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Effect of Training-Session Intensity Distribution on Session Rating of Perceived Exertion in Soccer Players

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Purpose: To examine the effect of different exercise-intensity distributions within a training session on the session rating of perceived exertion (RPE) and to examine the timing of measure on the rating. ***Methods:*** Nineteen junior players (age 16 ± 1 y, height 173 ± 5 cm, body mass 64 ± 6 kg) from a Swiss soccer team were involved in the study. Percentage of heart rate maximum (%HR) and RPE (Borg CR100®) were collected in 4 standardized training sessions (conditions). The Total Quality of Recovery scale (TQR) and a visual analogue scale (VAS) for pain of the lower limbs were used to control for the effect of pretraining fatigue. Every session consisted of three 20-min blocks of different intensities (ie, low-moderate-high) performed in a random order. RPE was collected after every block (RPE5), immediately after the session (RPE-end), and 30 min after the session (RPE30). ***Results:*** RPE5s of each block were different depending on the distribution sequence ($P < .0001$). RPE-end, TQR, and VAS values were not different between conditions ($P = .57$, $P = .55$, and $P = .96$, respectively). The %HR was significantly different between conditions ($P = .008$), with condition 3 higher than condition 2 (74.1 vs 70.2%, $P = .02$). Edwards training loads were not significantly different between conditions ($P = .09$). RPE30 was not different from RPE-end ($P > .05$). ***Conclusions:*** The current results show that coaches can design training sessions without concern about the influence of the within-session distribution of exercise intensity on session-RPE and that RPE can be collected at the end of the session or 30 min later.

Keywords: RPE timing, small-sided games, football, training load, session-RPE

To control the training process, it is important that both the internal training load and the outcomes of this stress be measured.[1] Internal training load is quantified from measurements of exercise intensity (physiological stress) and training duration. While the duration of a training session can be easily measured, exercise intensity can be quantified using many different indicators (eg, heart rate [HR], lactate, rating of perceived exertion [RPE]).[2] The session-RPE method is a common approach used to quantify internal training load and uses athletes' RPE as the indicator of exercise intensity. This method is now frequently used to monitor training load during a variety of physical activities,[3] and it has specifically been validated in soccer.[4–6] Indeed, the session-RPE is now widely used to monitor the loads imposed on soccer players during training, as it has been validated for both soccer-specific activities (ie, small-sided games [SSG]) and also more generic exercise modes (ie, resistance and sprint training) that are commonly used to physically prepare soccer players for competition.[4,7,8]

The session-RPE method requires players to rate the overall intensity of a session, based on their perceived exertion referred to the whole training session. It was originally recommended by Foster et al[5] (the developer of this method) that the athletes' RPE be provided ~30 minutes after the end of the session. This recommendation was made to mitigate the influence of the intensity of activities completed toward the end of the training session on the overall perceptions of exercise intensity. However, recent studies that have examined the influence of the activities completed toward the end of training sessions on the overall session-RPE have shown contradictory results. For example, Kilpatrick et al[9] suggested that the RPE of the session is influenced by the intensity of the last part of exercise performed. Indeed, after 30 minutes of self-regulated aerobic exercise performed on a treadmill, the session-RPE values were similar to the RPE collected near the end of the exercise and different from the average RPE of the trial. In contrast, Hornsby et al[10] found that session-RPE was not influenced by RPE experienced during the last part of endurance-cycling sessions. In that study, the warm-up and cooldown sections of 2 cycling sessions were manipulated to provide high or low terminal perceptions and different intensity distribution (but equated for duration and work volume). The 2 sessions showed RPE after 20 minutes to be different from the RPE collected in the terminal part of the exercise, suggesting that the 2 ratings were disconnected. To our knowledge no published studies have examined the effects of different intensity distributions within a training session on the session-RPE in soccer players.

The use of a latent period of 30 minutes when applying the session-RPE method is based on the assumption that the latency effect exists and that the RPE values taken at 30 minutes are less influenced by the intensity of exercise completed during the final stages of a training session. Assessment after 30 minutes can be impractical, however, as athletes and coaches often do not have time to wait 30 minutes before providing their rating. To address this issue, a recent study reported no differences between RPE values

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collected 10 and 30 minutes after boxing-training sessions of different intensity, suggesting that a latent period of the full 30 minutes may not be necessary.[11] At present, however, it is not known if the distribution of training intensity within a training session affects RPE values taken after soccer training or if the timing of collecting RPE affects players' ratings. Therefore the aim of this study was to examine whether the manipulation of the exercise-intensity distribution during a soccer session would affect the RPE reported immediately and 30 minutes after the end of the training.

