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Research article

Effects of Small-Sided Games and High-Intensity Interval Training on The Rating of Perceived Exertion in Soccer Players Across Competitive Levels: Controlling for Percentage of Heart Rate Reserve

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Abstract

This study investigated perceived exertion (RPE) differences among soccer players at two competitive levels - Tier 2 (trained) and Tier 3 (highly trained) - during small-sided games (SSGs) and high-intensity interval training (HIIT), while controlling for internal physiological load using percentage of heart rate reserve (%HRreserve). Seventy-seven male university players from the China University Football Association participated (Tier 2: n = 37; Tier 3: n = 40). Each player underwent a fitness assessment to determine HRmax and HRrest, followed by four randomized training sessions: 5v5 SSGs, 1v1 SSGs, long HIIT, and short HIIT. Heart rate was continuously monitored, and players reported RPE using the Borg CR10 scale immediately post-session. A linear mixed-effects model was used, with competitive level and training format as fixed effects, and %HRreserve included as a statistical covariate. The analysis revealed a significant interaction between training format and competitive level ($F(3, 224.761) = 3.20$, $p = .024$), indicating that the influence of training format on RPE varied by competitive level. A significant main effect of training format was also found ($F(3, 234.484) = 11.24$, $p < .001$). Specifically, Tier 3 players reported higher RPE during short HIIT than Tier 2 players ($p = .002$). Both groups reported lower RPE during 5v5 SSGs compared to 1v1 SSGs and HIIT formats (all $p \leq .003$). These findings show that training format influences RPE in a format- and tier-specific manner, even when accounting for internal physiological load. For coaches and sports scientists, larger-sided SSGs may be useful to reduce perceived exertion while maintaining cardiovascular demand. Future research should include elite players and assess psychological and physiological mediators to better understand the complex drivers of perceived effort.

Key words: Football, effort, sided games, interval training, load monitoring.

Introduction

Modern soccer is a high-intensity, intermittent sport that demands quick decision-making, explosive power, endurance, and tactical execution. Match analyses indicate that players operate at 80 - 90% of their maximal heart rate (HRmax) and engage in various activities, including short sprints, physical duels, directional changes, jumping, walking, and standing (Buchheit and Laursen, 2013; Paul et al., 2009; Stølen et al., 2005). Elite male players often cover 9 - 14 km during a match (Njororai, 2012), highlighting the significant physical demands of the sport. To meet these challenges, effective training strategies are essential. Soccer, widely played at the university level, involves athletes across various skill levels, with training drills designed to simulate the demands of a match. Small- and large-sided competitive drills are particularly effective in imposing high workloads across positions (Kupperman et al., 2021). Aerobic training plays a critical role in soccer performance by improving the distance covered, high-intensity play, and ball touches (Njororai, 2012). Additionally, body composition is a key factor, with fat mass directly influencing speed and overall physical performance (Ceballos-Gurrola et al., 2020).

Perceived exertion (RPE) is a key concept in sports science, providing a subjective measure of exercise intensity that integrates both physiological and psychological factors (Buckley and Eston, 2022). Developed by Gunnar Borg, RPE has become a versatile tool for assessing and regulating exercise intensity, widely used across different populations and sports, including soccer (Eston, 2012; Lopes et al., 2022). In soccer, RPE plays an essential role in monitoring training intensity, helping coaches optimize performance and minimize the risk of overtraining (Impellizzeri et al., 2005). Given the intermittent nature of the sport, which involves bursts of high-intensity activity such as sprints and directional changes, RPE provides valuable insights into how players perceive and manage the demands of the game (Stølen et al., 2005). Studies have shown a strong correlation between RPE and physiological markers such as heart rate, making it a reliable method for analyzing training load in soccer players (Buchheit, 2014; Izzo and Giovannelli, 2018). In elite soccer players, RPE has been found to strongly correlate with heart rate, with a high within-participant correlation ($r = 0.75$) across different playing positions, further validating its use in assessing training intensity (Kelly et al., 2016). By understanding the relationship between RPE, training format, and player characteristics, coaches can better tailor training programs to enhance performance and maintain players' well-being (Halson, 2014).

The control of physiological load during training is essential for optimizing performance and preventing overtraining. One of the most effective methods for monitoring internal load is the use of heart rate reserve (%HRreserve),

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which represents the difference between an athlete's maximal heart rate (HRmax) and resting heart rate (HRrest) (Pind and Mäestu, 2018). This approach provides a more accurate reflection of exercise intensity relative to an individual's cardiovascular capacity than heart rate alone (Buchheit, 2014).In soccer, monitoring %HRreserve allows coaches to assess cardiovascular load and adjust training intensity to optimize performance while minimizing injury risks (Impellizzeri et al., 2005). For instance, external-to-internal load ratios, such as PlayerLoad to %HRreserve, showed moderate-to-large correlations with fitness parameters and demonstrated acceptable reproducibility(Schimpchen et al., 2023). These findings underscore the reliability of %HRreserve as a tool for assessing exercise intensity, as it allows coaches and researchers to more precisely gauge the individual cardiovascular load and adjust training accordingly.

