Journal of Sports Sciences

ISSN: 0264-0414 (Print) 1466-447X (Online) Journal homepage: http://www.tandfonline.com/loi/rjsp20

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To cite this article: Markus J. Klusemann , David B. Pyne , Carl Foster & Eric J. Drinkwater (2012) Optimising technical skills and physical loading in small-sided basketball games, Journal of Sports Sciences, 30:14, 1463-1471, DOI: 10.1080/02640414.2012.712714

To link to this article: http://dx.doi.org/10.1080/02640414.2012.712714

Published online: 28 Aug 2012.

Journal of Sports Sciences, October 2012; 30(14): 1463–1471

Optimising technical skills and physical loading in small-sided basketball games

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(Accepted 12 July 2012)

Abstract

Differences in physiological, physical, and technical demands of small-sided basketball games related to the number of players, court size, and work-to-rest ratios are not well characterised. A controlled trial was conducted to compare the influence of number of players (2v2/4v4), court size (half/full court) and work-to-rest ratios (4x2.5 min/2x5 min) on the demands of small-sided games. Sixteen elite male and female junior players (aged 15–19 years) completed eight variations of a small-sided game in randomised order over a six-week period. Heart rate responses and rating of perceived exertion (RPE) were measured to assess the physiological load. Movement patterns and technical elements were assessed by video analysis. There were ~60% more technical elements in 2v2 and ~20% more in half court games. Heart rate ($86 \pm 4\%$ & $83 \pm 5\%$ of maximum; mean ± SD) and RPE (8 ± 2 & 6 ± 2; scale 1–10) were moderately higher in 2v2 than 4v4 small-sided games, respectively. The 2v2 format elicited substantially more sprints ($36 \pm 12\%$; mean ±90% confidence limits) and high intensity shuffling ($75 \pm 17\%$) than 4v4. Full court games required substantially more jogging ($9 \pm 6\%$) compared to half court games. Fewer players in small-sided basketball games substantially increases the technical, physiological and physical demands.

Keywords: *sport-specific conditioning, games-based training, basketball practice, basketball drills, basketball training*

Introduction

Over the last decade, a new approach to improving team-sport athletes' fitness has been developed in the form of game-based conditioning. The purported benefits of game-based conditioning include greater transfer of physiological adaptations when the exercise simulates sports-specific movement patterns (Baechle & Earle, 2008), athletes simultaneously develop technical and tactical skills under high physical loads (Gabbett, Jenkins, & Abernethy, 2009), and higher motivation of athletes performing sport-specific rather than traditional conditioning (Stone & Kilding, 2009). Sport-specific conditioning in the form of small-sided games has been evaluated extensively in team sports such as football (Hill-Haas, Dawson, Impellizzeri, & Coutts, 2011), rugby (Gabbett, 2006; Gabbett, Jenkins, & Abernethy, 2010; Gamble, 2004), handball (Buchheit et al., 2009), but less so in basketball (Castagna, Impellizzeri, Chaouachi, Ben Abdelkrim, & Manzi, 2011; Sampaio, Abrantes, & Leite, 2009). The small number of research studies on basketball training is surprising given the almost universal use of small-sided games in both junior and senior programs. Sport-specific conditioning can provide a similar or perhaps greater increase in physical fitness than traditional conditioning drills (Gabbett et al., 2009; Hill-Haas et al., 2011; Stone & Kilding, 2009). Game-based conditioning can elicit improvements in performance in competition through improvements in skill execution (Gabbett, 2006; Gabbett et al., 2009). Given the likely benefits of small-sided games in basketball practice in improving both skills and conditioning, it is important to characterise (under controlled conditions) variables of training prescription that influence the relative contributions of the physical (movement patterns), physiological (cardiovascular), and technical (skill repetition) demands of various small-sided basketball games. The organisational pattern of

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ISSN 0264-0414 print/ISSN 1466-447X online © 2012 Taylor & Francis
http://dx.doi.org/10.1080/02640414.2012.712714

small-sided basketball games defines the balance between physical and physiological demands and technical practice needed for competitive success.

