Repeated sprinting ability in basketball players: a brief review of protocols, correlations and training interventions

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Abstract:
Although repeated sprint ability (RSA) is a major determinant of performance in basketball, only a few studies have examined previously RSA in this sport compared to the extensive existing literature on other team sports (e.g. soccer). The aim of the present study was to review previous studies that have examined RSA in basketball players. The characteristics of RSA protocols (sprint distance, number of sprints, change of direction, duration and mode of recovery) and training interventions were analyzed, and we highlighted the differences with regards to these characteristics. Based on this review, it was concluded that (a) the different characteristics of existing RSA protocols make any comparison of scores among them impossible, (b) most of the existing protocols used in basketball players did not correspond to the dimensions of a basketball court, (c) repeated sprints can be implemented in a sports-specific physical fitness program to improve RSA and other physical fitness components (sprint, muscle power and aerobic capacity), and (d) more research in RSA of elite adult basketball players and in children is needed, because most of the existing studies has been conducted on a very narrow range of age (15-17 years).

Keywords: anaerobic metabolism, change of direction, high-intensity exercise, recovery, short-term power output

Introduction
Basketball is a complex team sport, in which performance is influenced by several physiological, psychological and technical parameters (Apostolidis & Emmanouil, 2015; Apostolidis, Nassis, Bolatoglou, & Geladas, 2004). Physiological characteristics of basketball players have been well studied during the last five decades. Parameters such as aerobic capacity and its variation during a competitive season have been studied already since 1960’s (McArdle, Magel, & Kyvallos, 1971; Sinning & Adrian, 1968). Ziv and Lidor (Ziv & Lidor, 2009) showed that basketball players are not characterised by very high aerobic capacity since their VO2max is ~45 and ~50 mL.min⁻¹.kg⁻¹ in women and men, respectively; instead, speed, agility and vertical jump are identified as parameters that discriminate athletes by competition level. Vertical jump has been reported to range from 22 to 48 cm in women and from 40 to 75 cm in men (Ziv & Lidor, 2010). Due to the specialization of basketball players in playing positions (guard, forward and center), physical and physiological characteristics vary according to playing roles (P. Nikolaidis, Calleja-González, & Padulo, 2014; Ziv & Lidor, 2009).

It has been observed that team sports athletes were demanded to perform sprints of short duration regularly over a prolonged period of time (Fitzsimons, Dawson, Ward, & Wilkinson, 1993). Thus, a relatively new component of sport-related physical fitness has been identified as repeated sprint ability (RSA). RSA can be defined either as the ability to produce the best possible average sprint performance over a series of sprints separated by short recovery periods (Bishop, Girard, & Mendez-Villanueva, 2011) or to perform repeated sprints with minimal recovery (Stojanovic, Ostojic, Calleja-González, Milosevic, & Mikic, 2012). A match analysis of women basketball games has shown that basketball players performed 4.4 repeated sprint sequences, where ~48% were linear and ~57% lasted 1 to 5 s (Conte et al., 2015). Older adolescents have better RSA than their younger counterparts (Te Wierike et al., 2014), a trend that has been observed for other parameters of physical fitness (P. T. Nikolaidis, Asadi, et al., 2015), too. Although there is not any direct evidence that RSA discriminates athletes by level, elite differed than non-elite in speed and change of direction which are two main components of RSA (Hoare, 2000).

Although repeated sprint ability (RSA) is a major determinant of performance in basketball, only a few studies have examined previously RSA in this sport. The main aim of the present study was to review previous studies that have examined RSA in basketball players. In addition, due to the limited existing literature on basketball RSA, studies from other team sports such as soccer and handball were also considered to draw inferences for basketball.

Protocols
An RSA protocol typically is characterised by (i) sprint distance, (ii) number of sprints, (iii) direction (in-line or with change(s) of direction, COD) and (iv) mode and duration of recovery (Fig. 1). The precise description of these characteristics is necessary in order to standardize a protocol. It should be highlighted that the comparison of scores from protocols differing for at least one characteristic would be impossible. Table 1 presents protocols that have been used on basketball players. Despite the various protocols, all of them use some common indices of RSA: best time, mean time and fatigue index.

