, albeit in a group  
278 of semi-professional soccer across a small number of training sessions, that some evidence  
279 for realistic agreement between coach and players was only seen for the post-training  
280 evaluation of technical exertion. Results of coach familiarisation with intensity estimation  
281 procedures show that familiarisation cannot be assumed without training. Future research  
282 should advance the current study by replicating our research design over a longer period and  
283 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).**

Session	Coach Prescribed dRPE			Coach Observed dRPE			Players' Reported dRPE		
	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.*

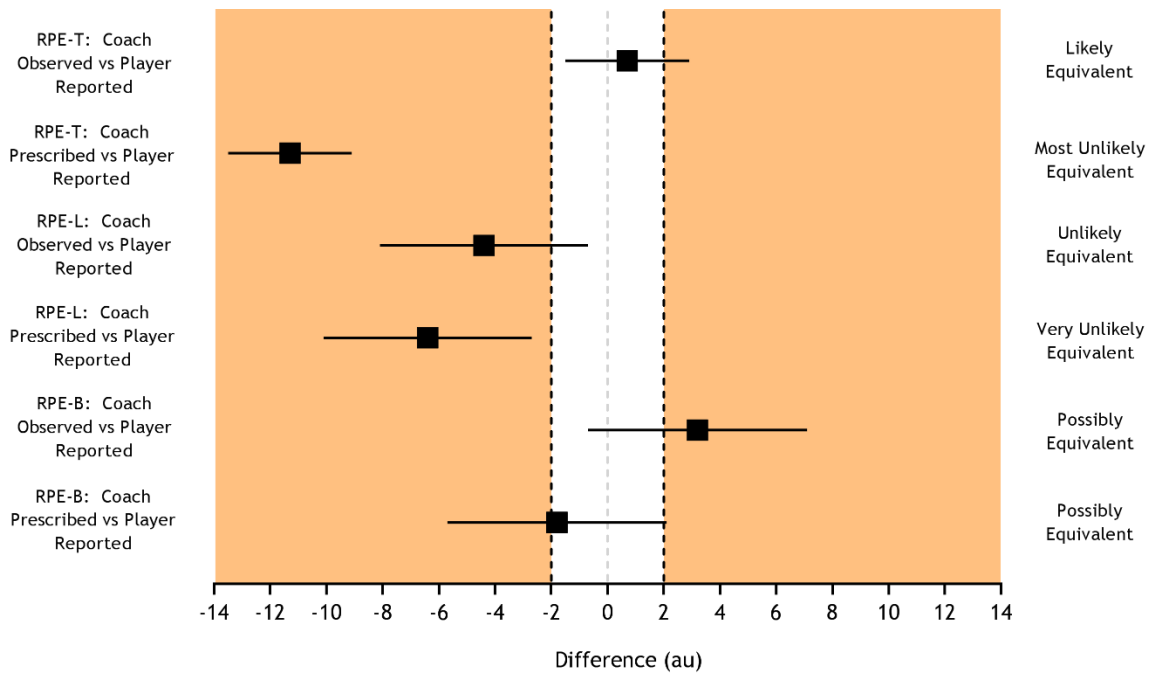


Figure 1. Mean difference (au) and uncertainty for the difference (90% confidence interval) between coach (prescribed and observed) and player reported differential RPE scores. The unshaded area represents our statistical equivalence region of 4 au (-2 au to 2 au). RPE-B (breathlessness); RPE-L (legs);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