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Authors and Affiliations: A. Vaquera[1,2], D. Suárez-Iglesias[1,3] , X. Guiu[1], R. Barroso[4], G. Thomas[2], A. Renfree[2].

[1] Faculty of Sciences of Physical Activity and Sport, University of León, Leon 24071, Spain.

[2] Institute of Sport & Exercise Science, University of Worcester, Henwick Grove, Worcester, United Kingdom, WR2 6AJ.

[3] FPU (University Teacher Training) Programme 2012.

[4] Faculty of Physical Education, State University of Campinas, Campinas, Brazil.

Corresponding Author: Andrew Renfree, Institute of Sport & Exercise Science, University of Worcester, Henwick Grove, Worcester, United Kingdom, WR2 6AJ.

Tel: +44 (0)1905 855376

Fax: +44 (0)1905 855132

Email: a.renfree@worc.ac.uk

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ABSTRACT

This study describes heart rate (HR) responses during different small sided games (SSGs) in junior basketball players, and identifies the level of agreement between athlete and coach perceptions of internal training load calculated using the in-task rating of perceived exertion (RPE) method. Over a 6 week period, 12 male junior basketball players who played in the Spanish national under-18 League, played 7 games of one-a-side (1v1), 6 games of two-a-side (2v2), 8 games of five-a-side (5v5), and 5 games of superiority (3v2) situations. During 1v1, 2v2, 5v5, and 3v2 peak heart rates were 90.27 ± 3.37%, 92.68 ± 3.29%, 92.01 ± 3.48%, and 88.74 ± 5.77% of HRmax respectively. These differences were statistically significant between 1v1 and 2v2 ($P<0.01$), 1v1 and 5v5 ($P<0.05$), 2v2 and 3v2 ($P<0.001$), and 5v5 and 3v2 ($P<0.001$). Mean heart rate was 79.5 ± 4.4%, 83.1 ± 4.2%, 91.2 ± 4.7%, and 78.5 ± 7.5% of HRmax during 1v1, 2v2, 5v5, and 3v2, respectively, and differences were observed between 1v1 and 2v2 ($P<0.001$), 2v2 and 3v2 ($P<0.001$), and 5v5 and 3v2 ($P<0.05$). There were differences in athletes and coaches in-task RPE in all SSGs (all $P<0.0001$ apart from 5x5 $P=0.0019$). The 2v2 format elicited a higher mean in-task RPE in comparison to all other SSGs ($P<0.001$), possibly because 2v2 imposes a greater cognitive load.

KEY WORDS: Training prescription, monitoring, RPE

INTRODUCTION

Small-sided games (SSGs) are widely used by basketball coaches in an attempt to simultaneously develop technical and tactical skills under high physical loads (Atl, Koklu, Alemdaroglu, & Kocak, 2013; Castagna, Impellizzeri, Chaouachi, Ben Abdelkrim, & Manzi, 2011; Delextrat & Martinez, 2014; Klusemann, Pyne, Foster, & Drinkwater, 2012; McCormick et al., 2012; Sampaio, Abrantes, & Leite, 2009). Previous research suggest that physiological (heart rate, HR) and perceptual (rating of perceived exertion, RPE) demands of SSGs can be manipulated by changing the size of the court and the number of players involved. Findings from (Atl et al., 2013) showed that in a group of 12 under-16 (U-16) female high school basketball players, full-court 3-a-side games elicited higher HR than half-court 3-a-side games. Klusemann et al., (2012) reported that even though HR was similar during half-court and full-court basketball SSGs; when 2v2 games were compared to 4v4 games mean HR was substantially higher in 2v2. Using a full sized basketball court, Castagna et al., (2011) investigated the effects of player number on HR in various SSGs. During 5v5, 3v3 and 2v2 mean HR was 84.0± 9.2%, 88.0± 8.4% and 92.0± 5.6%, of HR max respectively. The mean HR values achieved in the 5v5 condition were similar to those reported during a basketball match involving professional players (McInnes, Carlson, Jones, & McKenna, 1995). In combination, these findings suggest that increasing playing area while either keeping the number of players constant or reducing the number of players involved, whilst keeping the relative playing area the same, is an appropriate method for increasing physiological loading. Alternatively, increasing the number of players is appropriate to achieve match-specific intensities.

