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Differential Ratings of Perceived Exertion: Relationships With External Intensity and Load in Elite Men’s Football

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Purpose: To examine the utility of differential ratings of perceived exertion (dRPE) for monitoring internal intensity and load in association football. Methods: Data were collected from 2 elite senior male football teams during 1 season (N = 55). External intensity and load data (duration \times intensity) were collected during each training and match session using electronic performance and tracking systems. After each session, players rated their perceived breathlessness and leg-muscle exertion. Descriptive statistics were calculated to quantify how often players rated the 2 types of rating of perceived exertion differently (dRPEDIFF). In addition, the association between dRPEDIFF and external intensity and load was examined. First, the associations between single external variables and dRPEDIFF were analyzed using a mixed-effects logistic regression model. Second, the link between dRPEDIFF and session types with distinctive external profiles was examined using the Pearson chi-square test of independence. Results: On average, players rated their session perceived breathlessness and leg-muscle exertion differently in 22% of the sessions (range: 0%–64%). Confidence limits for the effect of single external variables on dRPEDIFF spanned across largely positive and negative values for all variables, indicating no conclusive findings. The analysis based on session type indicated that players differentiated more often in matches and intense training sessions, but there was no pattern in the direction of differentiation. Conclusions: The findings of this study provide no evidence supporting the utility of dRPE for monitoring internal intensity and load in football.

Keywords: training load, team sports, self-report, data, perceived effort

Monitoring training load is common practice in association football.¹,² Training load is the product of duration (DUR) and intensity and can be either external or internal.³ External load refers to the performance output of players during training and match sessions. It is quantified using electronic performance and tracking systems (EPTSs) such as global positioning system or other global navigation satellite systems. Internal load refers to the within-session psychophysiological stress experienced by players in response to the external load. The internal load determines the effect of training on players’ performance and health. However, precisely quantifying the internal load remains difficult in football.¹⁻⁴

A commonly used method is to ask players to rate their perceived exertion at the end of a session (sRPE).⁷,⁸ This rating should indicate the average internal intensity experienced throughout the session and can be multiplied by the DUR (in minutes) to reflect the internal load (sRPE-TL). Previous studies have shown that sRPE-TL is strongly associated with other internal intensity and load variables based on heart rate, blood lactate concentration, and muscle activity in different exercise activities.⁷ In team sports, positive dose–response associations have been observed between external load variables and sRPE-TL.⁹ These findings demonstrate the utility of sRPE-TL as an indicator of internal load. However, it is unlikely that complex constructs such as internal load can be attributed to a single indicator.

Differential ratings of perceived exertion (dRPE) have been proposed to provide more specific surrogates of the different psychophysiological stresses during exercise.¹⁰⁻¹² This method distinguishes between central respiratory and peripheral neuromuscular systems by asking for separate ratings for perceived breathlessness (sRPE-B) and leg-muscle exertion (sRPE-L). Previous research showed that players provide different ratings after resistance (ie, higher sRPE-L) and running-based aerobic endurance training (ie, higher sRPE-B).¹²,¹³ However, contrasting evidence exists regarding players’ ability to provide separate ratings after team-sport training and match sessions.¹²⁻¹⁶

To date, 2 studies have examined the relationship between external intensity or load variables and dRPE in team sport athletes. The first observed weak to moderate positive associations in Australian Football League match play, with sRPE-B being more strongly associated with variables reflecting high-speed and power demands compared with sRPE-B.¹⁵ The absence of strong associations in this study could be attributed to the lack of variation in external intensity and load in matches. A more recent study examined this relationship based on a sample of training and match sessions in elite youth football.¹⁶ In this study, sRPE-B-TL...
and sRPE-L-TL both showed similar small to large associations with external load variables. However, because external load is correlated to the DUR component in both sRPE-B-TL and sRPE-L-TL (ie, calculated as sRPE × DUR), mathematical coupling (ie, when one variable directly or indirectly contains the whole or part of another, resulting in a spurious correlation between the 2 variables) could explain these associations. Therefore, analyzing this relationship based on the intensity values rather than the load values is better.