Small-sided games (SSGs) and high-intensity interval training (HIIT) are both effective methods for improving soccer performance, each offering distinct advantages. SSGs are more enjoyable and motivating for young players, fostering better mood balance and greater perceived enjoyment compared to HIIT (Ouertatani et al., 2022; Selmi et al., 2020)They are particularly effective for enhancing technical skills, agility, and maintaining player engagement. On the other hand, HIIT excels in speed-based conditioning and endurance, making it more suited for developing high-intensity performance (Arslan et al., 2020). Both methods lead to similar improvements in aerobic capacity and high-intensity intermittent performance, with comparable physiological responses in heart rate, blood lactate, and rating of perceived exertion (RPE) (Ouertatani et al., 2022; Selmi et al., 2020). However, neither approach alone significantly improves repeated sprint ability, suggesting that combining SSGs and HIIT may be necessary for a more comprehensive training strategy. Measuring RPE is essential in both methods to assess intensity and ensure proper training loads for optimal performance outcomes (Clemente et al., 2021a; Selmi et al., 2020).

The increasing demand for high performance in soccer has highlighted the need for effective and individualized training strategies. Understanding how different training formats and intensity levels impact players' physiological and perceptual responses is essential for optimizing performance while reducing the risk of overtraining and injury. While previous studies have provided valuable insights into soccer training, many have not strictly controlled for internal load when assessing the effects of various training formats on perceived exertion (RPE) (Conte et al., 2023; Follador et al., 2018; Gantois et al., 2023; Muñoz-Chavez et al., 2015). As a result, observed differences in RPE across training formats may stem from variations in physiological load or external factors (e.g., temperature, intervals), rather than the training format itself (Yoder et al., 2025). To address this gap, the present study uses %HRreserve as a valid measure of internal load, which is significantly correlated with RPE (Romero-Caballero and Angel Campos-Vazquez, 2020).By controlling for internal load, this study ensures that any RPE differences reflect the true effects of training format rather than uncontrolled physiological variations. Moreover, while previous research has compared RPE differences between competition and training in professional soccer players, it did not account for consistent training conditions across competitive levels (Jose Gomez-Diaz et al., 2013). The current study improves upon these methodologies by having Tier 2 and Tier 3 athletes (McKay et al., 2022a) train under the same conditions, providing a more accurate and controlled comparison of RPE across competitive levels. By implementing stricter internal load control and examining competitive-level differences, this study offers a more precise understanding of how training formats affect RPE. These findings are critical for helping coaches optimize training intensity and load management strategies for players at different competitive levels, ensuring both performance gains and athlete well-being.

This study aims to evaluate differences in RPE scores among soccer players at the Tier 2 and Tier 3 competitive levels across various SSG and HIIT formats while controlling for %HRreserve. We hypothesize that training format will significantly influence RPE, with Tier 3 players reporting higher RPE scores for certain formats (e.g., short HIIT), potentially due to the increased intensity of these exercises relative to their conditioning. However, Tier 3 players may report lower RPE in other formats, potentially reflecting greater physiological adaptation and higher fitness levels.

Methods

Study design

This study employed a repeated-measures design to examine the effects of different training formats (5v5 SSGs, 1v1 SSGs, long HIIT, and short HIIT) and competitive levels (Tier 2 and Tier 3) on RPE in young adult male soccer players. Using convenience sampling, participants were recruited from four teams in the China University Football Association (CUFA) with two Tier 2 teams and two Tier 3 teams.

The experiment was conducted over two weeks, with each team completing one fitness assessment and four training sessions. The fitness assessment was performed before training interventions. To ensure consistency in the experimental conditions, all assessments and training sessions were conducted on an outdoor artificial grass pitch between 16:00 - 18:00 and under similar weather conditions.

To minimize bias from different training formats, participants within each team were randomly assigned into two subgroups (Group A & Group B, n = 10 per group) using a randomization tool (Research Randomizer, www.randomizer.org), a web-based application designed to generate random sequences for group allocation in experimental research. Each subgroup followed a different training order, and teams from the same competitive level also received a different training order, ensuring that training sequences varied not only within teams but also between the two levels of competition. During training sessions, players' HRs were continuously monitored to record internal loads. After each session, players reported the rating of RPE. Figure 1 illustrates the repeated-measures design of the present study.

