Original Article

Repeated Sprint Ability Exercise in a 9-Year-Old Basketball Players: Effect of Change of Direction

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Abstract

Background: The aim of the present study was to examine the effect of one or two changes of direction (COD) on performance indices in a 10x15 m repeated sprint ability exercise (RSA) in 9-year-old basketball players. Fourteen basketball players (age 9.4 ± 1.7 yrs, height 142 ± 13 cm and weight 39 ± 10 kg) performed an RSA protocol in three different conditions on a counterbalanced order on separate days: (A) in straight line (RSASL), (B) with one COD (RSACOD, i.e., 10 × (7.5 + 7.5 m)) and, (C) with two COD (RSA2COD, i.e., 10 × (5 + 5 + 5 m)). Sprints started every 30 s (passive recovery); time variables were total time (TT), best time (BT) and fatigue index (FI). Countermovement jump (CMJ) was tested before and after each RSA protocol. Heart rate (HR) was continuously monitored during testing procedures. RSASL, RSACOD and RSA2COD differed for TT ($p<0.001$, $\eta^2=0.98$), BT ($p<0.001$, $\eta^2=0.98$), with faster times in RSASL, and FI (higher value in RSA2COD; $p=0.001$, $\eta^2=0.67$). A repeated measure 2 × 2 ANOVA showed a main effect of RSA on CMJ (increase; $p=0.019$, $\eta^2=0.34$), whereas there was not main effect of RSA format ($p=0.061$, $\eta^2=0.19$) nor interaction ($p=0.945$, $\eta^2<0.01$). No difference was observed in HR_{mean} ($p=0.340$, $\eta^2=0.30$) and HR_{peak} ($p=0.418$, $\eta^2=0.25$). These findings showed that performing repeated sprints with two COD resulted in increased fatigue compared to RSA in-line or with one COD in 9-year-old basketball players.

Keywords: Exercise test; Performance; Running; Team sport; Vertical jump

Introduction

Basketball is one of the most popular team sports played worldwide [1]. In this sport, movements of high intensity and short duration, such as sprinting and jumping, are interchanged with actions of low-to-moderate intensity and relatively long duration, such as standing and walking [2,3]. Sprinting ability is considered as a major determinant of performance [4]. For instance, male basketball players of higher skill level have been shown to have higher vertical jump values and be faster and more agile than the less skilled players [5,6]. Repeated sprint ability (RSA) has been recently recognized as a novel component of sports-related physical fitness and administered regularly during a fitness battery in basketball [7]. RSA has been defined as the ability to perform repeated sprints with minimal recovery or the ability to produce the best possible average sprint performance over a series of sprints, separated by short recovery periods [8,9].

RSA has been evaluated in basketball players using various protocols, which differ mostly for sprint distance, number of sprints, mode and duration of recovery among sprints and mode of change of direction (COD) [10]. COD refers mainly to linear movements, but it is possible to use multi-directional sprints involving lateral directions [11,12]. Most of the existing RSA protocols use sprint distance from 20 to 35 m [13,14]. Considering that an official basketball court has length less than 28 m [1] and that the mean duration of sprint has been reported to last less than 2 s, [15] the abovementioned sprint distance of existing RSA protocols does not seem sport-specific. This observation revealed the need to develop new RSA protocols using shorter sprint distance. Actually, a recent study used 15 m sprints and showed that, compared to controls, basketball players showed relatively better performance in RSA when exercise is performed with a COD than in-line [16].

Most of previous studies on RSA were conducted on adult [17] and adolescent basketball players, [11,12,16] a trend that was also highlighted for other components of physical fitness examined mostly on adults [18,19] and adolescents [4,20-22]. On the other hand, little information was available with regards to RSA of children (i.e. with age <12 years old) especially using RSA exercises with COD. Children have been reported to engage in regular basketball training since the age of 6-8 years [23,24]. Although a main purpose of training in such age is developing motor skills, RSA with or without COD is inherent to basketball training and is used in the daily practice even in this age. In addition, exercises included in the training program are sport-specific, and since basketball involves many repeated sprints, it is subsequent to implement RSA exercises in the daily practice. Thus, information about the physiological impact of RSA exercises in children would be of great practical importance for coaches and trainers working with very young basketball

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players. Therefore, the aim of this study was to examine the effect of one or two changes of direction (COD) on performance indices in a 10 × 15 m RSA exercise in children.