Methods

Subjects and Design

Swiss youth soccer players (N = 24, age 16 ± 1 y, height 173 ± 5 cm, body mass 64 ± 6 kg) from the same second-division team participated in the study. Before data collection, players completed the Yo-Yo Intermittent Recovery Test level 1 to determine their peak HR.[12] Briefly, the players completed 20-m shuttle runs at increasing velocity with 10 seconds of active recovery between runs until exhaustion. The test started with 4 running bouts at 10 to 13 km/h followed by another 7 bouts at 13.5 to 14 km/h, which continued with increments of 0.5 km/h every 8 running bouts until exhaustion. The test was terminated when the players were not able to arrive at the marked finishing line on 2 consecutive occasions. Consistent verbal encouragement was given to participants during the test by the fitness coach of the team. After the test, players were randomly divided in 2 groups using an online tool (www.randomizer.org).

Both groups completed 4 standardized training sessions, once per week, over 4 weeks in a random order. Each training session consisted of a standardized 20-minute warm-up (running, light-intensity movement, lower-limb stretching, and agility exercises) followed by three 20-minute blocks of different intensities: low intensity (LO), moderate intensity (MOD), and high intensity (HIGH). Four conditions with different intensity distributions were created by placing the HIGH block at the beginning (condition 1), in the middle (2 conditions: MOD-HIGH-LO and LO-HIGH-MOD, condition 2 and condition 3, respectively), and at the end of the session (condition 4) (Figure 1).

The study was completed during the in-season period to avoid any potential influence of preseason training-induced changes in fitness. All experimental sessions were completed once a week at the same time in the morning. The study was approved by the ethics committee of the University of Verona, and informed consent was provided by all participants and their guardians.

Training Session. The HIGH block consisted of 3-a-side SSG.[13] The field dimensions (30 × 18 m), the number of bouts (n = 3), the bout and recovery duration (4 min with 4 min of recovery), and the rules were kept constant during all the experimental sessions. The 3-a-side SSG was performed with goalkeepers and prompt replacement of the balls when they were kicked out of the field. Only 2 touches of the ball were allowed, and consistent coach