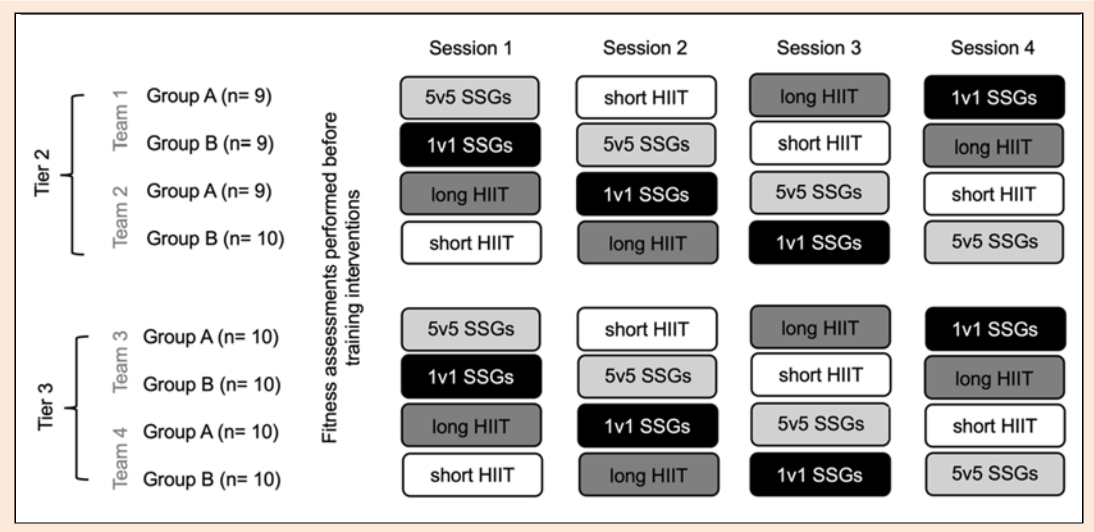

Figure 1. Representation of the study design.

This study was conducted in accordance with the principles of the Declaration of Helsinki. Ethical approval was granted by the Medical Ethics Committee of Xiamen (Approval Number: XDYX202406K34). All participants provided written informed consent before the experiment. Participation was entirely voluntary, and players could withdraw at any time without penalty.

Participants

The required sample size was computed a priori using G*Power (version 3.1.9.7) for a repeated-measures ANOVA with within-between interaction. Based on parameters including a medium effect size (f = .25), α = .05, power (1 - β) = .80, and ε = .75 nonsphericity correction, the analysis indicated a minimum of 44 participants. Anticipating potential attrition, we enrolled 80 individuals initially. After excluding 3 participants who missed experimental sessions, the final analyzable sample comprised 77 subjects. Demographic characteristics are detailed in Table 1.

Table 1. Characteristics of participants.

Characteristic	Competitive level	
	Tier 3 (N = 40)	Tier 2 (N = 37)
Age (years)	20.90 ± 1.72	20.35 ± 1.34
Height (cm)	180.78 ± 5.50	178.49 ± 4.85
Weight (kg)	73.15 ± 6.49	70.19 ± 6.29
BMI (kg/m²)	22.36 ± 1.34	22.04 ± 1.89
HRrest (bpm)	53.83 ± 5.51	58.65 ± 3.16
HRmax (bpm)	188.98 ± 6.69	187.68 ± 5.27
V_{IFT} (km/h)	20.03 ± 1.68	19.22 ± 1.04

BMI = Body Mass Index; HRrest = Resting Heart Rate; HRmax = Maximum Heart Rate; V_{IFT} = 30-15 Intermittent Fitness Test Speed.

Convenience sampling was used to recruit teams that met the inclusion criteria of (i) actively competing in the Chinese University Football Association (CUFA) and (ii) having at least 20 available players per team. Two teams were recruited from the CUFA Provincial League (Division 4), which represents a regional-level competition. These players train regularly at least three times per week. Two additional teams were recruited from CUFA Super Champions League (Division 1) and CUFA League One (Division 2), both of which are national-level competitions. These players participate in structured and periodized training, approaching the maximum training volume for soccer. Based on the six-level athlete classification framework (Tier 0~5) (McKay et al., 2022b), players in CUFA Division 4 were classified as Tier 2 (trained/developmental), while players in CUFA Division 1 and 2 were classified as Tier 3 (highly trained/national level). These two tiers were selected to allow comparison between athletes with distinct competitive experience and training exposure, while avoiding extreme performance discrepancies that might exist between novice or elite-level groups.