The distance per sprint in an RSA protocol has been ranged from 15 (P. T. Nikolaidis, Meletakos, Tasiopoulos, Kostoulas, & Ganavias, 2016) to 35 m (Balėiusnas, Stonkus, Abrantes, & Sampaio, 2006). The official dimensions of basketball court are 28 m in length and 15 m in width (International Basketball Federation FIBA). Thus, it was observed that the longest distance (35 m) in RSA protocols exceeded the court length questioning the suitability of such long distance in basketball.

The number of sprints in RSA protocols has been ranged from three (Te Wierike et al., 2014) to twelve (Meckel, Gottlieb, & Eliakim, 2009). Observing the relationship between distance per sprint and number of sprints, a trend of inverse relationship might be seen, i.e. the protocols using longer distances have relatively small number of sprints. The total distance (i.e. number of sprints × distance per sprint) covered in a protocol has been varied from 90 (Te Wierike et al., 2014) to 300 m (Caprino, Clarke, & Delextrat, 2012; Castagna et al., 2007). A recent study has compared repeated sprints of 30 m with a COD (15+15 m) varying from one to 10 repetitions and recommended five repetitions as representative of the lactic demands of team sports (Gharbi et al., 2014).

The rational for the use of COD in an RSA protocol is that basketball game involves not only sprint in-line, but also sprints in different directions, e.g. in the case of an offense-counter-offense. Protocols with COD can vary for the number and the direction of COD. There are protocols with one or two COD (Attene et al., 2015). A COD might be 180° (Attene et al., 2015; Te Wierike et al., 2014). In soccer players, a 7x30 m RSA protocol has been performed even with five COD, each being 60° (Ruscello et al., 2013).

The duration of recovery can influence the performance and the fatigue. A comparison among three durations (15, 20 and 25s) showed that the longer duration improved mean time by 3% in soccer players (Padulo et al., 2015). With regards to the mode of recovery, a comparison between passive and active (running at 50% of maximal aerobic speed) recovery during a 10×30 m protocol revealed higher fatigue index for the active condition (Castagna et al., 2008).

The reliability of RSA protocols has been tested with athletes performing at least twice an RSA test and using intraclass correlations. For instance, the reliability of a 6x40 m protocol with ~25 s has been established in team sport players, more reliable mean time, less reliable fatigue index (Fitzsimons et al., 1993). The validity of the abovementioned tests has been conducted by correlating their main indices with other physiological measures (see “Correlates” in part 3). However, the external validity of these protocols has not been tested yet. Future studies should compare protocols against sprint behaviour in basketball addressing issues such as peak velocity reached during in-game sprinting, number of sprints per game and number of consecutive sprints with recovery duration less than 30 s (Schimpchen, Skorski, Nopp, & Meyer, 2016).
Table 1. Repeated sprint ability test protocols in basketball players

<table>
<thead>
<tr>
<th>Sample</th>
<th>Distance per sprint</th>
<th>Number of sprints</th>
<th>COD</th>
<th>Recovery</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>17 yrs male Greeks (n=11)</td>
<td>15 m</td>
<td>10</td>
<td>0, 1</td>
<td>~25 s, passive</td>
<td>(P. T. Nikolaidis et al., 2016)</td>
</tr>
<tr>
<td>17 yrs male Israelis (n=12)</td>
<td>20 m</td>
<td>12</td>
<td>-</td>
<td>~16 s, active</td>
<td>(Meckel et al., 2009)</td>
</tr>
<tr>
<td>16 yrs male Dutch (n=48)</td>
<td>30 m</td>
<td>3</td>
<td>30 s</td>
<td>20 s</td>
<td>(Te Wierike et al., 2014)</td>
</tr>
<tr>
<td>21 yrs Spanish (n=14)</td>
<td>30 m</td>
<td>8</td>
<td>-</td>
<td>25 s</td>
<td>(Jiménez, Rios, Casas, &amp; Rios, 2009)</td>
</tr>
<tr>
<td>17 yrs male Italians (n=18)</td>
<td>30 m</td>
<td>10</td>
<td>1</td>
<td>30 s, passive</td>
<td>(Castagna et al., 2007)</td>
</tr>
<tr>
<td>16 yrs male Italians (n=10)</td>
<td>30 m</td>
<td>10</td>
<td>1</td>
<td>30 s, passive</td>
<td>(Caprino et al., 2012)</td>
</tr>
<tr>
<td>16 yrs male Italians (n=18)</td>
<td>30 m</td>
<td>10</td>
<td>2</td>
<td>30 s, passive</td>
<td>(Attene et al., 2015)</td>
</tr>
<tr>
<td>15-16 yrs male Lithuanians (n=35)</td>
<td>35 m</td>
<td>6</td>
<td>-</td>
<td>10 s, active</td>
<td>(Balēiunas et al., 2006)</td>
</tr>
<tr>
<td>Male and female Spanish</td>
<td>35 m</td>
<td>6</td>
<td>-</td>
<td>10 s, active</td>
<td>(Balsalobre-Fernández, Nevado-Garrosa, Del Campo-Vecino, &amp; Ganancias-Gómez, 2015)</td>
</tr>
</tbody>
</table>