In addition to HR, the perception of exertion (RPE) of players during SSGs can be used to monitor and prescribe the training load (Haddad, Padulo, & Chamari, 2014). However, to be confident in the ability to precisely prescribe and monitor training loads induced by SSGs it is necessary to establish the level of agreement between the RPE of the coach and that of the athlete. Studies from other sports that have investigated differences in internal load values generated using athletes self-reported and coach assessed RPE values have produced mixed results. Recently, in a group of 14 elite-level junior tennis players, (Murphy, Duffield, Kellett, & Reid, 2014) it was observed that coaches perceptions of individual drill RPE did not differ from that of athletes. However, with regards to the overall session RPE, coaches significantly underestimated the perceived exertion of the athletes, with only moderate correlation (r = .59) demonstrated between coach and athlete. This is contrary to recent findings involving a group of 15 professional volleyball players, where de Andrade Nogueira et al., (2014) reported good agreement between the session RPE predicted by the coach and that reported by the players. However, discrepancies did exist when analyzing the percentage of the athletes' RPE by the intensity proposed by the coach, whereby it was found that athletes perceived the sessions designed to be easy training as being harder than perceived by the coach, while they perceived heavy training to be easier than intended. The available research therefore suggests there may be differences between coach and athlete perception of exertion during training tasks, thereby potentially increasing the risk of inappropriate training prescription. (Barroso, Cardoso, Carmo, & Tricoli, 2014; Brink, Frencken, Jordet, & Lemmink, 2014; de Andrade Nogueira et al., 2014; Murphy et al., 2014; Viveiros, Caldas Costa, Moreira, Nakamura, & Saldanha Aoki, 2011a; Wallace et al., 2009). It is therefore of crucial importance to conditioning coaches that they are aware of any discrepancy between their own and athletes perceptions of the load imposed by differing training activities.

The aims of the current study were to describe the physiological and perceptual responses to different SSGs in elite junior basketball players, and also to determine the level of agreement between coach and player perceptions of exertion during the SSGs (in-task RPE).

METHODS

Experimental Approach to the Problem

The study analyzed heart rate and perceptual responses of 12 elite junior basketball players during a series of coach prescribed Small Sided Games (SSG's) in order to: i) describe physiological responses to SSG's comprising different player numbers (1v1, 2v2, 5v5, and 3v2), and ii) Determine the level of agreement between player and coach perceptions of perceived exertion during individual SSG's. Aim (i) was achieved through assessment of HR during a series of SSG's during routine training sessions over a 6 week period during the competitive season. Aim (ii) was achieved through comparison of in-task RPE reported by subjects in each game with a coaches assessment of the in-task RPE he perceived to be imposed by each game.

Subjects

Twelve male junior basketball players (16±0.4 years, 183.9 $\pm$ 5.8 cm, 10.1 $\pm$ 2.6% body fat) who were active in the under-18 (U-18) Spanish League and had a mean competitive experience of 8.7 $\pm$ 1.0 years, and a lead coach with 18 years of experience training U-16 and U-18 players participated in the study. With regards to the participants preferred playing positions, 3 were guards, 7 were forwards and 2 were centers. All procedures were conducted with approval of the Human Ethics Committee of Leon University, and in accordance with the Helsinki Declaration. All participants completed a pre-participation general health

screening questionnaire and provided written informed consent which was also signed by a parent or guardian.

Procedures

Anthropometric characteristics of participants were obtained prior to the start of the study at the commencement of the competitive season. Weight and height were measured with participants wearing only underwear and barefoot with a digital electronic balance (Seca Alpha, GmbH & Company, Igni, France; range 0·1 – 150 kg, precision 100 g) and a Harpenden digital stadiometer (Pfifter, Carlstadt, NJ, USA; range 70 – 205 cm, precision 1 mm), respectively. Body fat percentage was determined through electrical bioimpedance (Tanita OMRON BF306, Arlington Heights, USA). Individual HRmax was measured via radio-telemetry during a 20m shuttle test (Leger & Gadoury, 1989) on a regular basketball court.

The study took place over a period of 6 weeks in November-December at the start of the competitive season. The participant's weekly schedule consisted of three training sessions (~90 min) during the week (between 17.00 and 19.00), with a league game at the weekend. Participants completed 15 training sessions in total, each one consisting of 1-3 SSG's as prescribed by the coach, with 2-3 minutes of passive recovery period between games. Although training sessions were planned at the beginning of the season by the coaches, they were modified depending on weekly plans and the results obtained in league games. In total, each participant played 7 games of one-a-side (1v1), 6 games of two-a-side (2v2), 8 games of five-a-side (5v5), and 5 games of superiority (3v2) situations. All players had at least 2 years of prior experience of each SSG. All games were played on a full-size basketball court (28 x 15 m), other than 3 games of 1v1 which were played on a one quarter sized court. The duration of each game was predetermined by the coach, but could be modified based on his

subjective assessment of the benefit to be gained from continuation or otherwise. Teams were balanced for height and players were matched according to their playing position, and a man-to-man defense system was set. Neither free-throws or time-outs were utilized in any SSG.