The inclusion criteria included: (i) players participating in the same training session belonged to the same team; (ii) no injury or illness reported within one month before and during the study; (iii) no physical or cognitive disorders reported; (iv) no use of performance-enhancing drugs or medications; (v) no alcohol consumption within one month before the study. The exclusion criteria included: (i) lack of regular attendance in training sessions; (ii) players who developed illness or injury during the study period.

Anthropometric measurement

Players were measured while barefoot and wearing a t-shirt and shorts. Standing height (cm) was assessed using a SECA 213 stadiometer (Seca GmbH & Co. KG, Hamburg, Germany), and body weight (kg) was measured using a Tanita BC-558 digital scale (Tanita Corporation, Tokyo, Japan). After the anthropometric measurements, players rested in a supine position for 10 minutes, and the lowest recorded HR during this period was considered as the HRrest (Dellal et al., 2008, 2010; Young and Leicht, 2011).

Fitness assessment

To ensure accurate results, players were instructed to refrain from strenuous exercise for 48 hours before testing. All tests were conducted outdoors on artificial grass between 16:00 and 18:00, under an average temperature of 22.0 ± 2.45°C and relative humidity of 54.0 ± 19.06%. Prior to testing, players completed the FIFA 11+ standardized warm-up (Level 3), followed by a 3-minute passive recovery period to ensure readiness. The test protocol used was the 30 - 15 Intermittent Fitness Test (30 - 15_{IFT}). Studies have demonstrated high test-retest reliability for end-running speed, maximal heart rate, and VO_2max (Paravlic et al., 2022), in basketball players (Jeličić et al., 2020), and in soccer players (Čović et al., 2016). The test has demonstrated strong criterion validity through significant correlations with laboratory-based measures and its sensitivity to meaningful performance changes, with improvements of 0.5 - 1.0 km/h considered significant (Čović et al., 2016; Jeličić et al., 2020).

Players performed 30-second shuttle runs between 40-meter lines at progressively increasing speeds, with 15-second recovery periods in between. The test continued until a player failed to maintain the required pace for three consecutive attempts. The velocity at the final completed stage was recorded as V_{IFT} (Buchheit et al., 2010). Research has shown that, compared to continuous aerobic tests, intermittent aerobic tests provide a better estimation of HRmax in activities similar to soccer (Buchheit, 2008; Krustrup et al., 2003). This is because they share the same intermittent nature as football matches. Therefore, the highest HR measured by the player during this test was recorded as the HRmax. This test was conducted solely for HRmax measurement and HIIT program individualization and was not included in the study's analysis, as it fell beyond the research scope.

Training Intervention

The training protocol consisted of two SSGs formats (5v5 and 1v1) and two HIIT formats (long and short). The detailed design of each format is summarized in Table 2. Prior to each training session, players completed the FIFA 11+ standardized warm-up (Level 3), followed by a 3-minute passive recovery period. All training sessions were conducted outdoors on artificial grass at a fixed time (16:00 - 18:00) under consistent weather conditions (23.19 ± 3.06°C and 59.25 ± 22.99% relative humidity). During HIIT sessions, players ran at 80% (long HIIT) or 95% (short HIIT) of their V_{IFT}. The use of V_{IFT} was intended to equalize EI across players with different fitness levels. In SSGs sessions, each player was allocated a 175 m² playing area, a dimension designed to optimize player involvement, decision-making opportunities, and movement intensity, as used in previous research on SSGs (Riboli et al., 2020). Goalkeepers were excluded from the study due to their distinct training demands. Players were instructed to exert maximum effort and maintain ball possession for as long as possible. To ensure continuous play, two coaches positioned around the pitch provided new balls whenever necessary.

To promote consistent effort and tactical engagement across SSG conditions, standardized verbal encouragement was provided by coaches throughout all sessions. Additionally, players were familiarized with the SSG formats during preliminary training to minimize variability in tactical understanding and behavior. Match-ups were balanced in terms of playing ability within each team to reduce variability caused by opposition quality. Each SSG was preceded by a clear briefing outlining the objectives (e.g., maintain possession, apply pressure), which were kept consistent across sessions.

Percentage of HR reserve

HR data was continuously monitored using an optical HR monitor (INSAIT KS System, GenGee, China), which recorded HR throughout the entire training session, excluding the warm-up. %HRreserve was calculated using the following formula. (Karvonen et al., 1957):

$$\%\text{HRreserve} = \frac{\text{HRmean} - \text{HRrest}}{\text{HRmax} - \text{HRrest}} \times 100$$

The use of %HRreserve was important to provide a personalized and sensitive measure of cardiovascular load relative to each athlete's individual heart rate capacity. This allows for more accurate quantification of training intensity compared to using absolute heart rate values alone (Wolpern et al., 2015), enabling precise monitoring and adjustment of training loads tailored to each player's fitness level and physiological response.