Several factors that influence the physiological, physical and technical demands of small-sided games and thus the desired training stimulus from game-based conditioning have been identified in football (Hill-Haas et al., 2011). Variables such as number of players, field dimensions and work-to-rest ratios will determine the physical, physiological and technical demands and thus training adaptations from small-sided games. Increasing the number of players decreases the number of technical actions per player, while field dimensions have less of an effect on the total technical demands in small-sided football games (Dellal et al., 2011; Kelly & Drust, 2009; Owen, Twist, & Ford, 2004). Identifying the influence of different variables on the technical demands of small-sided basketball games would allow coaches to better plan and implement skill-based training programs. Decreasing the number of players while keeping the relative playing area constant increases the physiological and physical intensity of a small-sided football game (Dellal et al., 2011; Hill-Haas, Coutts, Dawson, & Rowsell, 2010; Hill-Haas, Dawson, Coutts, & Rowsell, 2009; Katis & Kellis, 2009; Köklü, Asçi, Koçak, Alemdaroglu, & Dündar, 2011; Rampinini et al., 2007; Williams & Owen, 2007). A decrease in team size on a full basketball court, thus increasing the relative court area, has also been shown to increase physiological demands (Castagna et al., 2011). This indicates that smaller team sizes would increase physiological and perhaps also physical demands of small-sided basketball games. An increase in playing area generally induces larger physiological responses in small-sided football games (Rampinini et al., 2007). Full court basketball practice games have higher physiological and physical demands than half court 5on5 scrimmages (Montgomery, Pyne, & Minahan, 2010), suggesting that a larger court area would increase physiological and physical demands in small-sided basketball games.

Another factor to consider is the effect of intermittent and/or continuous small-sided games. High intensity movement patterns occur longer and more frequently in intermittent small-sided football games, where as heart rate and perceived exertion responses are higher in continuous formats (Hill-Haas, Rowsell, Dawson, & Coutts, 2009). The impact of different work-to-rest ratios in small-sided basketball games remains unknown and this knowledge is crucial for employing game-based conditioning drills in practice. In basketball, most drills and small-sided games are conducted in either half of the court, or the full court with one to five players on a team, and a duration of approximately 5–10 minutes (Montgomery et al., 2010). Understanding the influence of training variables on the physiological, physical and technical demands of small-sided games in basketball should allow coaches and sport scientists to better prescribe and implement sport-specific training programs.

The aim of this study was to quantify the magnitudes of difference in physical, physiological and technical demands in various types of small-sided basketball games to assess the influence of number of players (2v2 versus 4v4), court size (half versus full) and work-to-rest ratio (4x2.5 min vs. 2x5 min). The existing research on small-sided games, particularly in football, is informative but basketball-specific research is needed to clarify important questions for basketball coaches, researchers and strength and conditioning staff.

Methods

Experimental approach

A controlled experimental trial was conducted to assess the physiological, physical and technical demands of small-sided games. The combination of player number (two players per team – 2v2, or four players per team – 4v4), court size (half or full court) and work-to-rest ratio (4x2.5 min or 2x5 min) resulted in eight variations of small-sided games. Small-sided games using the half-court size were created by incorporating a second basketball hoop, 3-point line and keyway at the halfway line. Creating a half-court game in this manner was necessary to ensure the entire half-court area (15 × 14 m) was used and rules were consistent between half-court and full-court games. The 4x2.5 min games were divided into four 2.5 min quarters with a one minute rest interval between each quarter. The 2x5 min small-sided games involved two five minute halves with a 30 second rest at half time which allowed teams to switch sides. The experimental design involved the participants playing each small-sided game in a randomised order. The small-sided games were scheduled over a six-week period during the pre-season.

Participants

Sixteen elite junior basketball players were recruited from the Australian Institute of Sport (AIS) Men's and Women's basketball program (eight male; age 18.2 ± 0.3 y, height 1.92 ± 0.06 m, mass 87 ± 4 kg; mean ± SD; eight female; age 17.4 ± 0.7 y, height 1.86 ± 0.09 m, mass 80 ± 16 kg). All participants and guardians gave informed consent and ethics approval was obtained from the Australian Institute of Sport's Ethics Committee, approval number 20100402. Due to

injury or illness six of the athletes were not able to compete in all versions of small-sided games. In these cases, other squad members of the same position were used as replacements. Comparisons were only made between game variations that were played by the same basketball player.