Exercise Measures

Individual HR data was recorded continually via radio telemetry using Suunto Memory Belts (Vantaa, Finland) operating on a secure 2.4 GHz frequency, and data was stored on an integrated memory chip at 1-second intervals. After each session, HR data was uploaded to a local computer using the manufacturer-supplied interfaces and software (Suunto Training Manager 2.3.0, Suunto, Finland) and then exported and analyzed using the Excel software programme (Microsoft Corporation, USA). Heart rate values were subsequently converted to percentage of individual maximum HR measured during the 20m shuttle run. Rest periods between each SSG were discarded.

The in-task RPE was obtained using the modified Borg 10-point Scale (CR-10)(Foster, 1998), which is a valid tool for evaluating the training load in small-sided games in team sports training (Coutts, E., Marcora, Castagna, & Impellizzeri, 2009). Familiarization with the use of the scale was given to players before commencing the study. To assess their in-task RPE, players were asked to provide a whole number response immediately after each game, and the scale was anchored by explaining that a score of 10 should equate to a previous memory of absolute exhaustion. The coach was also asked to provide his assessment of participant's in-task RPE's using the same scale.

Data Analysis

One-way ANOVA was used to determine differences in maximum and average heart rates, and RPE between SSG's. Pearson product moment correlation was used to determine the relationships between RPE and HR in each game. Differences in participants reported and coach assessed RPE values for each game were assessed using an independent samples t-test. Reliability of the coaches' assessment was determined by using the Spreadsheet for Calculating Reliability developed by Hopkins, (2000). Agreement between participant and coach assessments of RPE was determined through calculation of the mean difference with 90% confidence limits. Data is reported as mean **±** standard deviation, and significance was set at the $P < .05$ level.

RESULTS

Mean HR max of participants was 199.0 $\pm$ 4.0 beats.min^{-1}.

Mean small sided game durations were 12.3 ± 3.5 min, 10.7 ± 1.2 min, 16.8 ± 6.8 min, and 10.0 ± 3.5 min for 1v1, 2v2, 5v5, and 3v2 games respectively.

Maximal recorded HR values were 90.3 ± 3.4 beats·min^{-1}, 92.7 ± 3.3 beats·min^{-1}, 92.0 ± 3.5 beats·min^{-1}, and 88.7 ± 5.8 % HR max during 1v1, 2v2, 5v5, and 3v2 respectively. There were differences between 1v1 and 2v2 ($P<0.01$), 1v1 and 5v5 ($P<0.05$), 2v2 and 3v2 ($P<0.001$), and 5v5 and 3v2 ($P<0.001$). (Figure 1)

Please insert Figure 1 here

Mean recorded HR values were 79.5 ± 4.4%, 83.1 ± 4.2%, 91.2 ± 4.7%, and 78.5 ± 7.5% of maximum HR during 1v1, 2v2, 5v5, and 3v2 respectively. There were differences between 1v1 and 2v2 (P<0.001), 2v2 and 3v2 (P<0.001), and 5v5 and 3v2 (P<0.05). (Figure 2)

Please insert Figure 2 here

There were differences in mean game RPE between 2v2 and all other games (all P<0.001). All other differences were non-significant. (Figure 3)

Please insert Figure 3 here

There were significant weak to moderate correlations between RPE and maximal achieved HR in 1v1 (r = 0.37, P <0.006), 5v5 (r = 0.53, P <0.001), and 3v2 (r = 0.54, P <0.001). No significant correlation was found in 2v2. Maximum achieved HR accounted for 13.4%, 1.6%, 27.7%, and 28.6% of explained variance in RPE in 1v1, 2v2, 5v5, and 3v2 respectively.

Similar relationships were found between RPE and average HR in each game. Other than in 2v2, significant weak to moderate correlations were found between these two variables in 1v1 (r = 0.29, P <0.008), 5v5 (r = 0.49, P <0.001), and 3v2 (r = 0.54, P <0.001). Average heart rate accounted for 8.0%, 2.9%, 23.9%, and 29.4% of explained variance in RPE in 1v1, 2v2, 5v5, and 3v2 respectively.