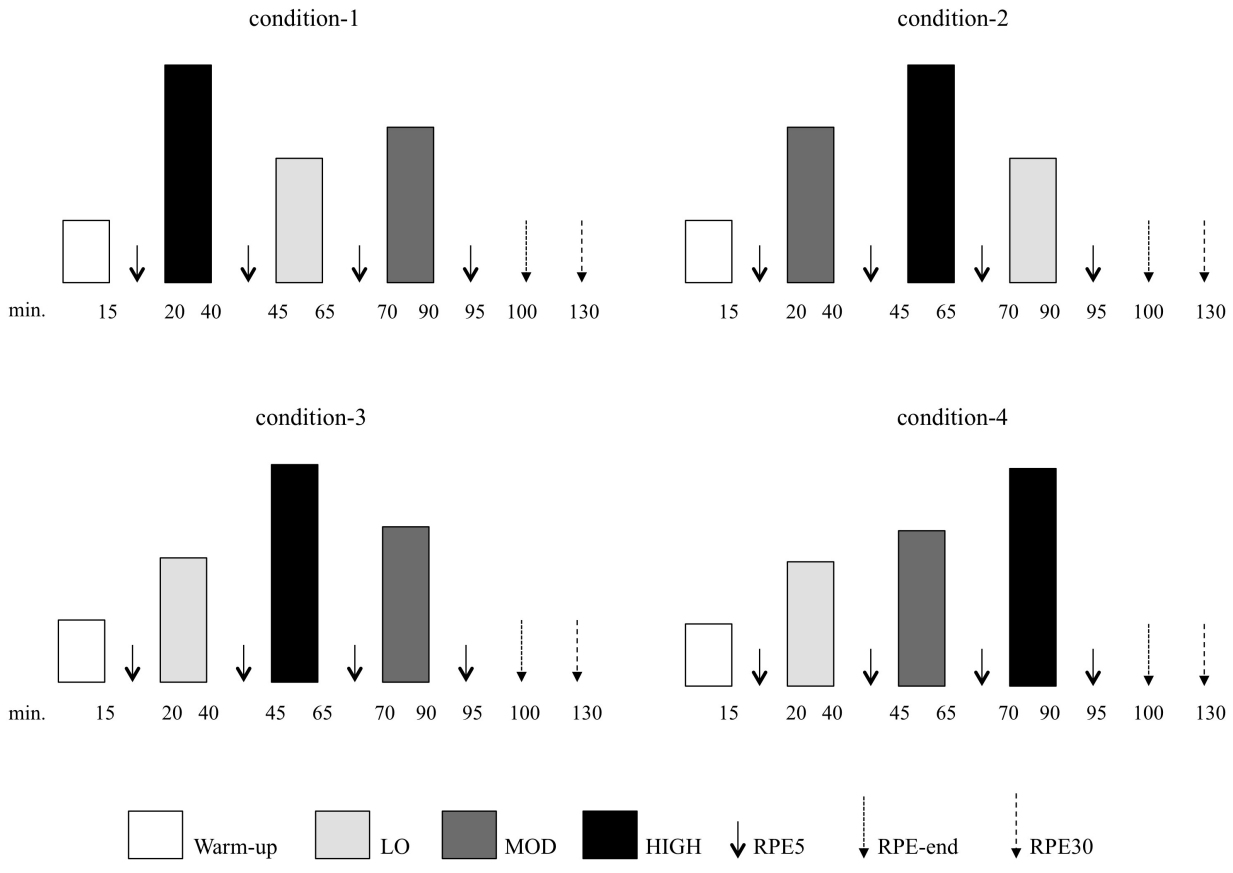

Figure 1 — Schematic representation of the study. Abbreviations: LO, low intensity; MOD, moderate intensity; HIGH, high intensity; RPE5, rating of perceived exertion after every block; RPE-end, RPE after the session; RPE30, RPE 30 minutes after the session.

encouragement was provided throughout.[14] The MOD block consisted of a soccer drill involving 3 teams of 4 players at the same time. The field dimensions (25 × 12 m), number of bouts (n = 5), the bout and recovery duration (3 min with 1 min recovery), and rules were kept constant during all sessions. The drill consisted of 8 versus 4 players with 4 forwards and 4 floaters playing versus 4 defenders. The main aim of the SSG was to move the ball to and from each side of the pitch while maintaining possession of the ball. The LO block consisted of individual technical exercises such as dribble, pass, and running with the ball. A 5-minute recovery period was provided after every block. The intensity of the drills was monitored via HR telemetry.

Training-Load Stress Assessment. Before each session, every player's recovery status was checked using the Total Quality Recovery scale (TQR) and a rating of lower-limb soreness.[15,16] Players were provided a rating of perceived quality of recovery using a scaling ranging from 6 (worst) to 20 (best). In addition, a 10-cm visual analog scale (VAS)[17] with the 2 descriptors *no pain* and *worst possible pain* at the upper and lower limits was also used to assess perceived soreness in the lower limbs. HRs were collected during both Yo-Yo Intermittent Recovery Test and all training sessions using a long-range telemetry system (Polar Team^2 Pro System, Polar Electro Oy, Kempele, Finland) that enabled real-time exercise-intensity checking and expressed as a percentage of the peak HR (%HR). The HR-based method described by Edwards[18] was used to assess internal training load. The Edwards training-load values were determined with the product of the accumulated training duration (minutes) in 5 %HR zones by a coefficient relative to each zone (50–60%HR = 1, 60–70%HR = 2, 70–80%HR = 3, 80–90%HR = 4, 90–100%HR = 5), and then summating the results.

The RPE values were collected with the Borg CR100 scale, which has been previously validated as a measure of exercise intensity in team sports.[19] Players were accustomed to the Borg scale and familiar with the CR100, as it was used in their routine training-load monitoring.[5,6] The RPE for every block (RPE5) was collected during the 5 minutes of recovery between different exercises (Figure 1). To investigate the timing effect on session-RPE, the rating was collected at the end of the session (RPE-end) and 30 minutes after the session (RPE30).

Statistical Analysis

Data are presented as mean ± SD. Variables were log-transformed to control for nonuniformity of residuals. An unpaired *t* test was used to assess differences between the distances covered in the Yo-Yo Intermittent Recovery Test level 1 in the 2 groups after randomization. The assumption of sphericity was verified with the Mauchley test. Where violated, the critical *F* value was adjusted by the Greenhouse–Geisser epsilon value to reduce the risk of type 1 error. The differences in TQR and VAS values were analyzed with a 1-way ANOVA. To examine the effect of different intensity distributions on RPE, a time (5 levels) × condition (4 levels) factorial design was used and repeated-measures ANOVA was completed. Between-conditions differences in the RPE-end and Edwards training loads were analyzed with repeated-measures ANOVA. To examine the effect of delay on session-RPE, a time (2 levels: RPE-end and RPE30) × condition (4 levels) factorial design (within subjects) was used. Effect size (partial eta-squared [η^2]) was also calculated, and values of .01, .06, and above .15 were considered small, medium, and large, respectively. The level of statistical significance was set at $P < .05$. Statistical analyses were performed using SPSS software (SPSS Statistics 17.0, SPSS Inc, Chicago, IL).