Rating of perceived exertion

RPE was recorded immediately after each training session using the original Borg printed scale (Borg, 1998), a validated tool for reliably estimating perceived effort intensity in athletic populations. To minimize peer influence, players rated their exertion individually without discussing their scores. RPE have been shown to be valid and reliable for monitoring training load in soccer players (Atan et al., 2021; Little and Williams, 2007). Moreover, the numerically blinded RPE scale has shown concurrent and construct validity compared to traditional methods, reducing verbal anchor clustering and integer bias (Lovell et al., 2020).

Table 2. Design and conditions of SSGs and HIIT training formats.

	5v5 SSGs	1v1 SSGs	Long HIIT	Short HIIT
Work duration	4 × 4 min	8 × 1 min	4 × 4 min	8 × 1 min
Passive recovery	3 min between sets	2 min (5 min between 4th-5th sets)	3 min between sets	2 min (5 min between 4th-5th sets)
Session duration	25 min	25 min	25 min	25 min
Intensity	Maximal effort	Maximal effort	80% V_{IFT}	95% V_{IFT}
Pitch size	50 m × 35 m	25 m × 14 m	N/A	N/A
Total area	1750 m²	350 m²		
Area per player	175 m²	175 m²		
Goals	7-a-side goals	5-a-side goals		
Goalkeepers	Yes (excluded from analysis)	Yes (excluded from analysis)		
Task conditions	No offside rule	No offside rule		

SSGs = Small-Sided Games; HIIT = High-Intensity Interval Training.

The use of RPE in the present study is important to provide a simple, cost-effective, and individualized method to assess players' internal responses to training load. By capturing subjective perceptions of effort, RPE complements physiological measures and allows for better monitoring and adjustment of training intensity tailored to each athlete's experience, thereby enhancing the effectiveness of training interventions.

Statistical Analysis

In this study, two-tailed statistical tests were conducted with a significance threshold set at 0.05. All statistical analyses were conducted using R (Version 4.3.1; R Core Team, 2023) and RStudio (Version 2023.06.1+524; RStudio Team, 2023). A linear mixed-effects model (LMM) was fitted to examine the effects of competitive level (between-subject factor) and training format (within-subject factor) on RPE. Fixed effects included competitive level, training format, and their interaction (competitive level × training format), while %HRreserve was included as a time-varying covariate (i.e., session-specific values per participant) to control for its influence on perceived exertion. To account for inter-individual variability, random intercepts for participants were included as random effects in the model. Effect sizes (partial eta squared, η^2) were calculated for fixed effects to estimate the magnitude of observed differences. Results were reported as least squares means (LS means), 95% confidence intervals (CIs), coefficient estimates (β), standard errors (SE), t-values, F-values, p-values, and multiple comparisons were adjusted using the Bonferroni method.

Results

A two-way mixed ANCOVA using a LMM was conducted to examine the effects of training format (5v5 SSGs, 1v1 SSGs, long HIIT, short HIIT) and competitive level (Tier 3 vs. Tier 2) on RPE, while controlling for %HRreserve. The interaction effect between training format and competitive level was significant (F (3, 224.761) = 3.20, p = .024, η_p^2 = 0.041), indicating a medium-to-large effect size, and showing that RPE varied across different training formats. There was a significant main effect of training format on RPE (F (3, 234.484) = 11.24, p < .001, η_p^2 = 0.131), indicating that RPE varied across different training formats. The main effect of competitive level was not statistically significant (F (1, 82.651) = 2.85, p = .095), suggesting no overall difference in RPE between Tier 2 and Tier 3 players. These results were obtained after adjusting for the covariate, ensuring that the reported effects reflect differences in subjective exercise intensity independent of objective exercise intensity.

The covariate had a significant effect on RPE (F (1, 293.220) = 9.57, p = .002, η_p^2 = 0.081), which corresponds to a medium effect size, indicating that %HRreserve significantly influenced RPE. Figure 2 presents the descriptive statistics for %HRreserve across different training formats. The values were as follows: 5v5 SSGs - 67.44 ± 7.02% (Tier 3), 74.92 ± 5.31% (Tier 2); 1v1 SSGs - 62.26 ± 8.76% (Tier 3), 68.86 ± 7.51% (Tier 2); Long HIIT - 73.01 ± 6.66% (Tier 3), 77.13 ± 6.77% (Tier 2); and Short HIIT – 62.04 ± 7.40% (Tier 3), 65.83 ± 5.80% (Tier 2).

