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ORIGINAL

A COMPARISON BETWEEN THE PHYSICAL PROFILE OF 3X3 AND 5X5 TASKS IN FORMATIVE BASKETBALL

COMPARACIÓN DEL PERFIL FÍSICO ENTRE 3X3 Y 5X5 EN BALONCESTO FORMATIVO

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ABSTRACT

The aim of the study was to compare the physical requirements taking into account the variables of distance, velocity and acceleration in basketball between two small-sided games, 3x3 and 5x5, using GPS technology. Ten women (15 ± 1.0 years) participated in the study, during two training sessions. The rules of 3v3 competitions were applied in a single basket half-court. The players participated in two games (5x5, 3x3) during 5 minutes each. The players were organized according to their specific position. The variables used to analyze the recorded data were grouped into: global physical indicators (total distance or DT, average speed or DT/min, Player Load or PL and maximum speed or Vmax), traversed distance in different ranges of speed and traversed distance in different ranges of acceleration. The data-analysis showed higher values in the 3x3, being significant differences in the variables DT, DT/min and PL, traversed distance in the range of 1.0 m/s^{-1} and in most of the ranges of acceleration. The interpretation of the results suggests that space affected the physical demand of the players.

KEY WORDS: Team sport, Small-Sided Games, GPS, Training.

RESUMEN

El objetivo del estudio fue comparar las demandas físicas a partir de variables de distancia, velocidad y aceleración en baloncesto entre dos juegos reducidos, 3x3 y 5x5, mediante tecnología GPS. Diez mujeres ($15 \pm 1,0$ años) participaron en el estudio, durante dos sesiones de entrenamiento. Se aplicaron las reglas de las competiciones 3 contra 3 en una sola canasta y a media cancha. Las jugadoras participaron en dos juegos (5x5 y 3x3) durante 5 minutos cada uno. Las jugadoras fueron organizadas en función de su puesto específico. Las variables utilizadas para analizar los datos registrados se agruparon en: indicadores físicos globales (distancia total o DT, velocidad media o DT/min, *Player Load* o PL y Velocidad máxima o Vmax), distancia recorrida en diferentes rangos de velocidad y distancia recorrida en diferentes rangos de aceleración. El análisis de datos mostró valores más altos en el 3x3, existiendo diferencias significativas en las variables DT, DT/min y PL, distancia recorrida en el rango de $>1,0 \text{ m/s}^{-1}$ y en la mayoría de los rangos de aceleración. La interpretación de los resultados sugiere que el espacio afectó en la demanda física de las jugadoras.

PALABRAS CLAVE: Deporte de equipo, Juego reducido, GPS, Entrenamiento.

1. INTRODUCTION

The development of portable devices has facilitated new avenues of research in sports science, contributing new evidence to the study of the physical demands in team sports (Castellano and Casamichana, 2014a). The use of Global Positioning System Devices (GPS) in basketball can provide valid information about the demands put on players by the training process and competition, which, together with physiological demands (Montgomery, Pyne, and Minahan, 2010), would mean that the training process could be adapted and performance optimized.

Basketball is an intermittent, high-intensity team sport (Drinkwater, Pyne, and McKenna, 2008), in which intense effort and periods of low intensity are interspersed with moderate intensity efforts and long recuperation periods (Sampaio, Gonçalves, Rentero, Abrantes, and Leite, 2013). The understanding and identification of the energy demand required in basketball in specific positions is important in order to design training exercises and optimal game simulations (Edgecomb and Norton, 2006), and thus be able to develop and improve fitness programmes (Sampaio et al., 2013), with the aim of optimizing performance.

Whilst time-motion analysis has not been frequently used to measure player activity profiles during matches (Scanlan, Dascombe, Reaburn, and Dalbo, 2012), this being partly conditioned by GPS device limitations in closed spaces (Castellano and Casamichana, 2014a), greater attention has been paid to physiological demands, by tracking heart rate and blood lactate levels (Scanlan et al., 2012) amongst other things. However these measures only provide an indirect assessment of external demand during competition in basketball (Scanlan, Dascombe, and Reaburn, 2011), and whilst they are considered to be appropriate values for measuring aerobic energy and lactate production, they may be incomplete physical indicators for assessing this type of activity (Ben Abdelkrim, El Fazaa, and El Ati, 2007).