Results

Subjects and Fitness Level

From the 24 subjects involved in the study, 5 players were excluded from the final analysis as they had incomplete data for all experimental conditions. Due to technical failure of the HR belts from 7 subjects in different sessions, these data were excluded from HR analysis. The 19 players participating in every condition were included in the final analysis.

The distance covered in the Yo-Yo Intermittent Recovery Test level 1 for all participants was 2083 ± 349 m, and there were no significant differences ($P = .83$) between the 2 groups after randomization (2067 ± 348 vs 2100 ± 380 m). The peak HR attained in the Yo-Yo Intermittent Recovery Test Level 1 was 199 ± 6 beats/min. The mean %HR during the different blocks was 63% (range 61–65%) in the warm-up, 73% (range 71–75%) in the LO, 76% (range 73–80%) in the MOD, and 90% (range 89–91%) in the HIGH block.

Training-Load Stress Assessment

All physiological and perceptual data are presented in Table 1. Values collected with TQR and VAS scales were not substantially different between sessions ($P = .55$, partial $\eta^2 = .04$, and $P = .96$, partial $\eta^2 = .007$, respectively). The mean %HR was significantly different between conditions ($P = .008$, partial $\eta^2 = .32$). Post hoc analysis showed that condition 3 was higher than condition 2 (5.6%, CI 90% 1.4–10.1, $P = .02$). Edwards training loads were not significantly different between conditions ($P = .09$, partial $\eta^2 = .18$).

A significant time × condition interaction was found in RPE5 ($P < .0001$, partial $\eta^2 = .60$). No significant differences were found between RPE5 assessed after warm-up ($P = .19$, partial $\eta^2 = .08$), LO ($P = .36$, partial $\eta^2 = .06$), and HIGH ($P = .31$, partial $\eta^2 = .06$) in the 4 conditions. The RPE5 of the MOD block was significantly different between conditions ($P = .03$, partial $\eta^2 = .18$, after Greenhouse-Geisser adjustment), with post hoc analysis showing that condition 2 was higher than condition 1 (16%, CI 90% 2–32; $P = .05$). RPE-end was not significantly different in the 4 conditions ($P = .57$, partial $\eta^2 = .04$) (Table 1).

Time-Collection Effect on RPE

The effect of time on session-RPE is shown in Table 1. There was no significant time × condition interaction ($P = .38$, partial $\eta^2 = .05$) for session-RPE ratings. Moreover, the main factors for time ($P = .61$, partial $\eta^2 = .01$) and condition ($P = .09$, partial $\eta^2 = .11$) were not significant. There was, however, a strong trend ($P = .05$) showing a higher RPE30 in condition 4 (15%, CI 90% 2–30) than in condition 3.

Discussion

The aims of this study were to examine the effect of different exercise-intensity distributions within a training session on the session-RPE and the timing of measure on the rating. The results showed that the manipulation of the intensity distribution during the soccer-training sessions did not affect the RPE reported immediately at the end of the training session (ie, RPE-end). Moreover, session-RPE was not influenced by the timing of measure either immediately or 30 minutes after soccer-specific training sessions.

The current study is the first to examine the effect of different intensity distribution on session-RPE in soccer players, and for this

Table 1 Physiological and Perceptual Data in the 4 Conditions (Mean ± SD)

Variable	Condition 1, MOD-HIGH-LO	Condition 2, LO-MOD-HIGH	Condition 3, HIGH-LO-MOD	Condition 4, LO-HIGH-MOD
Total Quality Recovery scale (n = 18)	14.6 ± 1.5	13.8 ± 1.5	14.1 ± 1.5	14.2 ± 1.6
Visual analogue scale (n = 18)	1.6 ± 0.8	1.8 ± 0.7	1.7 ± 0.7	1.7 ± 0.6
% of peak heart rate (n = 12)	71.8 ± 2.6	70.2 ± 4.0	74.1 ± 2.8#	72.8 ± 4.5
Edwards training loads (n = 12)	257 ± 43	260 ± 45	274 ± 37	274 ± 34
RPE5 warm-up (n = 19)	16.0 ± 5.6	13.5 ± 4.6	14.0 ± 4.5	15.6 ± 3.8
RPE5 LO (n = 19)	26.0 ± 8.5	25.3 ± 6.9	29.8 ± 10.1	26.9 ± 7.3
RPE5 MOD (n = 19)	29.5 ± 7.9	33.7 ± 7.0*	32.8 ± 7.4	38.5 ± 12.8
RPE5 HIGH (n = 19)	56.7 ± 13.2	53.8 ± 12.4	50.7 ± 14.5	53.0 ± 12.7
RPE-end (n = 19)	47.5 ± 15.2	47.7 ± 12.3	46.3 ± 11.5	51.2 ± 15.3
RPE30 (n = 19)	47.4 ± 12.1	47.5 ± 12.0	42.4 ± 8.1	51.7 ± 12.3