Methods

Fourteen children basketball players (age 9.4 (1.7) yrs, height 142 (13) cm and weight 39 (10) kg), members of a competitive club in the region of Athens (Greece), participated voluntarily in the present study which was conducted on March 2015. The participants constituted a sample of convenience, i.e. no randomized selection procedures were applied. They had sport experience >2 years and participated to three training sessions and one official match weekly. It should be noted that basketball in Greece is very popular that might explain the early engagement of children in systematic training in this sport. The local institutional review board approved the study, which was conducted according to the Declaration of Helsinki (1964). In order to participate, basketball players should be free of any injury and illness, and were instructed to abstain from strenuous physical activities on the testing days. All participants and their parents or guardians provided their informed consent for this study. The participants were invited in the following four testing sessions, which were separated by at least 48 h of rest and were completed within 10 days: (i) date of birth, body mass and height; (ii) 10 × 15 m RSA exercise in straight line (RSASL); (iii) 10 × 15 m RSA exercise with 180˚ change of direction, i.e. 10 × (7.5 + 7.5 m) (RSACOD); (iv) 10 × 15 m RSA exercise with two 180˚ change of direction, i.e. 10 × (5 + 5 + 5 m) (RSA2COD) [Figure 1]. It should be highlighted that no previously published data in such exercises exist and no relevant information regarding validity and reliability was available; thus, the term "RSA exercise" instead of "RSA test" was preferred and used consistently in the present study. A standard supervised 20 min warm-up was performed in each testing session including 5 min jogging, 10 min dynamic stretching and 5 min running drills in straight line or with one or two COD. Each testing session was realized in an outdoor basketball court at the same time-of-day (7 p.m. - 9 p.m.) under similar environmental conditions (temperature16-19°C and humidity 62-68%). The participants were assigned randomly to the following six groups, based on which the three RSA exercises were performed in a counterbalanced order: RSASL-RSACOD-RSA2COD, RSASL-RSA2COD-RSACOD, RSACOD-RSASL-RSA2COD, RSACOD-RSA2COD-RSASL, RSA2COD-RSASL-RSACOD and RSA2COD-RSACOD-RSASL.

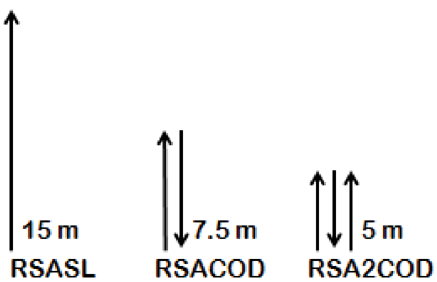

Figure 1: Presentation of repeated sprint ability protocols.

The date of birth was recorded and chronological age was calculated. A stadiometer (SECA, Leicester, UK) and an electronic scale (HD-351, Tanita, Illinois, USA) were used to measure body height (to the nearest 1 mm) and body mass (0.1 kg), respectively. The RSASL exercise consisted of 10 × 15 m sprints starting every 30 s (passive recovery). A hand-held stopwatch Seiko S056 (Seiko Sasaki, Tokyo, Japan) was used to time the 30-s sprint-recovery cycle and every sprint started following an auditory signal (whistle). Participants were encouraged to assume the ready position 5 s before starting the next sprint and were encouraged verbally in order to exert maximal effort in every trial. Each sprint was timed using a photocell system (Brower Timing Systems, Utah, USA) consisting of two pairs of photocells. The photocells were placed at the belt height in order the legs not to break the light beam according to manufacturer's guidelines and the participants started their attempts from a standing position 0.5 m behind the first pair of photocells. The following time variables were calculated: total time (TT), best time (BT) and fatigue index (FI). The Fitzsimons' formula FI = 100 × (TT/(10 × BT))−100 [25]. used to calculate FI. According to this formula, FI indicates how much the total performance in the test differs from the ideal performance, where the participant would perform all sprints as fast as the fastest sprint. The larger the FI, the larger the total performance deviates from the ideal; thus, the fatigue is increased.

Countermovement jump (CMJ) was tested on an optical measurement system consisting of a transmitting and receiving bar (Optojump next, Microgate Engineering, Bolzano, Italy) before (pre-test) and after each RSA test (post-test). This equipment calculated the height of CMJ based on flight time. In each occasion (pre-test or post-test), two trials were performed and the best was recorded. Heart rate (HR) was continuously monitored beat-to-beat (Polar team2, Finland) during testing procedures. Mean (HR_{mean}) and peak HR (HR_{peak}) was recorded for each RSA test.