Figure 3 illustrates the significance of the difference in simple main effects. The descriptive statistics were as follows: 5v5 SSGs - 4.65 ± 1.29 (Tier 3; 95% CI: 4.22 to 5.08), 5.03 ± 1.07 (Tier 2; 95% CI: 4.67 to 5.39); 1v1 SSGs - 6.05 ± 1.30 (Tier 3; 95% CI: 5.61 to 6.49), 6.03 ± 1.05 (Tier 2; 95% CI: 5.67 to 6.39); Long HIIT - 6.23 ± 1.28 (Tier 3; 95% CI: 5.79 to 6.67), 5.86 ± 1.09 (Tier 2; 95% CI: 5.50 to 6.22); and Short HIIT - 5.80 ± 1.25 (Tier 3; 95% CI: 5.36 to 6.24), 4.43 ± 1.13 (Tier 2; 95% CI: 4.09 to 4.77).

For 5v5 SSGs, no significant difference was observed between Tier 3 and Tier 2 players (β = 0.005, 95% CI [-0.92, 0.93], p = .992). The effect size for this comparison was small (Cohen's d = 0.30). For 1v1 SSGs, no significant difference was found between groups (β = 0.360, 95% CI [-0.55, 1.27], p = .466). The effect size was negligible (Cohen's d = 0.02). For long HIIT, no significant difference was found (β = 0.571, 95% CI [-0.38, 1.52], p = .242). The effect size was small (Cohen's d = 0.30). For short HIIT, Tier 3 players reported significantly higher RPE than Tier 2 players (β = 1.562, SE = 0.485, 95% CI [0.605, 2.518], t = 3.218, p = .002), indicating that Tier 3 players perceived short HIIT as more intense. This difference corresponded to a large effect size (Cohen's d = 1.09).

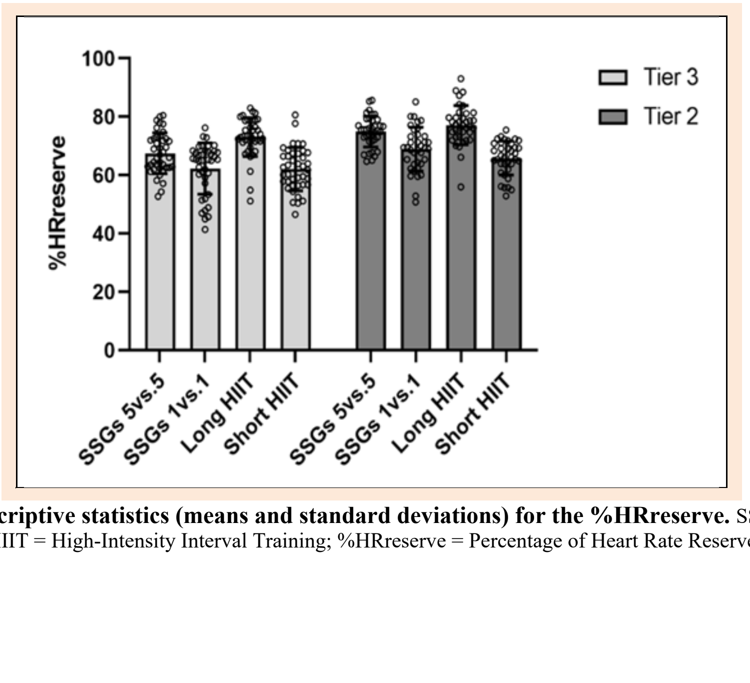

Figure 2. Descriptive statistics (means and standard deviations) for the %HRreserve. SSGs = Small-Sided Games; HIIT = High-Intensity Interval Training; %HRreserve = Percentage of Heart Rate Reserve.

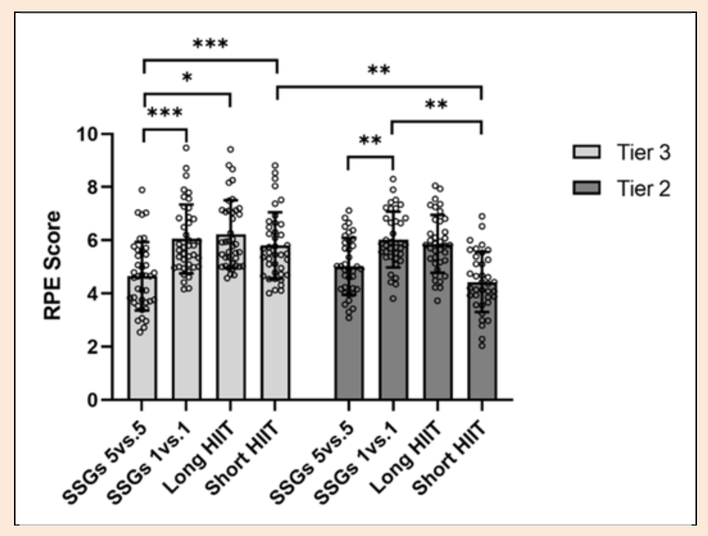

Figure 3. Simple main effects between and within groups on RPE score (LS means). *Denotes significance at p < 0.05; **Denotes significance at p < 0.01; ***Denotes significance at p < 0.001. SSGs = Small-Sided Games; HIIT = High-Intensity Interval Training; RPE = Rate of Perceived Exertion; LS means = least squares means.