Abbreviations: LO, low intensity; MOD, moderate intensity; HIGH, high intensity; RPE5, rating of perceived exertion of warm-up; RPE-end, RPE at end of session; RPE30, RPE 30 min after the session.

*Significantly higher RPE5 than in condition 1. #Significantly higher % of peak heart rate in condition 3 than in condition 2.

reason comparison with previous literature is limited. Nevertheless, our results are comparable to those found in research on cycling. For example, Hornsby et al[10] suggested that the perceived exertion at the end of the last activity performed in a cycle-training session should not been considered a confounding factor for assessment of the overall session-RPE. In that previous study the warm-up and cooldown were manipulated to obtain 2 cycling protocols of the same work volume but with different intensity distribution.[10] In contrast, Kilpatrick et al[9] reported that session-RPE was affected by the perceived intensity taken during the final part of a 30-minute running bout. In that study, RPE was collected 15 minutes after a 30-minute self-regulated treadmill running bout at either light, moderate, or vigorous intensity. The results demonstrated that the runners' final RPE was better related to the last part of the exercise than the average RPE. However, a limitation of that study was the order effect of the progressive intensity used in each running trial, which may have influenced the final ratings of RPE taken after the bout.

Another main finding of the current study was that the session-RPE collected immediately at the end of a soccer-specific training session is not different from session-RPE values taken 30 minutes later. These results agree with 2 previous studies showing that session-RPE values taken either 15 or 30 minutes after resistance-training sessions were not significantly different.[20,21] Moreover, Uchida et al[11] also recently demonstrated that RPE was not different when measured after 10 versus 30 minutes in boxing-training session of various intensities. When taken collectively with previous research, it appears that athletes are not required to wait 30 minutes before providing a session-RPE to achieve measurement accuracy.

In the current investigation, different distributions of training intensity for each session were obtained by changing the placement of the HIGH block within the training set. A player's recovery, fatigue, and lower-limb soreness before training could affect both RPE-end and RPE5. However, both the TQR and VAS values taken before each training session in the current study showed that the players were in the same physical condition before all the sessions.

In general, the perceptual and physiological measures of intensity between the 4 different sessions were similar. Indeed, there were no significant effects of the position of the HIGH block within the training session on RPE-end. In addition, with the exclusion of condition 3 being higher than condition 2, the average %HR between the experimental conditions were similar. The difference in %HR observed in this study is likely explained by differences in technical ability and/or fitness levels between the players, and this has been suggested to be a limitation in the use of SSG.[13] Notably, however, the differences observed between conditions 2 and 3 were not substantial, and this was further supported by the similar values for Edwards training loads for these conditions. Similarly, the RPE5 of the MOD block in session 2 was slightly higher (16%) than in condition 1. Again, this difference was not substantial and likely of limited physiological consequence. Moreover, the differences in %HR and RPE5 that were observed within the conditions have been suggested to affect RPE-end[5]; however, the current findings did not reveal such effects. These results suggest that there is only a small influence of differences of the within-session measures of internal load (ie, HR or RPE) on overall RPE during soccer-specific training.

Practical Application

The current results show that soccer coaches can design training sessions without specific concern about the effect of different intensity distributions on the overall session-RPE. Indeed, these results show that, if carefully planned, periods of high intensity can be placed at various phases within a session without effect on the overall perceived training loads. For example, coaches can be confident that if blocks of high-intensity SSG are performed after lower-intensity tactical exercises, overall session-RPE values will not be influenced. Moreover, they can also be confident that session-RPE values collected either close to the cessation of training or 30 minutes later as originally recommended provide similar information regarding the perceived training intensity of soccer-specific training sessions. In addition, the RPE collected at the end of the session may be a time-efficient approach for monitoring players, especially since it allows players and coaching staff to leave training sooner or spend additional time on recovery activities.

Conclusions

This study shows that RPE can be collected either at the end of training or after 30 minutes without concern about the influence of within-session distribution of exercise intensity.

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