There were significant differences in athletes and coaches perception of exertion in all games (all P<0.0001 apart from 5v5 P=0.0019). (Figure 4) Mean differences between coach and

athlete perceptions of exertion were 1.13 [0.92, 1.34], 1.72 [1.56, 1.88], 0.63 [0.31, 0.94], and 2.20 [1.92, 2.48] respectively (data expressed as difference in mean ± 90% confidence limits).

Please insert Figure 4 here

DISCUSSION

This study describes the HR responses to, and participant and coach assessments of in-task RPE during several different SSG's (1v1, 2v2, 5v5 & 3v2) in elite junior basketball players. The main findings were that 2v2 and 5v5 games induced greater physiological load than 1v1 and 2v2 games, but that, despite the lower HR values, the 2v2 format resulted in the highest in-task RPE. Additionally, it was also found that coach assessments of in-task RPE did not agree with those of participants.

The highest mean HR response was achieved in the 5v5 condition (91.2 ± 4.7%. HRmax), an intensity that is considered 'high' (Ziv & Lidor, 2009) and sufficient to elicit adaptions to improve aerobic fitness. In this study, only the 5v5 and 2v2 formats resulted in a sufficiently intense stimulus (above 80% of HRmax) to provoke adaptation. These findings are broadly in line with those of (Sampaio et al., 2009), and the high physiological load imposed by 5v5 could result from the high task complexity involved due to the requirement to consider a high number of tactical options. (Snow, 2004).

The mean HR in the 5v5 condition (91.2 ± 4.7% HRmax) is similar to HR data collected from 8 Spanish Basketball players over 5 professional games (ranging from 93.2 ± 4.1% to 95.0 ± 3.7%) (Vaquera et al., 2008) and values observed during competition by 8 elite players, who spent 75% of playing time over the 85% of their HRmax (McInnes et al., 1995). However, it is higher in comparison to HR data from a 5v5 small sided basketball game collected from regional level Italian male basketball players (mean HR as %HR max of 84.0±9.2) (Castagna et al., 2011). This difference in HR response maybe due to a longer playing period being adopted in the present study and the absence of recovery during these 5v5 games, or alternatively due to these players having superior physiological abilities which allow them to maintain a higher relative exercise intensity.

In contrast to the 5v5 game however, the mean HR in 2v2 games (83.1 ± 4.2%) found in our study was lower compared to previously reported findings in both elite junior (86.0 ± 4.0%) (Klusemann et al., 2012) and regional level Italian male players (92.0 ± 5.6%) (Castagna et al., 2011).

The highest maximal HR recorded in this study was achieved in the 2v2 condition (92.7 ± 3.3% HR max). This condition also produced the highest RPE (9.1±0.7), which was significantly greater than that recorded in any other games (1v1, 5v5 and 3v2). Previous studies that have investigated the effect of player number during SSGs in basketball have also found 2v2 to result in a higher perceived exertion than other SSGs (Klusemann et al., 2012). Castagna et al., 2011) reported higher RPE (6.8±1.5) following a 2v2 SSG in comparison to both 3v3 (5.8±1.1) and 5v5 (4.5±1.8). The RPE values for the 2v2 and 5v5 are lower than

those reported in the present study. In the study of Klusemann et al. (2012) the perceived exertion of 2v2 (8 ± 2) was moderately higher than 4v4 (6 ± 2).

SSGs involving fewer players increases the relative court area per player, meaning players are likely to be more actively involved throughout and that the number of times each player touches the ball increases (Klusemann et al., 2012). Therefore, this type of practice maybe effective in promoting individual skill development from both an offensive and defensive perspective. Interestingly, the psycho-physiological strain, as measured via RPE, experienced by the players was less in lv1 (8.3) in comparison to 2v2 (9.1). This may be due to the cognitive demand in 1v1 being slightly less, as it can be speculated that less decision making skills are required in 1v1 in comparison to 2v2. In 1v1 the players do not have to pass the ball, communicate with team mate(s) or react in response to their team mate(s) actions. It may therefore be proposed that the reason for the higher RPE reported during 2v2 results from the greater cognitive demand imposed by the requirement to make more tactical decisions.