For 5v5 SSGs, no significant difference was observed between Tier 3 and Tier 2 players (β = 0.005, 95% CI [-0.92, 0.93], p = .992). The effect size for this comparison was small (Cohen's d = 0.30). For 1v1 SSGs, no significant difference was found between groups (β = 0.360, 95% CI [-0.55, 1.27], p = .466). The effect size was negligible (Cohen's d = 0.02). For long HIIT, no significant difference was found (β = 0.571, 95% CI [-0.38, 1.52], p = .242). The effect size was small (Cohen's d = 0.30). For short HIIT, Tier 3 players reported significantly higher RPE than Tier 2 players (β = 1.562, SE = 0.485, 95% CI [0.605, 2.518], t = 3.218, p = .002), indicating that Tier 3 players perceived short HIIT as more intense. This difference corresponded to a large effect size (Cohen's d = 1.09).

For Tier 3 players, RPE was significantly lower in 5v5 SSGs compared to 1v1 SSGs (β = -1.665, SE = 0.373, t = -4.462, p < .001) and long HIIT (β = -1.665, 95% CI [-2.42, -0.91], SE = 0.373, t = -4.462, p < .001) and long HIIT (β = -1.290, 95% CI [-2.05, -0.53], SE = 0.375, t = -3.444, p = .001). Similarly, 5v5 SSGs also elicited a significantly lower RPE than short HIIT (β = -1.426, 95% CI [-2.18, -0.67], SE = 0.374, t = -3.813, p < .001). However, no significant differences in RPE were observed between 1v1 SSGs and long HIIT (β = 0.374, 95% CI [-0.74, 1.49], p = .533), 1v1 SSGs and short HIIT (β = 0.238, 95% CI [-0.87, 1.34], p = .614), or long HIIT and short HIIT (β = -0.136, 95% CI [-1.24, 0.97], p = .738).

For Tier 2 players, 5v5 SSGs resulted in significantly lower RPE compared to 1v1 SSGs (β = -1.310, 95% CI [-2.28, -0.34], SE = 0.391, t = -3.352, p = .003). However, no significant differences were found between 5v5 SSGs and long HIIT (β = -0.725, 95% CI [-1.68, 0.23], SE = 0.379, t = -1.911, p = .086) or 5v5 SSGs and short HIIT (β = 0.130, 95% CI [-0.80, 1.06], p = .749). Additionally, 1v1 SSGs induced significantly lower RPE than short HIIT (β = 1.440, 95% CI [0.51, 2.37], SE = 0.381, t = 3.781, p = .001), but no significant differences were found between 1v1 SSGs and long HIIT (β = 0.585, 95% CI [-0.28, 1.45], p = .176) or long HIIT and short HIIT (β = 0.855, 95% CI [-0.08, 1.79], p = .086).

Discussion

The present study investigated differences in RPE across various SSG and HIIT formats between Tier 2 and Tier 3 soccer players, while controlling for %HRreserve. Although no significant main effect of competitive level on RPE was observed, a significant interaction between training format and competitive level emerged, indicating that meaningful differences in perceived exertion emerged under specific training conditions - most notably, during short HIIT -, suggesting that Tier 3 players perceived this format as more demanding than their Tier 2 counterparts. This suggests that higher-level players do not uniformly report lower RPE across all formats, and that perceptual responses may be context dependent.

Across all participants, training format had a significant main effect on RPE, with 5v5 SSGs generally eliciting the lowest exertion and 1v1 SSGs and HIIT formats yielding higher RPE values. These findings align with previous literature showing that RPE is influenced more by exercise modality than by fitness level alone (Clemente et al., 2021b).Our results contribute to this body of work by demonstrating that training structure (not just intensity) plays a critical role in perceived exertion among competitive athletes.