In the last few years, GPS has been used to study sports performance and to analyse the burden placed on players during training (Castellano and Casamichana, 2014a). These devices allow athletes to be monitored through the recording of physical variables related to speed, but especially those related to the acceleration/deceleration dimension (Aughey, 2011), via the triaxial accelerometer, gyroscope and magnetometer contained in these devices. This new dimension is relevant in the description of the demands of team sports (Castellano et al., 2013; Varley, Aughey and Pedrana, 2011), as actions carried out at maximum acceleration but at low speed may be underestimated. For example, accelerometry has been applied to football as a sensitive variable to differentiate the profile between positions, (Casamichana, Castellano, Calleja-González, San Roman, and Castagna, 2012) or during different training tasks (Hodson, Akenhead and Thomas, 2014).

In this way, the study of how far training tasks (Casamichana et al., 2012), and, specifically, small-sided games resemble competition (Casamichana and Castellano, 2015) can be used to help coaches adjust training content to their objectives. With the aim of provoking an increase or reduction in the technical, physical and physiological demands of playing basketball, coaches can change the variables of different games in reduced spaces (Klusemann, Pyne, Foster, and Drinkwater, 2012). Variables such as number of players, pitch or court size and rest time determine physical, physiological and technical demands and, consequently, the adaptations to training for games in reduced spaces (Klusemann et al., 2012).

One aspect which has already been studied (Klusemann et al., 2012) is the effect on players' physiological demands provoked by a reduction in the number of players per team in a basketball task. The study concluded that physiological demands increased when player numbers were reduced. However, respecting the relative space per player was not considered and so it is not possible to know to what extent which one of the two variables, increase in space or reduction in player numbers per team, influenced the increase in physiological intensity. In tasks played in another team sport, football, there is a close relationship between the modification of both variables and the effects of physical-physiological demands on the players (Casamichana and Castellano, 2010). Aside from the limitations of space, each additional player increases interaction and the weight of decision making (McCormick, Hannon, Newton, Shultz, Miller, and Young, 2012), so reducing the number of players is a common strategy used in sport to work on a chosen ability and promote skills development without excessively altering the structure of the game. Recent research in different sports indicates that games played in reduced spaces increase average heart rate compared with games with more players, as shown by Sampaio, Abrantes, and Leite (2009) in their study. However there are no studies which have directly compared 3x3 basketball with 5x5, except that carried out by McCormick et al. (2012), which covered only physiological variables.

For these reasons, the aim of this study is to describe and compare the physical profile of basketball players via GPS in a half-court match between five-a-side (5x5) and three-a-side (3x3) teams. The objective is to provide more knowledge about the physical demands required in certain common basketball training tasks, evaluating variables associated with distance, speed and acceleration/deceleration. The results of this work will enable coaches to have more relevant information at their disposal when applying training tasks to small-sided game situations.

2. MATERIAL AND METHODS

2.1. Participants

Ten moderately trained young women took part in the study (age: 15±1, with 2 one-hour training sessions per week). They were all from the same school and were players for the federated junior female team competing in the second division of the Biscayan Basketball League. The ten players in the study were chosen for the position they played on the team, endeavouring to form balanced quintets which were familiar to them. Both teams were made up of three girls playing backcourt (a point guard and two forwards) and two centres. The same players who took part in the 5x5 exercise also took part in the 3x3 task, with the exception of four players. The players who participated in both formations remained in the same teams. All of them, together with their parents or guardians and the club directors were notified of the research design, along with possible benefits and risks, and gave their oral consent prior to their voluntary participation in the study. Furthermore, in the interests of data protection, the records were dissociated prior to the analysis.

2.2. Variables

The classification variable used was the type of small-sided game played, with two levels relating to the number of players per team. In one of the games three players played against another three (3x3), and in the other, five against five (5x5). In both tasks, the dimensions of one half of a basketball court were maintained, adapting the rules to avoid fast breaks or transitions via modification of the start following each steal or basket scored.