Procedures

Each of the eight variations of a small-sided game was conducted at the beginning of a regular training session, following a standardised five minute warm up. The male and female participants were divided into two groups of four which competed against each other in a tournament style format. Each group undertook one of the games during each session. The same pair or quad grouping of players was used throughout the study of 19 games. The teams were controlled for positional balance by including one or two perimeter and post players each in 2v2 or 4v4 games, respectively. Due to a shortage in player numbers, five 2v2 games were only played once. Scores were recorded and an incentive (movie tickets) offered to the group with the most wins at the end of the study period. Verbal encouragement was given by the research and coaching staff during the games. No technical or tactical aspects of basketball were emphasised or coached to avoid influencing the athletes' style of play. Slight rule modifications including a 12 second shot-clock and rewarding a point when being fouled in shooting motion to exclude foul shots, were incorporated to allow for continuous play. Pilot testing indicated that a 24 second shot-clock (in a half-court setting with fewer players) was too long to invoke high physical and physiological demands necessary for conditioning purposes.

The physiological, physical and technical demands of each game were quantified through heart rate monitoring, sessional rating of perceived exertion (RPE) taken one min after the end of the game, movement pattern analysis and video coding. Heart rate profiles were captured through a commercially available telemetry heart rate system (Suunto^{TM}, Vantaa, Finland). Values were expressed as mean and peak heart rate as a percentage of each subject's individual maximum heart rate (HRmax), percentage of time spent in Zone 4 (80–89% of HRmax), and Zone 5 (90–100% of HRmax). HRmax was determined through the Yo-Yo Intermittent Recovery Test Level 1 which was undertaken one month prior to the study. Movement patterns and technical elements were obtained from notational video analysis using sports coding software (SportsCode Elite, Sydney, Australia). The events coded for movement patterns were stand/walk, jog, run, sprint, low, medium and high intensity shuffle and jumps (Abdelkrim, Fazaa, & Ati, 2007; McInnes, Carlson, Jones, & McKenna, 1995) and expressed as movement counts. In brief, jogging was defined as forward movement involving a flight phase without urgency, while running involved moderate urgency and a more pronounced arm swing. Sprinting efforts were forward movements with high to maximal intensity. Shuffling was defined as any sideways or backwards movement from low to high intensity. Technical demands were coded as dribbling, passing, mid-range shots (shots outside key area, within 3 point line), 3 point shots (shots outside 3 point line), close range shots (shots within key area), rebounding and ball-screens. The technical demand of each small-sided game was indicated by the frequency of each of the technical elements. Estimating the frequency of movement patterns has good reliability with a coefficient of variation of 2–4% (Abdelkrim et al., 2007). Test-retest reliability of the frequency of technical elements was deemed acceptable with an intraclass correlation of 0.99 and typical error of 4%.

Statistical analysis

Technical, physical and physiological data of each player was collated into an MS Excel database. Gender as a covariate had no clear effect on the dependent variables. The data from the male and female participants was thus pooled and analysed together. All measures were log-transformed prior to analysis to reduce the non-uniformity of error (Atkinson, Pugh, & Scott, 2010). Comparisons between the small-sided game variables (number of players, court size and work-to-rest ratio) were made by estimating the magnitude of difference of each variable between games. Standardised changes and differences (effect sizes) were calculated with precision of estimation indicated by 90% confidence limits (Hopkins, Marshall, Batterham, & Hanin, 2009). An effect was inferred to be unclear if its confidence interval spanned substantial positive and substantial negative values. Clear effects were expressed as substantial and described qualitatively with the following descriptors: trivial <0.2, small 0.2–0.6, moderate 0.6–1.2, large 1.2–2.0 and very large >2.0 (Hopkins, 2010). Test-retest reliability for the technical and physical demands was calculated with the typical error of measurement and intraclass correlation coefficient.