The aforementioned studies analyzed the relationship with external intensity and load for the 2 RPE types independently. It is also interesting to examine if the difference in rating between sRPE-B and sRPE-L (dRPEDIFF) is associated with the external intensity and load of the session. Moreover, when quantifying external intensity and load, the value of a single variable may give some insight, but the combined analysis of multiple variables provides more context on the different types of activities that a player performed. For example, a similar high-speed running distance could be achieved by multiple accelerations resulting in various efforts above the high-speed threshold or by just one acceleration resulting in one long high-speed running effort. Therefore, clustering session types based on multiple external variables may provide better insight into the association between the external intensity or load and dRPEDIFF.

This paper presents an exploratory analysis of dRPE that has the following 3 objectives. First, we aimed to describe the extent to which elite male senior football players provide different ratings for sRPE-B and sRPE-L after training and match sessions (expressed as dRPEDIFF). Second, we examined the association between single external intensity or load variables and dRPEDIFF. The third objective was to cluster session types with distinct external intensity and load profiles and to examine the association between these session types and dRPEDIFF. Insights from our exploratory study help assessing the utility of employing dRPE for monitoring the internal intensity and load in football.

**Methods**

**Participants**

This study included data from 55 elite male outfield players belonging to 2 professional football teams. Team 1 competed in the second league in Belgium (n = 27 players; 24.4 [3.4] y; 182.4 [5.7] cm; 75.2 [6.8] kg). Team 2 competed in the premier league in The Netherlands (n = 28 players; 24.9 [4.8] y; 181.4 [7.3] cm; 77.4 [6.4] kg). The study was conducted according to the requirements of the Declaration of Helsinki and was approved by the KU Leuven ethics committee (s57732). All participants provided their informed consent before the start of the study.

**Design**

An observational study design was used. Data were collected during the 2019–2020 season. For team 1, the data collection ended at the outbreak of the COVID-19 pandemic in March 2020. For team 2, the data collection ended at the start of the winter break in January 2020 because the system for collecting external intensity and load data was changed. Figure 1 overviews the exclusion criteria that were applied to determine the data set used for analysis. Missing data were not imputed. Only in-season data from match and team training sessions were included. If 2 sessions were organized in one day, only the first session was included. External intensity and load data were collected during each session. After the session, players provided their sRPE-B and sRPE-L. Because of differences in methodology (Tables 1 and 2), the data of teams 1 and 2 were analyzed separately.

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Figure 1 — Overview of exclusion criteria for teams 1 and 2. The percentage values show the proportion of sessions that were still included in the data set after applying the different exclusion criteria. dRPE indicates differential ratings of perceived exertion; GPS, global positioning system.
Table 1 Included Volume, External Intensity, and External Load Variables for Teams 1 and 2

<table>
<thead>
<tr>
<th>Construct</th>
<th>Variable</th>
<th>Abbreviation</th>
<th>Threshold team 1</th>
<th>Threshold team 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume</td>
<td>Duration</td>
<td>DUR</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>External intensity</td>
<td>Total distance per minute</td>
<td>TD-min⁻¹</td>
<td>&gt;0.00 m·s⁻¹</td>
<td>&gt;0.00 m·s⁻¹</td>
</tr>
<tr>
<td></td>
<td>High-speed distance per minute</td>
<td>HSD-min⁻¹</td>
<td>&gt;5.83 m·s⁻¹</td>
<td>&gt;5.55 m·s⁻¹</td>
</tr>
<tr>
<td></td>
<td>Acceleration efforts per minute</td>
<td>AC eff⁻¹</td>
<td>&gt;2 m·s⁻²</td>
<td>&gt;2 m·s⁻²</td>
</tr>
<tr>
<td></td>
<td>Deceleration efforts per minute</td>
<td>DEC eff⁻¹</td>
<td>&lt;2 m·s⁻²</td>
<td>&lt;2 m·s⁻²</td>
</tr>
<tr>
<td>External load</td>
<td>Total distance</td>
<td>TD</td>
<td>&gt;0.00 m·s⁻¹</td>
<td>&gt;0.00 m·s⁻¹</td>
</tr>
<tr>
<td></td>
<td>High-speed distance</td>
<td>HSD</td>
<td>&gt;5.83 m·s⁻¹</td>
<td>&gt;5.55 m·s⁻¹</td>
</tr>
<tr>
<td></td>
<td>Acceleration efforts</td>
<td>AC eff</td>
<td>&gt;2 m·s⁻²</td>
<td>&gt;2 m·s⁻²</td>
</tr>
<tr>
<td></td>
<td>Deceleration efforts</td>
<td>DEC eff</td>
<td>&lt;2 m·s⁻²</td>
<td>&lt;2 m·s⁻²</td>
</tr>
</tbody>
</table>

*External load = volume × external intensity.