The statistical package IBM SPSS v.20.0 (SPSS, Chicago, USA) was used to perform all statistical analyses. The dependent variables were tested for the assumption of normality using the Shapiro-Wilk test and visual inspection of normality plots. All data were presented as mean (standard deviation). A repeated measures analysis of variance (ANOVA) examined differences among the three RSA formats with regards to time variables (TT, BT and FI), HR_{peak} and HR_{mean}. A 2 × 2 repeated measures ANOVA was used to examine the effect of RSA format (RSASL vs. RSACOD vs. RSA2COD) and exercise (post-test vs. pre-test) on CMJ. To evaluate the effect size (ES) for differences in ANOVA the following criteria of eta squared were used: $\eta^2 = 0.01$, small ES; $\eta^2 = 0.06$, medium ES; $\eta^2 = 0.13$, large ES [26]. Significance level was set at alpha = 0.05.

Results

Sprint time of each trial in the three RSA protocols can be seen in Figure 2. RSASL, RSACOD and RSA2COD differed for TT (36.69 (2.81), 47.64 (3.41) and 60.24 (4.77) s; p<0.001, η2=0.98), BT (3.47 (0.23), 4.54 (0.26) and 5.56 (0.43) s; p<0.001, η2=0.98) and FI (5.8 (2.6), 5.0 (2.9) and 8.3 (2.6)%; p=0.001, η2=0.67) [Table 1 and Figure 3]. TT in RSA2COD and RSACOD were slower than RSASL by 64.2 and 29.8%, respectively, whereas TT in RSA2COD was 26.4% slower than RSACOD. BT in RSA2COD and RSACOD were slower than RSASL by 60.2% and 30.8%, respectively, whereas BT in RSA2COD was 22.5% slower than RSACOD. An increase in variability of scores, assessed by standard deviations, was also observed with adding COD.

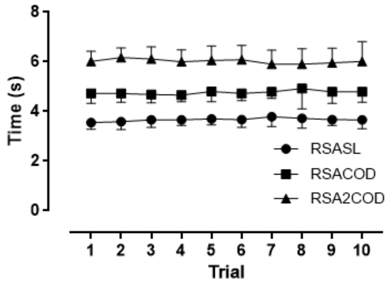

Figure 2: Sprint time by trial in RSASL, RSACOD and RSA2COD.

Table 1: Time variables in the three formats of RSA exercise.

	RSASL	RSACOD	RSA2COD	Comparison
Total time (s)	36.69 ± 2.81†‡	47.64 ± 3.41*‡	60.24 ± 4.77*†	$p<0.001$, $\eta^2=0.98$
Best time (s)	3.47 ± 0.23†‡	4.54 ± 0.26*‡	5.56 ± 0.43*†	$p<0.001$, $\eta^2=0.98$
Fatigue index (%)	5.8 ± 2.6‡	5.0 ± 2.9‡	8.3 ± 2.6*†	$p=0.001$, $\eta^2=0.67$
Peak HR (bpm)	177 ± 13	182 ± 6	182 ± 6	$p=0.418$, $\eta^2=0.25$
Mean HR (bpm)	164 ± 16	171 ± 8	169 ± 11	$p=0.340$, $\eta^2=0.30$

RSASL = RSA exercise in straight line, RSACOD = RSA exercise with one change of direction, RSA2COD = RSA exercise with two changes of direction. HR = heart rate. Data are presented as mean ± standard deviation. *, † and ‡ denote differences from RSASL, RSACOD and RSA2COD, respectively, at p<0.05.

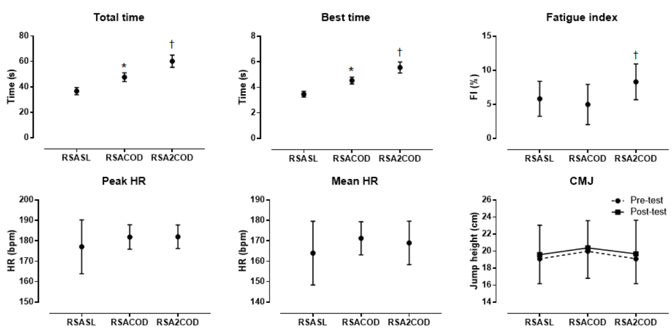

Figure 3: Time variables, mean and peak HR in three formats of RSA test and changes in countermovement from pre-test to post-test. * and † denote differences from RSASL or both from RSASL and RSACOD, respectively.

A repeated measure 2 × 2 ANOVA showed a main effect of RSA on CMJ (pre-RSA vs. post-RSA 19.4 vs. 19.9 cm, $p=0.019$, $\eta^2=0.34$), whereas there was not main effect of RSA format ($p=0.061$, $\eta^2=0.19$) nor interaction ($p=0.945$, $\eta^2<0.01$). No difference was observed in HR_{mean} (164 (16), 171 (8) and 169 (11) bpm; $p=0.340$, $\eta^2=0.30$) and HR_{peak} (177 (13), 182 (6) and 182 (6) bpm; $p=0.418$, $\eta^2=0.25$).