Results

Technical demands

The number of players per team had the largest effect on all technical elements. The total number of technical elements per player was substantially higher ($\sim$60%) in 2v2 games (Figure 1) compared to 4v4

games. The number of close range shots performed was ~three fold higher in 2v2 small-sided games. The number of dribbles, passes, rebounds and ball screens were moderately higher in 2v2 games. Similarly, the number of mid-range jump shots and 3-point shots were higher in 2v2 games (Table 1). The quadrants outlined in Figure 1 show that 2v2 games elicited ≥ five technical elements per min.

Court size was less influential on the technical demands. Half court games elicited ~20% more total technical elements and passing than full court games. Except for ball-screens, the number of all other technical elements was substantially higher in half court games. The work-to-rest ratio had a small effect on the overall technical demands with 4 ±2 (difference in means ±90% confidence limits) more technical elements in 4x2.5 min type games. There were no substantial differences in the number of individual technical elements between 4x2.5 min or 2x5 min small-sided games. The coefficient of variation for the total number of technical elements from game to game across all combinations of the small-sided games was 34%.

Physiological demands

The number of players had the largest influence on RPE scores (Figure 2). RPE scores (scaled 1–10)

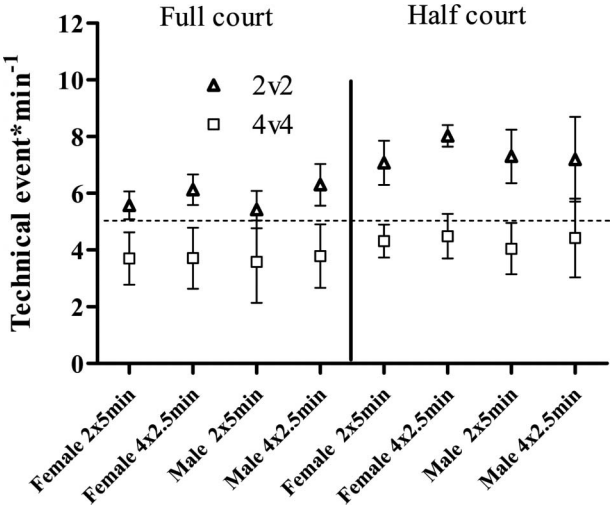

Figure 1. Comparison of technical elements per min for 2v2 and 4v4, full court and half court games. Subject gender and 2 × 5 min and 4 × 2.5 min work-to-rest ratios indicated on x-axis. Bars indicate mean ± SD.

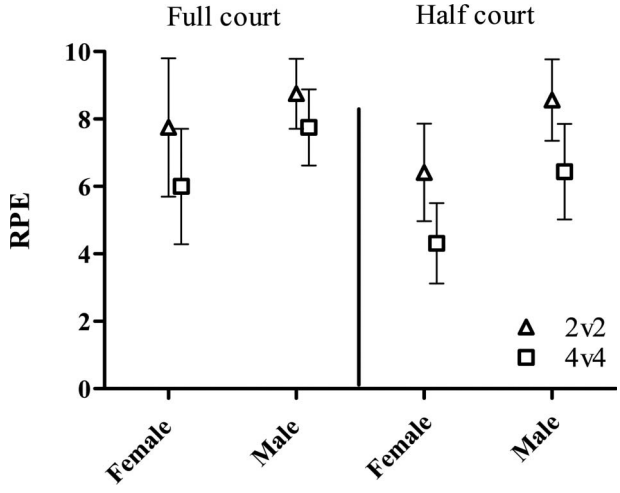

Figure 2. Comparison of rate of perceived exertion (RPE) responses to 2v2 and 4v4, full court and half court games. RPE values were substantially higher for full court and 2v2 small-sided games. Bars indicate mean ± SD.

Table I. Magnitude of difference (effect size ±90% confidence limits) in number of technical elements between different variables of small-sided games. *substantial difference.