Although some studies (Castagna et al., 2011; Klusemann et al., 2012; Sampaio et al., 2009) have used RPE to quantify training load during basketball SSGs, no study has investigated the agreement between coach and athletes perceptions of exertion during basketball SSGs. However, some data is available for athletes and coaches in other sports including athletics (Foster, Heimann, Esten, Brice, & Porcarid, 2001), judo (Viveiros, Caldas Costa, Moreira, Nakamura, & Saldanha Aoki, 2011b), swimming (Wallace et al., 2009), and tennis (Murphy et al., 2014). In team sport competitors, Brink et al. (2014) found differences in the perceived exertion of football training sessions between coaches and players. This study also found that training sessions designed to be 'easy' and 'intermediate' were perceived as harder by players; however, sessions designed to be 'hard' were perceived as less intense by the players.

Although distinction between ‘easy’ and ‘hard’ training was not made in the present study, a similar poor agreement between athlete and coach assessment of in-task RPE suggests similar discrepancies may be evident within basketball. A disparity in athletes–coach perceptions of exertion in SSGs has important implications in the design of training programs. If coaches are unable to accurately estimate internal training load imposed, then it will be difficult to design a training schedule, characterized by low levels of monotony and strain that positively impacts upon performance. Overtime, this is likely to induce maladaptive responses and result in the overtraining syndrome (Foster, 1998) .

PRACTICAL APPLICATIONS

This study has found that varying the number of players active in small sided basketball games influences both the physiological demands and the in-task RPE. Coaches may find this information useful when designing sport specific conditioning programs aiming to develop different performance related qualities, and indeed it would suggest that monitoring of individual perceptual responses is important. Furthermore, it has demonstrated that there are significant discrepancies between athlete and coach perceptions of in-task RPE and therefore of internal training load imposed. Coaches should be aware of these differences and the potential implications when prescribing and monitoring conditioning programs in junior basketball players.

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Figure Captions

Figure 1. Maximum HR during each SSG (statistical significance removed for clarity)

Figure 2. Mean HR during each SSG (statistical significance removed for clarity)

Figure 3. Mean RPE in each SSG ($P<0.001$ between 2v2 and all other games)

Figure 4. Athlete and coach perception of exertion during each SSG (all $P<0.001$ except 5v5 where $P<0.01$)

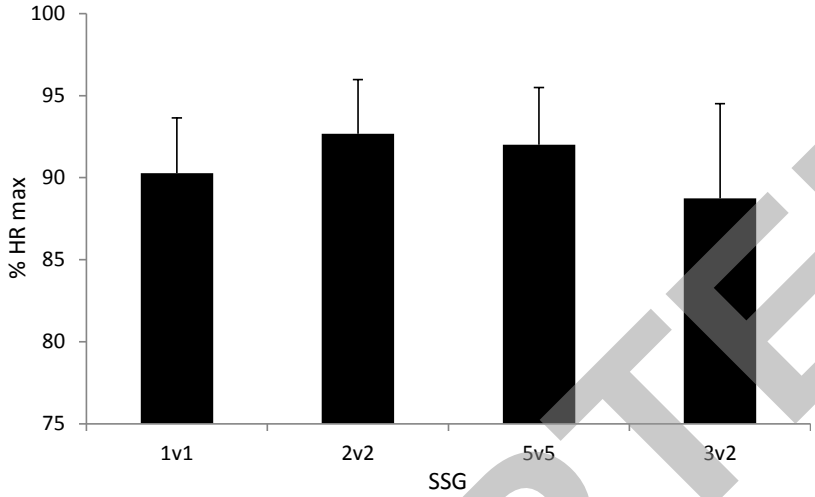

Figure 1. Maximum HR during each SSG (statistical significance removed for clarity)

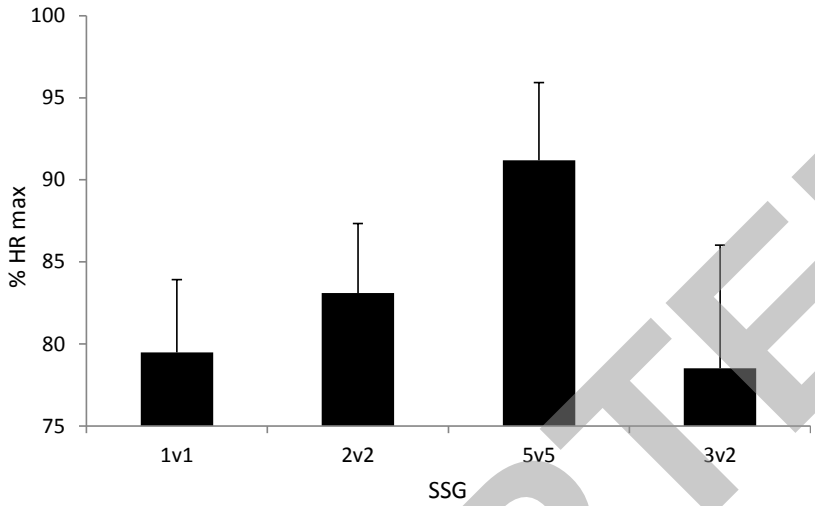

Figure 2. Mean HR during each SSG (statistical significance removed for clarity)