Correlates

The main indices (best time, mean time and fatigue index) of an RSA protocol correspond to different qualities and provide information about both anaerobic and aerobic energy transfer systems of human body. This has been shown by a study on soccer players, where predictors differed for each index (P. T. Nikolaidis, Dellal, Torres-Luque, & Ingebrigtsen, 2015). For instance, the performance in single sprint was predictor of best time and mean time, but not of fatigue index. With regards to anthropometric characteristics, body fat percentage has been correlated with BT and MT, the higher the BF the worst the performance in RSA (P. T. Nikolaidis, Dellal, et al., 2015). The role of aerobic capacity might be related to the effect of oxidative metabolism on reductions in fatigue (McGawley & Bishop, 2015). A smaller fatigue index might be related to faster oxygen uptake kinetics as it was shown in a study on a 7×30 m RSA protocol with 20 s of active recovery (Dupont, McCall, Prieur, Millet, & Berthoin, 2010).

Training interventions

According to Bishop et al. (Bishop et al., 2011), two approaches have been proposed to train RSA. First, based on the concept of training specificity a training program should use repeated sprints. Second, a training program should concentrate on those parameters limiting RSA (e.g concentration of hydrogen, energy supply). Training programs based on repeated sprints affected not only RSA, but also other indices of physical fitness. A review of RSA training indicated a beneficial effect of RSA training on 10, 20 and 30 m sprint, countermovement jump and high-intensity intermittent running performance (Taylor, Macpherson, Spears, & Weston, 2015).

The studies that have investigated the trainability of RSA have used either an experimental group and a control group (Gonzalo Skok, Tous Fajardo, Arjol Serrano, Suárez Arrones, & Méndez Villanueva, 2014; Soares-Caldeira et al., 2014; Vernillo et al., 2015), or two experimental groups each of which performed a different training intervention (Attene et al., 2014; Delextrat & Martinez, 2014). For instance, an 8-week program of 3 times per week, 18 15-m sprints with 17 s passive recovery in male adults improved RSA and post-exercise heart rate recovery and heart rate variability (Vernillo et al., 2015). Two 6-week programs, RSA training and intermittent training, were examined in female basketball players, both improved RSA with higher effectiveness characterizing the intermittent training (Attene et al., 2014). Also, a 6-week program of leg press exercise (1-2 blocks of 5 sets x 5 repetitions with 20 s recovery between sets and 3 min recovery between blocks) resulted in improved RSA of basketball players (Gonzalo Skok et al., 2014). On the other hand, all training interventions did not improve RSA (Delextrat & Martinez, 2014). For instance, two 6-week programs in junior basketball players, the one using small-sided games and the other one high intensity intermittent training, did not impact RSA (Delextrat & Martinez, 2014). In futsal players, additional training with repeated sprints during did not result in enhanced performance (Soares-Caldeira et al., 2014).

Summary

The present brief review summarized the application of RSA in basketball. RSA was defined briefly and its relevance for this team sport was highlighted. RSA protocols that have used in basketball were identified, their strengths and limitations were reported. The correlations of RSA main indices (best time, mean time and effort) were reported.
fatigue index) with anthropometric and physical fitness characteristics were presented. Finally, training strategies used to train RSA were presented. Based on this review, it was concluded that (a) the different characteristics of existing RSA protocols make any comparison of scores among them impossible, (b) most of the existing protocols used in basketball players did not correspond to the dimensions of a basketball court, (c) repeated sprints can be implemented in a sports-specific physical fitness program to improve RSA and other physical fitness components (sprint, muscle power and aerobic capacity), and (d) more research in RSA of elite adult basketball players and in children is needed, because most of the existing studies has been conducted on a very narrow range of age (15-17 years).

References