Table 2 Procedures for Collecting Differential Ratings of Perceived Exertion Data for Teams 1 and 2

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Team 1</th>
<th>Team 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scale</td>
<td>0–10 (Foster)</td>
<td>0–10 (Foster)</td>
</tr>
<tr>
<td>Language</td>
<td>English (and translated to French)</td>
<td>English (and translated to Dutch)</td>
</tr>
<tr>
<td>Hardware</td>
<td>Players’ smartphones</td>
<td>Team iPad</td>
</tr>
<tr>
<td>Software</td>
<td>Athlete management system (TopSportsLab)</td>
<td>Athlete management system (TopSportsLab)</td>
</tr>
<tr>
<td>Timing</td>
<td>After the session (any time before next session)</td>
<td>After the session (within 30 min)</td>
</tr>
<tr>
<td>Location</td>
<td>Off-field</td>
<td>On-field and off-field</td>
</tr>
<tr>
<td>Anonymity</td>
<td>No other persons involved</td>
<td>Under the supervision of the physiotherapist</td>
</tr>
</tbody>
</table>

Methodology

External Intensity and Load. Team 1 used a 10-Hz global positioning system (OptimEye X4, OpenField software, Catapult Sports). Team 2 used a 10-Hz global navigation satellite system (combining global positioning system, GLONASS and GALILEO; Johan Sports V4, Johan Sports software, Johan Sports). Before the study started, the authors instructed staff members on the recommended procedures for processing external intensity and load data. However, the authors had no control over processing methods that were actually applied.

Table 1 shows the variables that are included in the analysis. To quantify these variables, aggregate data originating from the software of the EPTS were used. The computation of these variables differs between the 2 teams, as they used different EPTS with custom thresholds, filtering methods and minimum effort duration settings. To our knowledge, information on some settings has not been made available by the hardware providers.

Nevertheless, by consensus, we considered the variables listed in Table 1 a representative and complementary set that allows characterizing sessions with distinct external intensity and load profiles. Previous studies showed that this set of variables receives most attention in elite football practice. In addition, exploratory analyses such as principal component analysis indicated that, although these variables are often highly correlated to each other, the activity profile of football sessions can be described by a component representing the overall running “volume” (ie, TD) and a component representing high-intensity actions above a certain speed (ie, high-speed distance [HSD]) or acceleration threshold (ie, acceleration and deceleration efforts [AC eff and DEC eff]). We anticipated that sessions with distinct profiles based on these variables might induce different psychophysiological stresses in terms of breathlessness and leg-muscle exertion.

Internal Intensity. An athlete management system (TopSportsLab) was used to collect dRPE (Table 2). Players were asked to provide sRPE-B and sRPE-L separately, after completing each session. These questions were posed in randomized order using the original scale and labels without color coding and other, often inappropriate, additions such as smileys. Before the start of the study, the authors instructed staff members on the purpose, procedures, and content of the questions. The staff members subsequently instructed the players at the start of preseason, which was used as a familiarization period. We used the modified 0 to 10 scale of Foster because this scale was already used by the involved clubs prior to the start of the study. To avoid mathematical coupling, both RPE types were analyzed as intensity values (ie, they were not multiplied by DUR) in all of our statistical analysis.

Statistical Analysis

The statistical analysis involved 3 components in line with our research aims.