Technical Element (per player per game)	Player number (4v4; 2v2)		Court size (Half; Full)		Work-to-rest ratio (2x5 min; 4x2.5 min)	
	mean ± SD	Effect size ±CL	mean ± SD	Effect size ±CL	mean ± SD	Effect size ±CL
Total Elements	43 ± 10; 68 ± 12	2.28 ±0.30* very large	57 ± 18; 46 ± 13	−0.64 ±0.17* moderate	51 ± 17; 55 ± 18	0.22 ±0.13* small
Dribble	12 ± 5; 20 ± 6	1.18 ±0.27* moderate	16 ± 8; 13 ± 6	−0.32 ±0.18* small	14 ± 7; 15 ± 8	0.18 ±0.15 trivial
Pass	15 ± 5; 19 ± 5	0.94 ±0.31* moderate	18 ± 6; 14 ± 4	−0.75 ±0.23* moderate	16 ± 5; 17 ± 6	0.17 ±0.16 trivial
Close range shot	3 ± 2; 8 ± 3	1.71 ±0.37* large	6 ± 4; 5 ± 3	−0.32 ±0.26* small	6 ± 3; 6 ± 4	−0.07 ±0.24 trivial
Mid-range jump shot	2 ± 2; 4 ± 3	0.44 ±0.33* small	3 ± 3; 2 ± 2	−0.53 ±0.38* small	3 ± 2; 3 ± 3	0.17 ±0.27 trivial
3-point shot	2 ± 2; 3 ± 3	0.37 ±0.36* small	3 ± 3; 2 ± 2	−0.30 ±0.29* small	2 ± 2; 2 ± 3	0.11 ±0.23 trivial
Rebound	5 ± 3; 8 ± 3	1.18 ±0.38* moderate	7 ±2; 5 ± 3	−0.58 ±0.25* small	6 ±3; 7 ± 3	0.23 ±0.27 trivial
Ball Screen	3 ± 3; 5 ± 4	1.17 ±0.44* moderate	4 ± 4; 4 ± 5	−0.24 ±0.34 unclear	3 ± 4; 4 ± 4	−0.15 ±0.30 unclear

were moderately higher by two units in 2v2 games compared to 4v4 games. Mean heart rate was also substantially higher in 2v2 games by ~3 ±1 beats per min (difference in mean ±90% confidence limits). Court size had a moderate effect on RPE with full court games eliciting higher RPE ratings than half-court games. No clear substantial differences were seen in any of the heart rate variables for court size (Table 2). Mean heart rate was moderately higher in 2x5-min small-sided games compared to 4x2.5-min types. RPE was substantially higher and the amount of time spent at >90% of maximum heart rate was two-fold longer in 2x5-min small-sided games. Conversely, time spent with a heart rate in the range of 80–89% of maximum heart rate was substantially longer in the small-sided games with 4x2.5-min work-to-rest ratios.

Physical demands

The number of players, court size and work-to-rest ratio had variable impacts on specific movement patterns in small-sided games (Table 3). The number of players has the largest influence on high intensity exercise with 2v2 games involving higher frequencies of sprints (36 ±12%; mean ±90% confidence limits), high intensity shuffling movements (75 ±17%) and jumps (69 ±9%). Court size also had the largest influence on low to moderate intensity movement patterns and the total number of movements. Half court games included 25% more standing and walking, and more low (32 ±9%), medium (26 ±10%) and high (40 ±19%) intensity shuffling type movement patterns than full court games. Full court games involved a similar number of sprints but substantially more jogging movements

Table II. Magnitude of difference in RPE and heart rate data (effect size ± 90% confidence limits; qualitative descriptor) between different variables of small-sided games. *substantial difference.

	Player number (4v4; 2v2)		Court size (Half; Full)		Work-to-rest ratio (2x5 min; 4x2.5 min)	
Physiological demand	Mean ± SD	Effect size ±CL	Mean ± SD	Effect size ±CL	Mean ± SD	Effect size ±CL
RPE	6 ± 2; 8 ± 2	0.95 ±0.26* moderate	6 ± 2; 7 ± 2	0.62 ±0.22* moderate	7 ± 2; 7 ± 2	−0.50 ±0.23* small
Peak heart rate as % of max heart rate	92 ± 3; 92 ± 3	0.28 ±0.29* small	92 ± 3; 92 ± 3	0.06 ±0.26 trivial	92 ± 3; 92 ± 2	−0.17 ±0.22 trivial
Mean heart rate as % of max heart rate	83 ± 5; 86 ± 4	0.53 ±0.26* moderate	84 ± 5; 85 ± 4	0.18 ±0.21 trivial	86 ± 4; 83 ± 3	−0.83 ±0.19* moderate
Mean % time spent in Zone 4 (80–89% HR max)	51 ± 20; 55 ± 24	0.10 ±0.40 unclear	46 ± 27; 56 ± 19	0.18 ±0.33 unclear	53 ± 26; 58 ± 9	0.43 ±0.29* small
Mean % time spent in Zone 5 (90–100% HR max)	22 ± 25; 30 ± 31	0.10 ±0.33 unclear	20 ± 27; 25 ± 27	0.18 ±0.40 unclear	33 ± 32; 14 ± 13	−0.49 ±0.32* small