The dependant variables to describe physical demands were organised into three groups for analysis. In the first group were the global indicators of physical demands: total distance covered (TD) measured in m, maximum speed (V_{max}) measured in m/s^{-1} and distance covered per minute (TD/min) measured in m/min^{-1} . The *Player Load* (PL) was also recorded in arbitrary units (AU). This is a reliable, sensitive indicator of the different demands on sports people (Boyd Ball and Aughey, 2011). The PL indicator has been used to compare matches with different formats of small-sided games (Castellano, Casamichana and Dellal, 2013). This indicator (PL) is calculated by the following formula, where *aca* is acceleration on the antero-posterior or horizontal axis, *act* is acceleration on the transversal or lateral axis, *acv* is acceleration on the vertical axis, *i* is real time and *t* is time:

$$PL = \sqrt{((aca_{t=i+1} - aca_{t=1})^2 + (act_{t=i+1} - act_{t=1})^2 + (acv_{t=i+1} - acv_{t=1})^2) / 100}$$

The second group showed the total distance covered in different speed ranges ($<0.5 m/s^{-1}$; $0.5/1.0 m/s^{-1}$; $1.0/1.5 m/s^{-1}$; $1.5/2.0 m/s^{-1}$; $>2.0 m/s^{-1}$). These speed

zones were similar to those applied in a previous study (Hodgson, Akenhead, & Thomas, 2014), being slightly modified following an analysis of the obtained data and observing that the distribution of the values reached by the players suggested a classification that would consider low ranges of displacement speeds.

The third group contained variables related with accelerations and decelerations. The distance covered (in metres) was differentiated into four acceleration ranges (0/0.5; 0.5/1.0; 1.0/1.5 and >1.5. all in m/s^2). Deceleration had the same ranges but with negative values (<-1.5; -1.5/-1.0; -1.0/-0.5 y -0.5/0.0 all in m/s^2).

2.3. Instruments

The required data from the study was collected using 10 GPS devices (MinimaxX v.4.0, Catapult Innovations), with a sample frequency of 10 Hz. The players wore a special harness which allowed the device to be carried on the upper part of their backs. The GPS device was activated 15 minutes before the start of the exercise, in accordance with the manufacturer's instructions. The data was then downloaded to a computer and analysed using the software *Sprint 5.1* (Catapult Innovations, 2010). The reliability and precision of the devices used in this study have been previously assessed in short distance exercises in football (Castellano, Casamichana, Calleja-González, Román, and Ostojic, 2011).

2.4. Procedure

In the week before the study, the players were familiarised with the format and rules of the tasks by carrying out different 3x3 and 5x5 repetitions with the same duration, but without the GPS devices.

The study was carried out on an outdoor standard-sized basketball court (15x28 m). The physical demands were calculated in two training sessions. Each task lasted 5 minutes, with a five-minute pause between each one to alleviate possible fatigue. Both exercises lasted a little longer than 5 minutes in order to avoid a possible lack of rhythm in the first part (30") (Köklü, Aşçi, Koçak, Alemdaroğlu, and Dündar, 2011); these first 30 seconds were eliminated from the analysis. The two sessions were programmed on the same day and at the same time, with one week between them. The two tasks (3x3 and 5x5) were carried out in each session, and the order of the tasks was modified in each session, starting with the 5x5 task in the first session and with the 3x3 task in the second session. The weather conditions were similar with regard to temperature, relative humidity and wind.

The 5x5 task was carried out on one half of the basketball court (15x14 m). The dimensions of the field of play were maintained for the 3x3 exercise. The game rules were modified and some rules introduced to avoid wasting time when the ball was stopped, such as: fouls were eliminated from the game and the players were

not to move when the ball went out of play. Likewise, following a goal, the opposing player furthest from the hoop restarted the attack. The players made no movements except when the ball was in play, remaining static for most of the time whilst the ball was put into play. Furthermore, following a defensive rebound, the ball had to leave from the three-point line via passing. In this respect, the coach gave constant instructions from the sideline so that the players would respect the protocol as much as possible.