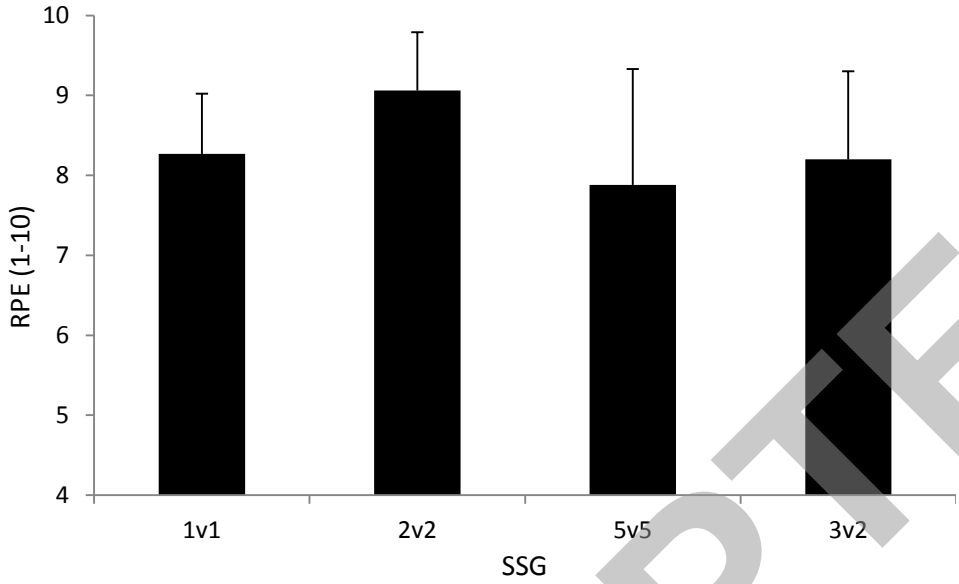

Figure 3. Mean RPE in each SSG (*P<0.001* between 2v2 and all other games)

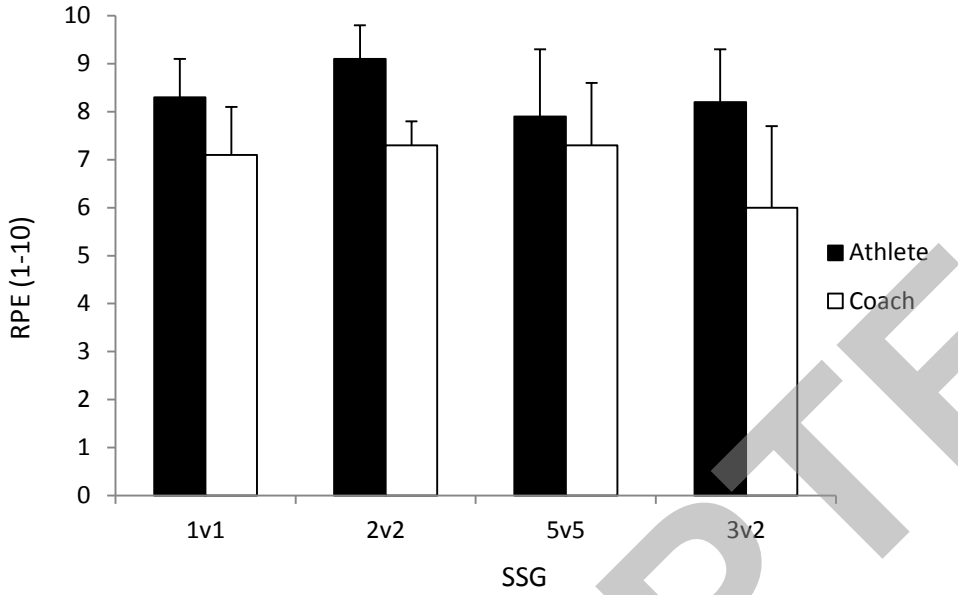

Figure 4. Athlete and coach perception of exertion during each SSG (all *P<0.001* except 5v5 where *P<0.01*)