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BRIEF REPORT

Validity of Session Rating of Perceived Exertion Assessed via the CR100 Scale to Track Internal Load in Elite Youth Football Players

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Purpose: To assess the convergent validity of the Borg CR100® scale to track internal training load (TL) in youth football players. ***Methods:*** A total of 19 youth football players (age = 15 [1] y, height = 175.9 [12.3] cm, and body mass = 69 [15.4] kg) were monitored for 27 sessions, including training and games. Internal TL was assessed via session rating of perceived exertion (sRPE) and 2 heart-rate-based methods (Banister training impulse and Edwards TL). The correlations between sRPE and heart-rate-based TL, the differences in individual player intercepts and slopes, and the differences between types of sessions (training vs games) were assessed using a general linear mixed model with magnitude-based inferences. ***Results:*** Correlations between sRPE and Banister training impulse were very large at overall group level ($r = .77$; 90% confidence limits, .72–.80) and individual level (range .70–.95). Correlations between sRPE and Edwards TL were very large at overall group level ($r = .84$; 90% confidence limit, .82–.86) and large to very large at individual level (range .64–.93). A very likely small difference was found in the comparison between games and training sessions for the relationship between sRPE and Banister training impulse. ***Conclusions:*** The Borg CR100 scale is a valid method for monitoring TL in youth football players.

Keywords: RPE, training load, soccer

Ratings of perceived exertion (RPE) have been proposed as a simple, noninvasive method to assess exercise intensity.[1] When multiplied by exercise duration, RPE can be used to assess internal training load (TL), this being named session-RPE (sRPE).[2] Traditionally, sRPE has been obtained by using the Borg CR10® scale[1] or the Foster modified version of the CR10,[2] both ranging from 0 to 10. Although the validity of sRPE has been demonstrated in adults, the results of studies conducted in youth are varied. Small correlations ($r = .17$) between heart rate (HR)-based and sRPE-based TL using the Foster scale have been reported in youth soccer players (11.4 [0.5] y).[3] These results are in contradiction to those showing a large correlation between CR10-based sRPE and HR-based TL ($r = .54$–$.78$) in players aged 17.6 (0.7) years.[4] Previous studies indicated that children may have difficulties with understanding the written anchors used in scales such as the CR10 or the Foster modified scale.[5] Therefore, specific scales such as the OMNI scale have previously been validated to assess intensity in youth.[6] However, there is a tendency in the football practice to continue using the RPE scales with youth players.

A more recent scale named CR100® was created to overcome some of the limitations associated with previous scales.[7] The CR100 is a category-ratio scale with numerical and verbal anchors (starting at absolute zero and with equidistant steps) ranging 0 to 100 arbitrary units. The CR100 scale has been validated to monitor TL in Australian football[8] and soccer.[9] In addition, the CR100 showed to be interchangeable with the CR10 scale and to be more finely graded compared with the CR10 scale, allowing more accurate collection of TL in team sports.[9] However, to the best of our knowledge, no previous study has validated the CR100 scale in youth football. Therefore, the aim of the study was to assess the convergent validity of the CR100 scale to assess the internal TL in youth football players, the differences in individual player intercepts and slopes, and the differences between types of sessions (training vs games).

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Methods

Experimental Overview

A total of 19 state-level youth football players (age = 15 [1] y, height = 175.9 [12.3] cm, body mass = 69 [15.4] kg) participated in the study. Training and game data were collected at the end of the competitive season (September–December), in which the team prepared for, and participated in the National Championships. Two anchoring sessions and a 4-week familiarization were conducted before data collection, which comprised 27 sessions, including training and competitive matches. The construct validity of the CR100 to measure internal TL was examined by calculating its correlations with 2 HR-based methods, Banister's training impulse (TRIMP)[10] and Edwards' TL.[11] HR data were collected through wearable technology devices (Team Pro; Polar Electro Oy, Kempele, Finland) and analyzed via a Microsoft Excel customized spreadsheet. The study was conducted according to the Declaration of Helsinki and received ethical approval by Victoria University's human research ethics committee (HRE15-190).

CR100 Anchoring

An anchoring session was performed during the Yo-Yo intermittent recovery test level 1, which was also used to obtain peak HR. Before the commencement of the test, the official CR100 instructions were read out to players. Players were asked to provide staff with a reading from the CR100 scale after each shuttle run.

The final RPE scores were collected within 20 minutes after the sessions concluded.

Familiarization

Familiarization of the CR100 was conducted for 4 weeks before data collection. All players involved had a minimum of a 7-month exposure to the CR10 scale. The official CR100 instructions were read out to players prior to the commencement of the first familiarization session and every 4 weeks thereafter.