2.5. Statistical analysis

The data is presented as mean and standard deviation (mean \pm sd). The *Levene* statistic was used to test the homogeneity of the variables and normality was tested using the *Shapiro-Wilk* test. To calculate the presence of differences between the variables which represent physical demands, the Student's t-test for independent samples was used. Furthermore, in order to interpret the practical applications and significance of the results, the effect size data used to evaluate the size of the difference between the mean and standard deviation is shown, calculated in accordance with the Cohen deviation. The criteria for the interpretation of the effect size is as follows: 0.2 trivial, 0.2-0.6 small, 0.6-1.2 moderate, 1.2-2.0 large and more than 2.0 very large (Batterham and Hopkins, 2006). All the statistical analysis was carried out using the SPSS v.21.0 pack for Windows and the accepted significance level was $p < 0.05$.

3. RESULTS

Table 1 shows the mean and standard deviation (mean \pm sd) of the global indicators depending on the type of game. As can be seen, the mean is higher in all the global indicators in 3x3 compared with the 5x5 format, with a significant difference in the TD, TD/min and PL variables. There were no significant differences in the Vmax variable, although the 3x3 game value was higher. Furthermore, it can be seen that the effect size was large in the values with significant differentiation.

Table 1. The mean, standard deviation (\pm ds) and the effect size (d) for the global indicators of physical variables for different game formats in reduced spaces.

Global indicators	3x3 (mean \pm sd)	5x5 (mean \pm sd)	d
TD (m)*	249.6 \pm 32.8	209.2 \pm 35.8	1.2
TD/m (m/min ⁻¹)*	49.9 \pm 6.6	41.8 \pm 7.2	1.2
Player Load (PL)*	47.6 \pm 7.4	34.8 \pm 8.6	1.6
Vmax (m/s ⁻¹)	3.0 \pm 0.4	2.8 \pm 1.1	0.2

*Significant difference ($p < 0.05$) between reduced games

Table 2 shows the total values of speed in metres per second, differentiating speed ranges, together with significant differences between 3x3 and 5x5. The analysis reveals that in speed ranges between 1.0/1.5; 1.5/2.0 and >2.0 m/s⁻¹ there was a higher frequency of movement in the 3x3 game than in the 5x5. Likewise, the effect size value was between moderate and large.

Table 2. The mean, standard deviation (\pm ds) and effect size (d) of the distance covered (in metres) in different speed ranges and in different game types.

Speed ranges (m/s ⁻¹)	3x3 (mean \pm sd)	5x5 (mean \pm sd)	d
<0.5	48.7 \pm 31.6	70.6 \pm 35.3	-0.7
0.5/1.0	59.2 \pm 14.8	59.2 \pm 13.3	0.0
1.0/1.5*	60.6 \pm 19.4	38.0 \pm 21.3	1.1
1.5/2.0*	43.4 \pm 19.1	23.8 \pm 16.6	1.1
>2.0*	37.8 \pm 16.1	17.6 \pm 15.6	1.3

* Significant difference ($p < 0.05$) between reduced games

Table 3 shows the acceleration and deceleration ranges of the different movements. The values of the 3x3 game variable were higher in all the acceleration ranges.

Significant differences were observed in all the ranges of greater acceleration and greater deceleration: the deceleration range between <-1.5 m/s² and -1.0 m/s² and the acceleration range between 0.0 m/s² and >1.5 m/s². Furthermore, the effect size data was between moderate and large.

Table 3. The mean, standard deviation (\pm ds) and effect size (d) of movements in the different acceleration and deceleration ranges and in different game types.

Acceleration ranges (m/s ⁻²)	3x3 (mean \pm sd)	5x5 (mean \pm sd)	d
<-1.5*	8.6 \pm 3.1	5.2 \pm 3.5	1.0
-1.5/-1.0*	7.6 \pm 2.5	5.0 \pm 2.7	1.0
-1.0/ -0.5	15.9 \pm 5.6	11.9 \pm 5.3	0.7
-0.5/0.0	42.5 \pm 10.0	34.6 \pm 10.6	0.8
0.0/0.5*	103.5 \pm 20.3	81.2 \pm 18.6	1.1
0.5/1.0*	16.4 \pm 4.8	11.5 \pm 4.6	1.0
1.0/1.5*	8.6 \pm 2.3	5.9 \pm 2.6	1.1
>1.5*	14.6 \pm 4.9	9.8 \pm 5.4	0.9