Table III. Magnitude of difference in frequency (count) of movement patterns (effect size ±confidence limits; qualitative descriptor) between different variables of small-sided games. *substantial difference.

Physical demand (count)	Player number (4v4; 2v2)		Court size (Half; Full)		Work-to-rest ratio (2x5 min; 4x2.5 min)	
	mean ± SD	Effect size ±CL	mean ± SD	Effect size ±CL	mean ± SD	Effect size ±CL
Total Movements	378 ± 51; 382 ± 52	0.07 ±0.18 trivial	407 ± 30; 340 ± 35	−1.73 ±0.24* large	365 ± 45; 393 ± 49	0.57 ±0.15* small
Stand/Walk	125 ± 23; 120 ± 18	−0.20 ±0.17* small	137 ± 14; 103 ± 11	−2.62 ±0.24* very large	119 ± 20; 124 ± 20	0.25 ±0.13* small
Jog	66 ± 12; 63 ± 11	−0.28 ±0.25* small	63 ± 13; 68 ± 10	0.50 ±0.30* moderate	65 ± 11; 66 ± 11	0.08 ±0.22 trivial
Run	35 ± 10; 35 ± 10	0.06 ±0.33 unclear	34 ± 9; 37 ± 11	0.15 ±0.30 unclear	33 ±8; 38 ± 8	0.49 ±0.17* small
Sprint	11 ± 5; 15 ± 5	0.73 ±0.26* moderate	13 ± 6; 13 ± 6	0.08 ±0.24 trivial	12 ± 5; 14 ± 6	0.47 ±0.28* small
Low shuffle	42 ± 10; 39 ± 12	−0.39 ±0.28* small	45 ± 9; 32 ± 9	−1.53 ±0.34* large	39 ± 12; 40 ± 12	−0.10 ±0.21 trivial
Med shuffle	75 ± 17; 72 ± 19	−0.19 ±0.24 trivial	81 ± 13; 62 ± 20	−1.06 ±0.34* moderate	69 ± 17; 77 ± 18	0.40 ±0.22* small
High shuffle	8 ± 4; 13 ± 6	0.97 ±0.28* moderate	11 ± 5; 7 ± 3	−0.86 ±0.29* moderate	9 ± 6; 12 ± 6	0.55 ±0.26* small
Jump	16 ± 6; 26 ± 5	1.75 ±0.29* large	23 ± 8; 18 ± 6	−0.53 ±0.18* small	20 ± 7; 22 ± 7	0.27 ±0.14* small

(9 ±6%). The total number of movements is 17% higher in half-court games and 7% higher with 4x2.5 min work-to-rest ratios compared to 2x5 min small-sided games. The 4x2.5 min type small-sided games had substantially higher frequencies of moderate to high intensity movement patterns with small to moderate differences in running, sprinting, jumping, medium and high intensity shuffling.

The relationship between the technical and physiological demands is illustrated in Figure 3. All 2v2 games elicited higher RPE responses and technical elements than 4v4 games. Full-court 4v4 games with longer playing periods can produce similar physiological demands to 2v2 games, but involve fewer individual technical elements.

Discussion

The results from this study allow a better understanding of the effect of different variables on the technical, physiological and physical demands of small-sided games using a 12 second shot-clock. This is the first study to systematically investigate the effect of the number of players, court size and work-to-rest ratios on the various demands of small-sided basketball games. The main finding is that the number of players has the largest influence on the technical, physiological and high intensity movement patterns in small-sided basketball games. While the general findings are consistent with other reports on small-sided games (Hill-Haas et al. 2011), the specific details of the technical, physiological and physical demands of basketball small-sided games should provide useful information for basketball coaches and support staff. The primary outcome here is that the number of players in small-sided basketball games is the key factor influencing physical and technical demands.