Extent of Differentiation. Descriptive statistics were calculated to quantify how often players provided different ratings for sRPE-B and sRPE-L (ie, dRPE Diff). Between-player variability in the same session was quantified using the intraclass correlation coefficient (ICC [1,1]) for all external and internal variables, as well as for dRPE Diff.
**Association Based on Single External Intensity and Load Variables.** The association between single external intensity or load variables and dRPEDIFF was analyzed using a mixed-effects logistic regression model (the binomial family in the lme4 R package; version 1.1-26). For this analysis, dRPEDIFF was transformed to a binary variable. That is, all sessions were either labeled as “higher sRPE-B” or “higher sRPE-L” and sessions with no difference between both ratings were discarded. Hence, the analysis of binary variable. That is, all sessions were either labeled as sRPE-B showed limited separation (ie, no or very small differences) while judging the magnitude of the difference is more challenging. This assumption is supported by the observation that players may have a unique tendency to differentiate between sRPE-B and sRPE-L based on their individual responses to varying external loads. Improvement over a null model using only a random intercept for Player ID was verified using analysis of variance tests. External intensity and load variables were median centered and rescaled to an interquartile range of 0.25 to properly evaluate the magnitude of the between-player fixed effects. As such, a median-centered interquartile range gauge of the effects can be justified as the change in probability of being classified as “higher sRPE-B” between a typical high and low external intensity and load session.

**Association Based on Cluster Analysis of External Intensity and Load Variables.** Because the interpretation of single external variables provides limited insight into a session’s activity profile, a cluster analysis was performed using the external variables. An agglomerative hierarchical clustering approach (scikit-learn Python package, version 0.24; Scikit-learn) was used to identify sessions with distinct activity profiles. Starting with all sessions as singleton clusters, the most similar clusters were iteratively merged until a clustering that balances interpretability and granularity (ie, what type of session does each cluster represent) and granularity (ie, how similar are the sessions within each cluster) was formed. The optimal granularity was determined using the elbow method based on the silhouette score. The similarity between 2 clusters was defined as the variance in external intensity and load (ie, the Ward linkage method) when the clusters are merged. Finally, a Pearson’s chi-square test of independence (scipy Python package, version 1.5.4) was used to identify significant associations between specific session types and dRPEDIFF. Post hoc testing was conducted using Bonferroni correction. Significance levels were set at \( P = .05 \). Cramér’s V was used to indicate the strength of the associations.

**Results**

**Extent of Differentiation**

Figure 2 shows the percentage of sessions with higher RPE-B and RPE-L for each player. Overall, players provided different ratings in 22% of all sessions (team 1: 21% and team 2: 25%).

Figure 2 — The percentage of sessions with higher RPE-B and higher RPE-L for each player. The 2 RPE types were rated similarly for the remaining sessions. RPE-B indicates session rating of perceived breathlessness; RPE-L, session rating of perceived leg-muscle exertion.
Association Based on Single External Intensity and Load Variables

The large between-player variability cannot be explained by individual responses to a single external intensity or load variable (Table 3 and Figures 3 and 4). Confidence limits for the within-player effects of external variables on dRPEDIFF spanned across largely positive and negative values for all variables, indicating no conclusive findings (Table 3).

Association Based on Cluster Analysis of External Intensity and Load Variables

For team 1, a cluster analysis identified 6 session types with typical activity profiles (Table 4). Two of these session types correspond to match day (MD). They are characterized by a difference in external intensity, with sessions in the first match cluster having a significantly higher amount of HSD per minute, ACCeff per minute, and DECeff per minute than sessions in the other match cluster. These differences can be attributed to individual players who perform at lower intensity throughout the entire season, as well as general differences in intensity between individual players. Six hundred twenty training sessions can be classified as a “conditioning” session (MD-3 and MD-4) where the overall external load is lower than most match sessions, but higher than other training sessions. Furthermore, “taper” (MD-2 and MD-1) and “recovery” sessions (MD + 1 and MD + 2) were identified, both characterized by few high-intensity efforts. However, recovery sessions have a moderate TD, while taper sessions have a low TD. Finally, short training sessions with a relatively high amount of ACCeff and DECeff were identified. These are “top-up” sessions for nonstarting players (MD or MD + 1).

Analogously for team 2, a cluster analysis identified 6 session types with typical activity profiles (Table 5). In contrast to team 1, only one cluster of “match” sessions was identified. All match sessions have a higher load than training sessions. The “top-up,” “recovery,” “conditioning,” and “taper” session types are characterized by the same properties as team 1, although team 2’s training sessions are noticeably longer. A final session type—which was not observed for team 1—are sessions with a low intensity (TD per minute) like recovery sessions, but a very high volume (DUR). We refer to these as “high volume” sessions, given that they were not related to specific MD-X days within the training week. Supplementary Material (available online) graphically illustrates the clusters for both teams and provides additional details.