HR Measurements

Banister's TRIMP[10] was calculated as follows:

$$\text{TRIMP} = \text{Duration (min)} \times \Delta\text{HR ratio} \times y$$

where $\Delta\text{HR ratio} = (\text{HR}_{\text{exercise}} - \text{HR}_{\text{rest}})/(\text{peak HR} - \text{HR}_{\text{rest}})$ and y is a multiplying factor of $0.64e^{1.92x}$, whereby $e = 2.712$ and $x = \Delta\text{HR}$.

Resting HR was obtained by having the players resting for 10 minutes in a seated position before one of the training sessions.

Edwards' TL[11] was calculated as follows:

$$\text{Edwards' TL} = \text{Time at each HR zone} \times \begin{cases} \text{Zone 5; 90–100\% peak HR} = 5 \\ \text{Zone 4; 80–89\% peak HR} = 4 \\ \text{Zone 3; 70–79\% peak HR} = 3 \\ \text{Zone 2; 60–69\% peak HR} = 2 \\ \text{Zone 1; 50–59\% peak HR} = 1 \end{cases}$$

Statistical Analysis

The (convergent) construct validity of sRPE was assessed via Pearson's correlation coefficient and 90% confidence limits between sRPE and Edwards' TL, and between sRPE and Banister's TRIMP. Data were log transformed to minimize bias due to nonuniformity of error. A general linear mixed model (Proc Mix) was used to assess differences between individual intercepts and slopes, and between type of session (ie, game and training) with SAS Studio (version 9.4; SAS Institute, Cary, NC). Player identity (to specify a different intercept for each player) and interaction of player identity with sRPE (to specify a different slope for each player) were used as random effects with an unstructured covariance matrix to allow for correlation between slope and intercept.

The magnitude of correlations was classified as follows: $r < .1$ = trivial, .1 to .3 = small, .3 to .5 = moderate, .5 to .7 = large, .7 to .9 = very large, >.9 = nearly perfect, and 1 = perfect. The differences between the 2 correlations (ie, sRPE/Edwards vs sRPE/TRIMP) within individuals were assessed via magnitude-based inference statistics assuming a smallest important difference of 0.2 raw units (corresponding to the magnitude of the correlation thresholds up to $r = .9$).

Table 1 shows the descriptive data regarding the scores from the Yo-Yo intermittent recovery test level 1 test and the TL averages for the sessions analyzed.

A very large correlation was found between sRPE and Edwards' TL both at the overall and individual level (Table 2). A very large correlation was found between sRPE and Banister's TRIMP at overall level, whereas individual correlations were large to very large (Table 2). No meaningful differences were found between individuals' intercept and slopes for Banister TRIMP and Edwards TL, and in the comparison between games and training for sRPE and Edwards TL (Table 3). Conversely, a very likely small difference was found in the comparison between games and training for the relationship between sRPE and Banister TRIMP (Table 3).

Table 1 Descriptive Data From the Yo-Yo IR1 Test and the TL Averages for the Sessions Analyzed

Yo-Yo IR1 results	
Final score (distance), m	1800 (600)
Peak heart rate, beats/min	204 (14)
Load averages (all sessions)	
Banister TRIMP, AU	100 (33)
Edwards TL, AU	214 (71)
sRPE, AU	5580 (2227)
Load averages (games)	
Banister TRIMP, AU	88 (31)
Edwards TL, AU	165 (59)
sRPE, AU	3824 (1817)
Load averages (training)	
Banister TRIMP, AU	103 (33)
Edwards TL, AU	225 (70)
sRPE, AU	5944 (2131)

Abbreviations: AU, arbitrary units; sRPE, session rating of perceived exertion; TL, training load; TRIMP, training impulse; Yo-Yo IR1, Yo-Yo Intermittent Recovery Test Level 1.