Technical demands

The number of players had the largest influence on the technical demands with 2v2 games involving ~60% more technical executions than 4v4 games. This finding was not surprising as the smaller number of players in a team allows for more 'ball touches' and hence skill executions per player. A similar finding of more touches with fewer players has been reported in small-sided football games (Jones & Drust, 2008; Owen et al., 2004; Owen, Wong del, McKenna, & Dellal, 2011). Especially close range shots were performed more frequently in 2v2 games. This finding supports the use of 2v2 games for incorporating a higher number of repetitions of close range shots which are a key performance indicator in differentiating winning from losing teams (Csataljay, O'Donoghue, Hughes, & Dancs, 2009; Sampaio, Lago, & Drinkwater, 2010; Trninic, Dizdar, & Luksic, 2002; Tsamourtzis, Saloninkidis, Taxildaris, & Mawromatis, 2002).

While decreasing the number of players and thus increasing the amount of ball touches would be beneficial for individual skill development, the addition of players shows an increase in the total number of technical actions performed overall (Owen et al., 2004). The value of involving a larger number of players in small-sided games therefore lies in enhancing team-specific decision making skills – more team members and opposition players are involved in the decision making processes. Additionally, technical demands executed without the ball such as cutting, off-ball screening, maintaining spacing, sealing, and leading were not coded. Assessing the frequency of these technical elements may distinguish the technical demands of 2v2 and 4v4 small-sided games. It is likely that technical elements executed without the ball occur more frequently in 4v4 games than 2v2 games.

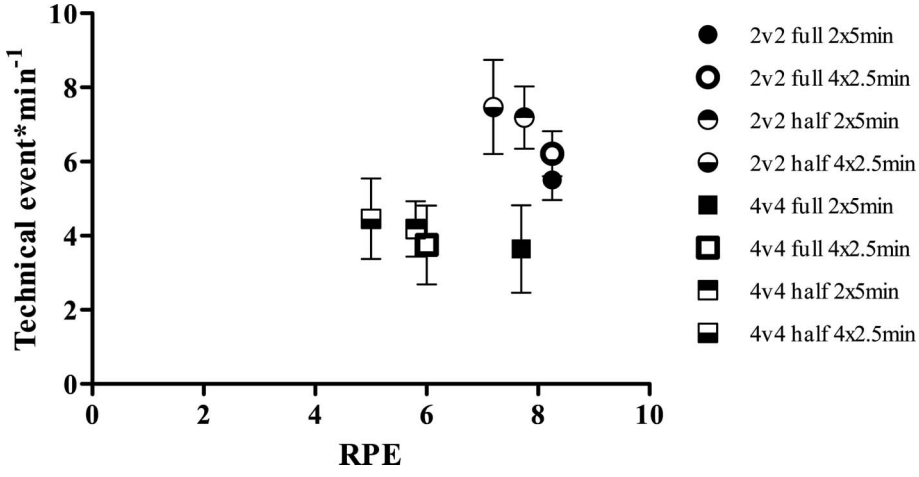

Figure 3. Relationship between technical element per minute and rate of perceived exertion in the eight variations of small-sided games. Mean ± SD indicated by symbol and error bars.

Defensive skill elements of basketball were not tracked in the small-sided games, but can be associated with the corresponding offensive elements. For example, the fact that ball screens occurred more frequently in 2v2 games means that ball screen defence would correspondingly occur more often in these games too. To further maximise the frequency of technical elements, half-court games should be implemented over full-court games. In particular there are substantially more passes in the half-court variant. The higher technical demands in half-court games are due to shorter durations of possession, allowing more possessions and thus more technical elements or touches per game. The higher frequency of possessions with smaller playing surface sizes has also been reported in football with more shots occurring on smaller pitch sizes (Kelly & Drust, 2009). Future research should incorporate other aspects of technical demands, such as offensive and defensive technical elements executed without the ball, in sport-specific small-sided games.