The session type and level of differentiation between sRPE-B and sRPE-L showed to have a significant but small association for team 1 (P < .01, V = 0.05) and team 2 (P = .03, V = 0.07). A pairwise post hoc analysis with Bonferroni correction revealed that players of team 1 differentiate more frequently in conditioning sessions, compared with top-up (P = .032, V = 0.11), match (type 1) (P = .013, V = 0.13), and taper sessions (P = .014, V = 0.12). Players of team 2 differentiated more often in conditioning sessions compared with taper (P < .01, V = 0.15), recovery (P < .01, V = 0.29), and high-volume sessions (P = .042, V = 0.17). Also, they differentiated more often in match sessions compared with taper (P < .01, V = 0.19), recovery (P < .01, V = 0.37), and high-volume sessions (P < .01, V = 0.24). The effects could be interpreted as small (0.07 < V < 0.21) to medium (0.21 < V < 0.35).13 No significant differences were found with respect to the direction in which the differentiation is made between session types for both teams.

Discussion

Our study aimed to examine the utility of dRPE to monitor internal intensity and load in football. Therefore, we first analyzed the extent to which elite male senior football players provide different ratings for sRPE-B and sRPE-L, expressed as dRPEDIFF. Second, we between external intensity and load variables and dRPEDIFF. Third, we examined the association between typical session types and dRPEDIFF.

The sRPE-B and sRPE-L were rated differently in ±22% of the sessions. This finding is in line with previous studies, showing small differences and high correlations between the 2 RPE types.13,14,16 A clear between-player variability was present, with individual players differentiating in 0% to 64% of their sessions. The high variability between players was confirmed by a poor agreement in dRPEDIFF between players in the same session, despite a moderate to good agreement in external intensity and load. This poor agreement in dRPEDIFF may suggest that players varied in their self-assessment approach. Alternatively, the poor agreement may be explained by the effects of unmeasured external load variables (eg, impacts), or by individual and contextual variability in rating bias.

Table 3 Within-Player Effects of Volume, External Intensity, and External Load Variables on dRPEDIFF

<table>
<thead>
<tr>
<th>Construct</th>
<th>Variable</th>
<th>IQR</th>
<th>Effect, %</th>
<th>95% CI</th>
<th>IQR</th>
<th>Effect, %</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume</td>
<td>DUR, min</td>
<td>17.3</td>
<td>-7.4</td>
<td>-29.3 to 15.1</td>
<td>20.4</td>
<td>-19.3</td>
<td>-41.7 to 4.8</td>
</tr>
<tr>
<td>External intensity</td>
<td>TD-min⁻¹, m</td>
<td>24.8</td>
<td>4.6</td>
<td>-27.0 to 35.3</td>
<td>39.6</td>
<td>0.0</td>
<td>-33.2 to 33.2</td>
</tr>
<tr>
<td></td>
<td>HSD-min⁻¹, m</td>
<td>2.83</td>
<td>-20.0</td>
<td>-42.4 to 4.6</td>
<td>3.40</td>
<td>3.2</td>
<td>-20.7 to 26.7</td>
</tr>
<tr>
<td></td>
<td>ACCeff-min⁻¹, no.</td>
<td>0.11</td>
<td>-13.7</td>
<td>-41.4 to 16.1</td>
<td>0.52</td>
<td>12.7</td>
<td>-17.5 to 41.1</td>
</tr>
<tr>
<td></td>
<td>DECeff-min⁻¹, no.</td>
<td>0.07</td>
<td>7.5</td>
<td>-21.9 to 35.6</td>
<td>0.54</td>
<td>12.4</td>
<td>-17.9 to 40.9</td>
</tr>
<tr>
<td>External load</td>
<td>TD, km</td>
<td>2.69</td>
<td>-5.1</td>
<td>-35.8 to 26.5</td>
<td>2.39</td>
<td>-11.2</td>
<td>-34.1 to 12.8</td>
</tr>
<tr>
<td></td>
<td>HSD, km</td>
<td>0.21</td>
<td>-20.1</td>
<td>-40.1 to 1.6</td>
<td>0.32</td>
<td>3.3</td>
<td>-25.3 to 31.4</td>
</tr>
<tr>
<td></td>
<td>ACCeff, no.</td>
<td>7.00</td>
<td>-14.5</td>
<td>-36.0 to 8.5</td>
<td>41.5</td>
<td>6.2</td>
<td>-26.1 to 37.5</td>
</tr>
<tr>
<td></td>
<td>DECeff, no.</td>
<td>5.00</td>
<td>4.0</td>
<td>-23.4 to 30.9</td>
<td>43.0</td>
<td>9.8</td>
<td>-19.2 to 37.5</td>
</tr>
</tbody>
</table>