* Significant difference ($p < 0.05$) between reduced games

4. DISCUSSION

The aim of this study was to measure physical activity with respect to speed, acceleration and deceleration in young female basketball players in a static position via the use of GPS technology. For this, the physical demands on the players were compared in two usual basketball tasks which were carried out on one half of a basketball court with player numbers per team modified to three (3x3) and five (5x5). This knowledge could be used in the design of efficient training programmes for the improvement of formative basketball. The main result of the study is the discovery of significant differences in almost all the analysed variables, with the highest values being found in the 3x3 game with respect to the 5x5 game, largely due to increased player participation when fewer players took part in the task. The original aspect of this work is the inclusion of variables that describe the acceleration and deceleration dimension, which is becoming an increasing focus of attention in sports of an intermittent nature (Gaudino, Alberti, and Iaiá, 2014). Until now there has been a general lack of information related to the exercise load involved in team sports such as basketball as it is only physiological demands which have usually been described (Scanlan et al., 2011 and 2012). Specifically, there is little known about certain, possibly crucial, physical components such as acceleration and deceleration in different training tasks, and especially when the proposed tasks are to be carried out in a reduced playing area. Research applied to the description of demands in other team sports (Gaudino et al., 2014; Hodsong et al., 2014), has shown that energy input, distance covered in different metabolic power categories, or accelerations and decelerations, in addition to speed and distance values, may provide more realistic information about the physical demands imposed on players.

The global physical indicators data showed greater total movement of the players in the 3x3 game, along with greater PL and greater distance covered per minute (TD/min). These results are in line with those of Sampaio et al. (2009), which indicate that a reduction in the number of players in the same space provokes an increase in player participation, which would increase physical effort. One aspect of the results which should be underlined is the reduced values of the speed peaks which the players reached in the tasks where they were analysed, which on very few occasions exceeded 3 m/s^{-1} (11 Km/h^{-1}). Coaches should take this into account in order to assess the need to design tasks or exercises which involve this type of demand.

As far as the speed dimension is concerned, the number of players did not affect distance covered in low speed ranges. However, from ranges above $1.0 \text{ m}\cdot\text{s}^{-1}$, these differences did exist. It seems, therefore, that increased individual or relative space per player results in the players having to cover greater distance at higher travelling speeds. In line with McCormick et al. (2012), a reduction in players in a

three-a-side game increases the physiological intensity of the exercise, and in our case, it also increased the physical demand.

Finally, with regard to player movement in terms of the acceleration/deceleration dimension, our results indicate higher values in all the acceleration ranges and in the ranges of high intensity deceleration. This would appear to suggest that player numbers had some effect on patterns of high intensity movement in reduced size basketball games, as concluded by Klusemann et al. (2012). Significant values were shown between the 3x3 and 5x5 games in all the acceleration ranges, with the highest means being found in the 3x3 game ranges. In terms of deceleration, the significant data are found among the high deceleration values, that is, <-1.5 and -1.0 m/s^{-2} . The need to perform explosive actions in order to get near to the basket whilst overcoming the opponent could explain this.

The main limitation of the study was the exclusion of an assessment of the physiological dimension, which would have provided a more holistic vision of the energy demands of this type of task. The second limitation comes from analysing only tasks which used one half of a basketball court. This distances it somewhat from the dynamics of a competition match in which the teams have to move from one point of the court to the other to attack or defend.

5. CONCLUSION

This exploratory study suggests that the 3x3 task with respect to the 5x5 task, played on one half of a basketball court, demands greater movement, faster running speeds and greater intensity in acceleration and deceleration as a result of there being fewer numbers of participants per team and increased relative space per player. This research has important practical implications as it provides guidelines on how to use the information to optimise the design of training sessions and tasks adapted to players of formative basketball. The results of this study reveal that different game formats (from a modification of the number of participants) provoke different demands and therefore basketball coaches should consider this when creating training tasks. The effects generated in the expected physical demands will depend on the modifications applied to the tasks, thus enabling coaches to adapt them to the training objectives they wish to achieve.

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