Physiological and physical demands

When designing small-sided games from a conditioning point of view, choosing the number of players per team seems to have the largest influence on the physiological demands and high intensity movement patterns. Using fewer players in a team increases the relative court area per player forcing players to be more involved in game play. These adjustments increase the physiological demands and high intensity movement patterns. Similar responses have been reported in basketball (Castagna et al., 2011; Sampaio et al., 2009) and football small-sided games (Hill-Haas et al., 2011; Köklü et al., 2011; Rampinini et al., 2007). Mean heart rate in 2v2 games was lower compared to previously reported findings in regional level Italian male basketball players ($86 \pm 4\%$ versus $92 \pm 6\%$ of estimated maximal heart rate) (Castagna et al., 2011), but comparable to 3v3 games in younger basketball athletes ($87 \pm 4\%$) (Sampaio et al., 2009). These differences in heart rate responses may be due to including the rest periods in our calculation of mean heart rate and/or higher fitness levels in our national level participants. Interestingly, RPE results from our 2v2 games (8 ± 2; mean $\pm$ SD) are similar to those (7 ± 2) reported by Castagna et al. (2011) indicating a relatively consistent psychophysiological response.

The perceived demand of a small-sided game is also moderately higher in the full court. The higher RPE scores ($7–8 \pm 2$ vs. 3 ± 0.5) from our study and previous findings (Castagna et al., 2011) on 2v2 small-sided games compared to 3v3 small-sided games presumably relates to the small court size ($12m^2$) used in the research project by Sampaio et al. (2009). A higher RPE can be attributed to the higher frequency of moderate intensity exercise at the cost of low intensity exercise. However, half-court small-sided games elicit more shuffling type movements and changes in movement patterns which reflect the movement characteristics of basketball competition (Abdelkrim et al., 2007; Janeira & Maia, 1998; Matthew & Delextrat, 2009; McInnes et al., 1995).

Intermittent work-to-rest ratios (4x2.5 min + 1-min rest period) induce more moderate to high intensity movement patterns, and a more frequent change in movement patterns compared to 2x5 min small-sided games. Half court 4x2.5 min type small-sided games would therefore suit conditioning basketball athletes to specific movement demands of basketball games. Full court 2x5 min small-sided games have higher cardiovascular demands and are more likely to elicit improvements in aerobic fitness.

Understanding the influence of the different small-sided games on the physiological and physical demands allows coaches to design specific basketball conditioning games according to specific conditioning goals. Full court, 2v2 2x5 min small-sided basketball games have the highest cardiovascular demand and induce physiological responses required for aerobic adaptations. Half-court, 4x2.5 min small-sided basketball games provoke more moderate to high intensity shuffling type movement patterns and changes in movement that replicate a majority of specific competition demands. Coaches should explore possibilities with the 12 second shot-clock in small-sided games to ensure physical and physiological loads are high enough to promote improvements in conditioning.

The findings from this research can help coaches and support staff plan and program their training sessions to meet specific technical and conditioning goals. It is now clear that 2v2 small-sided games involve the highest technical and physiological demands. Manipulating court size and work-to-rest ratio influences the balance between technical and physiological/physical demands. An improved understanding of how to modify the demands of small-sided basketball games will assist coaches to prescribe more effective training loads and periodised training programs. Further research in game-based conditioning basketball drills is needed to clarify the effects of different variations (e.g. 1v1 and 3v3) of small-sided games that influence technical, physiological and physical demands.

Conclusion

The number of players on court has the largest effect on physiological and technical demands in small-sided basketball games. Court size and work-to-rest ratios can also influence the frequency of various movement

patterns. Basketball coaches can manipulate different variables of small-sided games to establish the technical, physiological and physical demands of their basketball practice. When planning game-based drills with a small number of players (e.g. 2v2), the frequency of technical elements and thus skill repetition in these games will be high. The effect on the physical and physiological load of 2v2 must also be considered. The physical and physiological demands of 2v2 small-sided basketball games are substantially higher than 4v4 games. Game-based basketball drills that have intermittent type profiles (whether this is planned or arises from frequent stoppages for coaching instructions) will have more changes in movement and higher intensity movement patterns. Full court, 2x5 min games will create more low to moderate intensity movements and higher cardiovascular demands. Applying these training concepts will help coaching staff meet specific training and conditioning goals.

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