Discussion

Our results showed that the CR100 scale has acceptable validity to track internal TL in elite youth football players and are consistent with those of previous studies, which validated the use of the CR100 scale in soccer[9] and Australian football.[8] As children may have difficulties with understanding the written anchors within the CR10 scale,[5] the CR100 scale may provide an alternative for monitoring TL in youth. As the CR100 scale is a more finely graded scale than the CR10, this may explain the current findings suggesting a more acceptable level of validity in youth players.[12] The results of the current study are consistent with those comparing the same HR-based methods of Banister's TRIMP and Edwards TL with sRPE using the Foster modified CR10 scale.[4]

Interestingly, we found a very likely small difference between games and training in the relationship between sRPE and Banister's TRIMP, whereas no difference was found when the comparison was made with Edwards' TL. The most plausible explanation for this difference could be due to the calculations underpinning the 2 TL methods. Banister's TRIMP is calculated using an exponential multiplying factor,[10] whereas Edwards' TL assigns a linear weighing factor of 1 to 5 for the duration of exercise within each HR zone.[11] Therefore, Banister's TRIMP returns an exponentially higher overall load as a player exercises for a longer duration near peak HR. This is more likely to occur in games than in training, as highlighted by the higher average HR for games than for training sessions in the present study (167 [14] and 146 [12], respectively). However, it is also of interest to consider a different interpretation of these results; it may be argued that for a given Banister's TRIMP, the corresponding perceived load is

Table 2 Individual Correlation Coefficients for the Relationship Between sRPE and Edwards TL and Between sRPE and Banister TRIMP

Player number	Number of sessions	Edwards TL, Pearson correlation (*r*) with 90% CL	Banister TRIMP, Pearson correlation (*r*) with 90% CL
1	27	.75 (.56–.86)	.69 (.47–.83)
2	27	.95 (.91–.98)	.89 (.79–.94)
3	27	.93 (.87–.97)	.85 (.73–.92)
4	27	.93 (.87–.97)	.88 (.79–.94)
5	27	.79 (.63–.89)	.68 (.46–.82)
6	27	.91 (.83–.95)	.84 (.71–.91)
7	27	.70 (.48–.83)	.64 (.40–.80)
8	27	.86 (.75–.93)	.80 (.65–.90)
9	27	.80 (.64–.89)	.74 (.55–.86)
10	27	.83 (.69–.91)	.78 (.61–.88)
11	27	.94 (.89–.97)	.87 (.77–.93)
12	27	.85 (.73–.92)	.81 (.66–.90)
13	27	.90 (.82–.95)	.83 (.69–.91)
14	26	.88 (.77–.94)	.83 (.69–.91)
15	15	.86 (.68–.94)	.82 (.59–.93)
16	21	.87 (.73–.94)	.82 (.64–.91)
17	19	.77 (.54–.89)	.70 (.43– .86)
18	11	.92 (.76–.97)	.92 (.75–.97)
19	17	.93 (.84–.97)	.93 (.83–.97)
Overall	460	.84 (.82–.86)	.77 (.74–.80)

Abbreviations: CL, confidence limits; sRPE, session rating of perceived exertion; TL, training load; TRIMP, training impulse.

Table 3 Individual Differences in the Intercept and Slope, and Group Differences in Game Versus Training, for the Correlations Between sRPE and Banister TRIMP/Edwards TL

	sRPE vs Banister TRIMP		sRPE vs Edwards TL	
	Effect size (90% CL)	Qualitative inference	Effect size (90% CL)	Qualitative inference
Intercept	–0.25 (–0.44 to 0.27)	Possibly small	–0.21 (–0.43 to 0.32)	Possibly small
Slope	–0.16 (–0.31 to 0.22)	Possibly small	0.15 (–0.27 to 0.35)	Possibly small
Game[a] vs training[b]	0.49 (0.27 to 0.71)	Very likely small	–0.14 (–0.36 to 0.08)	Possibly trivial

Abbreviations: CL, confidence limits; sRPE, session rating of perceived exertion; TL, training load; TRIMP, training impulse.
[a] n = 79. [b] n = 381 individual sessions.

meaningfully lower in games compared with training. This could be due to unique aspects that may influence the intensity and therefore the perception of the activity performed during a game, such as the activity performed by the opponent, the score line, coach's evaluation, etc. These results are in line with previous research showing differences in the relationship sRPE/Edward's TL between different types of training or between training and games in other youth team sports.[13,14] These differences were attributed to the possibility that, during games, players underestimate their efforts as a consequence of preferring the game activity overtraining.

Additional research is needed to fully understand the relationship between type of activity and perceptual responses in youth players.

Practical Applications

Practitioners are frequently involved in youth academies where they have to lead and monitor training sessions in multiple teams. Monitoring tools (such as HR systems) can be expensive and time-demanding. The session-RPE is a simple, inexpensive, and valid tool for monitoring internal TL. The results of our study suggest that the CR100 scale can be used for assessing sRPE in youth football athletes.

Conclusion

The validity of the Borg CR100 scale has been determined in elite youth football players through correlation of 2 HR-based methods as measures of TL; therefore, we support the use of the sRPE method assessed with the CR100 scale to monitor TL in youth players.

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