Abbreviations: ACCeff, acceleration efforts; DECeff, deceleration efforts; dRPEDIFF, difference in rating between sRPE-B and sRPE-L; DUR, duration; HSD, high-speed distance; IQR, interquartile range; sRPE-B, session rating of perceived breathlessness; sRPE-L, session rating of perceived leg-muscle exertion; TD, total distance. Note: The effects are gauged by 2 SDs of the external load variable and measure the change in probability for a session to be perceived as having a higher sRPE-B than sRPE-L when increasing the load from a typical low to a typical high value. Uncertainty of the effect is indicated by 95% CI.
The probability in Team 1 of a session being rated with a higher sRPE-B than sRPE-L explained by external intensity and load variables. The x-axis shows the external intensity or load value. The y-axis shows the probability that a session with the corresponding intensity or load will be labeled as having a higher sRPE-B than sRPE-L. The solid black regression lines are the within-player effect with 95% CIs (shaded area). The thin gray lines represent individual responses. Box plots represent the distribution of the variable on the x-axis for sessions that were rated with a higher sRPE-B (in the top box plots) and higher sRPE-L (in the bottom box plots). ACCeff indicates acceleration efforts; DECell, deceleration efforts; DUR, duration; HSD, high-speed distance; sRPE-B, session rating of perceived breathlessness; sRPE-L, session rating of perceived leg-muscle exertion; TD, total distance.
Figure 4 — The probability in Team 2 of a session being rated with a higher sRPE-B than sRPE-L, explained by external intensity and load variables. The x-axis shows the external intensity or load value. The y-axis shows the probability that a session with the corresponding intensity or load will be labeled as having a higher sRPE-B than sRPE-L. The solid black regression lines are the within-player effect with 95% CIs (shaded area). The thin gray lines represent individual responses. Box plots represent the distribution of the variable on the x-axis for sessions that were rated with a higher sRPE-B (in the top box plots) and higher sRPE-L (in the bottom box plots). ACCeff indicates acceleration efforts; DECeff, deceleration efforts; DUR, duration; HSD, high-speed distance; sRPE-B, session rating of perceived breathlessness; sRPE-L, session rating of perceived leg-muscle exertion; TD, total distance.
Table 4  Different Session Types Identified by the Cluster Analysis for Team 1