Our results align with studies which found that RPE was not significantly influenced by age-related fitness differences during SSGs Clemente et al. (Clemente et al., 2021b).However, they diverge from studies suggesting that professional athletes typically report lower RPE than amateurs under similar training conditions (Dellal et al., 2011). One possible explanation for this discrepancy is the relatively small physiological gap between Tier 2 and Tier 3 university-level players, who are both likely to follow structured, high-intensity training regimens. Although we controlled for %HRreserve, we acknowledge that direct measures of aerobic capacity (e.g., VO_2max), anaerobic thresholds, or neuromuscular fatigue were not collected. Future studies should include these metrics to confirm whether our observed similarities in RPE reflect underlying physiological equivalence or are influenced by other variables. We also recognize that RPE is shaped by psychological and cognitive factors, such as motivation, attentional focus, and affective states (Hall et al., 2005; Stults-Kolehmainen et al., 2016). However, our study did not include psychometric assessments to quantify these factors. Including tools like the Profile of Mood States (POMS) or the Intrinsic Motivation Inventory (IMI) in future research would help disentangle the psychological contribution to perceived exertion.

The covariate effect of %HRreserve on RPE highlights its utility as a control variable in perceptual studies. This finding aligns with a previous study (Coutts et al., 2009) that observed RPE during SSGs was significantly mediated by the combination of peak heart rate and blood lactate concentrations, thereby depending on objective physiological responses. Consistent with prior research (Coutts et al., 2010), our findings suggest that RPE is closely linked to internal physiological markers. However, unlike studies reporting similar %HR responses across formats (Selmi et al., 2020), our data indicate meaningful variability in %HRreserve, reinforcing the notion that training modality significantly alters cardiovascular demand even under matched intensities.

Our findings further support the idea that larger-sided SSGs may be perceived as less demanding, not necessarily because of lower physiological load – but due to intermittent effort patterns and more distributed responsibilities among players (Gantois et al., 2023; Hammami et al., 2018; Zouhal et al., 2020). Conversely, HIIT formats and small-sided games like 1v1 impose higher levels of sustained anaerobic and psychological stress (Buchheit and Laursen, 2013; Díaz-García et al., 2023). These variations in format may influence players' perception of effort more than objective intensity measures alone.

Despite its strengths, our study has several limitations. The sample was restricted to Tier 2 and Tier 3 soccer players, which may have limited the range of physiological and perceptual differences observed. As such, the findings may not generalize to elite or professional populations. Including higher-level athletes in future research would offer a more comprehensive understanding of how competitive level influences RPE across the performance spectrum. Furthermore, while %HRreserve was used as a proxy for internal load, it does not capture the full physiological picture. Other markers such as blood lactate, oxygen consumption, heart rate variability, and neuromuscular fatigue were not measured and could provide deeper insight into the mechanisms driving perceptual responses. Additionally, although we discuss the potential role of psychological factors such as motivation, perceived competence, and affective states, these were not directly assessed. Future studies should incorporate psychometric tools to better contextualize RPE across training modalities. Despite these limitations, the findings offer practical value: since 5v5 SSGs elicited lower perceived exertion than 1v1 SSGs and HIIT formats, larger-sided games may be a strategic way to maintain cardiovascular stimulus while reducing perceived load. Coaches are encouraged to use RPE in conjunction with objective indicators like %HRreserve to more accurately monitor training intensity and manage athlete workload.

Conclusion

This study investigated how different training formats (SSGs and HIIT) affect RPE in Tier 2 and Tier 3 soccer players while controlling for %HRreserve. Although competitive level alone did not significantly influence perceived exertion, an interaction effect showed that Tier 3 players reported higher RPE during short HIIT. Training format had a pronounced impact on RPE, with larger-sided SSGs eliciting lower perceived exertion than smaller-sided games or HIIT. These findings highlight the multidimensional nature of RPE, which integrates both physiological and psychological inputs. From a practical standpoint, coaches can manipulate training formats to adjust perceived load: larger-sided games may reduce psychological and physiological strain, while smaller-sided SSGs and HIIT formats may increase it. Monitoring both RPE and %HRreserve provides a more nuanced approach to training load management, helping optimize performance and recovery.

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Key points

- The study found significant differences in Rating of Perceived Exertion (RPE) across training formats, with 5v5 small-sided games (SSGs) eliciting lower RPE compared to 1v1 SSGs and HIIT protocols, even when controlling for physiological load (%HRreserve).
- While no overall RPE difference existed between Tier 2 (developmental) and Tier 3 (national-level) players, a key interaction revealed that Tier 3 players perceived short HIIT as more strenuous than Tier 2 players, suggesting competitive-level nuances in effort perception.
- %HRreserve significantly influenced RPE, confirming its role as a valid internal load metric. However, RPE variations persisted beyond physiological strain, highlighting the multifactorial nature of perceived exertion (e.g., psychological and exercise modality).

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