<table>
<thead>
<tr>
<th>Construct</th>
<th>Variable</th>
<th>Match 1 n = 171</th>
<th>Match 2 n = 92</th>
<th>Top-up n = 381</th>
<th>Recovery n = 799</th>
<th>Conditioning n = 620</th>
<th>Taper n = 292</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume</td>
<td>DUR, min</td>
<td>95.3 (5.72)</td>
<td>95.1 (4.24)</td>
<td>49.9 (19.1)</td>
<td>66.7 (14.4)</td>
<td>72.6 (14.9)</td>
<td>59.4 (11.5)</td>
</tr>
<tr>
<td>External intensity</td>
<td>TD-min⁻¹, m</td>
<td>115.0 (13.5)</td>
<td>114.0 (1.74)</td>
<td>74.3 (16.2)</td>
<td>78.8 (23.0)</td>
<td>88.0 (16.1)</td>
<td>54.9 (12.9)</td>
</tr>
<tr>
<td></td>
<td>HSD-min⁻¹, m</td>
<td>4.64 (2.31)</td>
<td>8.12 (2.26)</td>
<td>1.06 (1.16)</td>
<td>0.82 (1.28)</td>
<td>3.50 (2.79)</td>
<td>0.17 (0.52)</td>
</tr>
<tr>
<td></td>
<td>ACCeff-min⁻¹, no.</td>
<td>0.16 (0.08)</td>
<td>0.24 (0.08)</td>
<td>0.19 (0.08)</td>
<td>0.11 (0.07)</td>
<td>0.20 (0.09)</td>
<td>0.08 (0.07)</td>
</tr>
<tr>
<td></td>
<td>DECeff-min⁻¹, no.</td>
<td>0.09 (0.04)</td>
<td>0.16 (0.06)</td>
<td>0.09 (0.06)</td>
<td>0.05 (0.04)</td>
<td>0.10 (0.07)</td>
<td>0.02 (0.03)</td>
</tr>
<tr>
<td>External load</td>
<td>TD, km</td>
<td>10.8 (1.17)</td>
<td>10.8 (1.17)</td>
<td>3.67 (0.895)</td>
<td>5.15 (1.70)</td>
<td>6.37 (1.61)</td>
<td>3.30 (0.82)</td>
</tr>
<tr>
<td></td>
<td>HSD, km</td>
<td>0.44 (0.22)</td>
<td>0.77 (0.25)</td>
<td>0.06 (0.06)</td>
<td>0.05 (0.08)</td>
<td>0.25 (0.17)</td>
<td>0.01 (0.03)</td>
</tr>
<tr>
<td></td>
<td>ACCeff, no.</td>
<td>16.0 (7.50)</td>
<td>23.0 (8.00)</td>
<td>10.0 (6.00)</td>
<td>7.00 (4.000)</td>
<td>14.0 (6.00)</td>
<td>5.00 (4.20)</td>
</tr>
<tr>
<td></td>
<td>DECeff, no.</td>
<td>9.00 (4.00)</td>
<td>15.0 (5.00)</td>
<td>5.00 (4.00)</td>
<td>3.00 (3.00)</td>
<td>7.00 (4.20)</td>
<td>1.00 (2.00)</td>
</tr>
</tbody>
</table>

Table 5  Different Session Types Identified by the Cluster Analysis for Team 2

<table>
<thead>
<tr>
<th>Construct</th>
<th>Variable</th>
<th>Match 1 n = 110</th>
<th>Top-up n = 99</th>
<th>Recovery n = 174</th>
<th>Conditioning n = 209</th>
<th>Taper n = 493</th>
<th>High volume n = 203</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume</td>
<td>DUR, min</td>
<td>94.4 (21.1)</td>
<td>71.1 (38.3)</td>
<td>94.8 (15.1)</td>
<td>98.2 (17.1)</td>
<td>94.8 (15.1)</td>
<td>118 (11.9)</td>
</tr>
<tr>
<td>External intensity</td>
<td>TD-min⁻¹, m</td>
<td>115 (12.1)</td>
<td>86.4 (29.1)</td>
<td>50.9 (10.7)</td>
<td>75.6 (27.0)</td>
<td>57.6 (14.7)</td>
<td>52.8 (8.25)</td>
</tr>
<tr>
<td></td>
<td>HSD-min⁻¹, m</td>
<td>8.35 (3.09)</td>
<td>5.50 (3.74)</td>
<td>0.61 (0.98)</td>
<td>2.88 (3.11)</td>
<td>1.47 (1.74)</td>
<td>1.65 (1.19)</td>
</tr>
<tr>
<td></td>
<td>ACCeff-min⁻¹, no.</td>
<td>1.58 (0.33)</td>
<td>1.15 (0.46)</td>
<td>0.56 (0.18)</td>
<td>1.24 (0.31)</td>
<td>0.90 (0.21)</td>
<td>0.64 (0.18)</td>
</tr>
<tr>
<td></td>
<td>DECeff-min⁻¹, no.</td>
<td>1.52 (0.32)</td>
<td>0.89 (0.56)</td>
<td>0.42 (0.22)</td>
<td>1.03 (0.25)</td>
<td>0.70 (0.20)</td>
<td>0.49 (0.15)</td>
</tr>
<tr>
<td>External load</td>
<td>TD, km</td>
<td>10.4 (2.24)</td>
<td>6.77 (2.74)</td>
<td>4.65 (1.10)</td>
<td>7.43 (3.73)</td>
<td>5.54 (1.66)</td>
<td>6.33 (1.12)</td>
</tr>
<tr>
<td></td>
<td>HSD, km</td>
<td>0.75 (0.25)</td>
<td>0.39 (0.30)</td>
<td>0.06 (0.10)</td>
<td>0.29 (0.32)</td>
<td>0.14 (0.17)</td>
<td>0.19 (0.16)</td>
</tr>
<tr>
<td></td>
<td>ACCeff, no.</td>
<td>140 (40.0)</td>
<td>77.0 (24.0)</td>
<td>54.0 (22.0)</td>
<td>120 (28.0)</td>
<td>83.0 (20.0)</td>
<td>77.0 (20.0)</td>
</tr>
<tr>
<td></td>
<td>DECeff, no.</td>
<td>139 (36.0)</td>
<td>59.0 (26.0)</td>
<td>40.0 (22.0)</td>
<td>104 (19.0)</td>
<td>67.0 (19.0)</td>
<td>58.0 (19.0)</td>
</tr>
</tbody>
</table>

Abbreviations: ACCeff, acceleration efforts; DECeff, deceleration efforts; DUR, duration; HSD, high-speed distance; sRPE-B, session rating of perceived exertion breathlessness; sRPE-L, session rating of perceived leg-muscle exertion; TD, total distance. Note: The median (interquartile range) of the different volume, external intensity, and external load variables is presented together with the level of differentiation toward higher sRPE-B and higher sRPE-L in each cluster.
to changes in intensity, and this may be independent of the type of activities performed during training (e.g., continuous running vs intermittent running with or without changes of direction). Thus, it remains unclear to which extent dRPE provides additional insight in the dose–response relationship between external and internal load.

The involvement of 2 elite football clubs is a strength of this study. The separate analysis for the 2 clubs allowed us to distinguish between club specific and more general insights. Moreover, it enables readers to understand how load measures are applied differently between clubs. While the impact of the study would have benefited from a larger data set arising from merging data from multiple clubs, we felt that the methodological differences in collection strategies employed by the clubs made this inappropriate. The daily administration of self-report measures requires considerable time investment from staff members who are already burdened with many tasks and responsibilities. Changing data collection procedures or implementing not-validated measures for research purposes is therefore challenging.

Data were collected during an extended in-season period. We recommend that future research considers alternative time periods to collect the data. This may include shorter and more specific periods such as preseason or in-season blocks with a specific training purpose and content that are aligned with the research questions. Such designs may enable data collection in a very standardized and controlled way. Also, it may improve the detail of analysis. While this study already clustered sessions based on multiple external variables instead of analyzing them independently, more specific information on the training content (e.g., type and sequence of movements) may help contextualizing the external intensity and load of sessions, and thus its relationship to self-report measures. Therefore, it may be interesting to delve into the ratings of the different exercises within a session.

### Practical Applications

The concept of dRPE originates from researchers’ interest in understanding the different psychophysiological cues that influence RPE in different exercise tasks and settings. While dRPE can be useful for this purpose, the findings of our study suggest that translating this concept to load monitoring in football needs more specific consideration. A training load variable should provide insights to evaluate and adapt the training process. Our study does not show that dRPE provides additional insight for this purpose. In specific training types such as lower-limb resistance training, separate ratings for RPE-B and RPE-L are expected, with RPE-L being more sensitive to changes in (external) intensity. dRPE may therefore be a useful tool to integrate data from resistance and field-based training sessions into a longitudinal monitoring program but there is no evidence for its utility for monitoring field-based sessions in isolation. Practitioners should also be aware that players vary in their approach to this method. The utility of dRPE should therefore be considered for every player individually.

### Conclusions

We examined the utility of dRPE to monitor internal intensity and load in football. Our results showed a high between-player variability in the extent to which players provided separate ratings for sRPE-B and sRPE-L. This variability cannot be explained by individual responses to the external intensity or load of the session, because no within-player relationships were observed between external variables and the difference in rating between sRPE-B and sRPE-L. In this respect, clustering sessions based on multiple external variables did not result in a clearer relationship. Future research could see whether increased differentiations observed during high intensity sessions (matches or conditioning sessions) are in fact relevant. Altogether, the main conclusion is that our study findings provide no evidence supporting the utility of dRPE to monitor internal intensity and load in football.

### Acknowledgments

Houtmeyers and Robberechts share first authorship. Davis and Helsen share last authorship. The authors would like to thank all players and coaches for their participation. This work was part of a research project supported by the Agency for Innovation by Science and Technology-IWT, Belgium under Grant IWT HBC.2017.0569 (Houtmeyers). The research grant contains a collaboration between the University of Leuven and the company TopSportsLab.

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