Discussion

The present study examined the effect of different formats of 10 × 15 m RSA exercise on performance parameters in children basketball players. The main findings were that (a) RSASL, RSACOD and RSA2COD differed for TT, BT (fastest times in SL) and FI, (b) a main effect of RSA on CMJ (compared to pre-RSA, increased in post-RSA), and (c) no difference was observed in HR_{mean} and HR_{peak}.

Match analysis reported that 55 to 105 high-intensity runs occurred during a basketball match with very short sprinting periods (2 to 6 seconds) and with great frequency (every 21 to 39 seconds) [15,27]. Despite this profile fit with RSASL tests, the reality of the game requires short sprints with changes of direction and small distances [7]. considering that during a match a frequency of 997 to 1050 movements are made [27]. For that reason, we compared a RSASL test of 15 m, a RSACOD (7.5 + 7.5 m) and a RSA2two COD (5 + 5 + 5 m). Analysis of variance revealed that both tests with COD statistically increased the time to perform the test. Particularly, the RSA2COD was the slowest. This can be justified by the double task of decelerate and accelerate the run, thus losing time twice than the regular straight line run or one more time than the run with a single COD [16]. Despite of these results, tests with COD may fit better in the specificity of basketball. A previous study conducted in adolescent players and high-school students revealed that basketball players reduced the gap to the control group in the test with COD, thus suggesting the beneficial effects of sports specialization [16]. In the same study conducted in adolescents basketball players it was verified that they spent 27.98 s in straight line test and 38.55 s in RSACOD [16]. The results obtained in our study for the same tests showed a worse performance in both tests (~30% slower in RSASL and ~24% slower in RSACOD). The age-related differences in RSA performed by young soccer players suggested that maturation may justify the best performances until a plateau that occurs from 15 years old [28].

Statistical variance of FI between RSA protocols was also revealed. Greater values of FI were found in RSA2COD, thus suggesting that fatigue effect can be more prominent in sprints with multiple accelerations and decelerations. The occurrence of a great mechanical work in the multiple changes of directions may contribute to increase the gap between the initial sprint and the remaining runs [7]. This evidence was verified in straight line runs, identifying that players with a greater initial sprint performance may have greater changes in muscle metabolites, arising secondary to a higher anaerobic contribution which in turn has been related to greater decreases in sprints performance [29]. Another indicator that was not analyzed in this study can be associated with the index used to analyses the fatigue. The FI can be highly influenced by a very good or very bad first of last sprint [29]. The percentage decrement score that considers all sprints may fit better, especially for the case of double COD, considering that the initial sprint can be much better that the remaining sprints [25].

As previously discussed, the high frequency of short movements requires that after a sprint players may need to perform a jump or the inverse [30]. For that reason, this pattern of movement of explosive effort-sequences should be considered as a determinant fitness component to characterize the athletes [30]. A previous study analyzed the effect of jumping ability within the recovery of repeated sprints at thirteen team sports players [31]. Despite the different protocols of RSA, the main results showed that repeated-jump performance was better maintained with straight-line run and that repeated sprint-sprints and repeated-jumps displayed different performance decrements and were not highly associated [31]. Surprisingly, our results revealed a statistical better performance in CMJ after RSA protocol, with no differences between types of RSA. A similar protocol tested in adolescent basketball players revealed similar evidences [16]. These results may be justified by the preliminary suggestion that repeated-sprint and jump ability might exist as separate and specific qualities [31]. This is not new considering that both require different energy systems. Following this idea, the correlations between single sprints (10 m) and jump performances tested in basketball players revealed weak correlations [32]. Actually, the age-related effect may contribute more to the jumping performance than the fatigue effect caused by RSA. The results obtained with the same protocol in adolescents [16]. revealed jumps of 34.8 cm (in pre-test) and 36.6 cm (in post-test), thus being considerable greater than the obtained by the present study (19.4 cm and 19.9 cm, respectively). Future studies may follow this idea to compare the age-related effect in both RSA and jumping performance tests in basketball players.

The HR rate responses were also studied during the RSA tests. Despite of some empirical evidences suggest that running with COD may increase the energy demands, the blood lactate concentrations, HR and oxygen uptake in comparison with straight-line runs, [33,34]. a recent study on soccer that adjusted the limitations of these previous studies (the time spent during the turns) revealed that COD-sprints are largely less metabolically demanding than straight-line runs [35]. Our comparison between RSA tests revealed no statistical differences in HR_{mean} and HR_{peak}, thus not confirming the abovementioned studies.

The present study highlighted the importance of testing RSA with and without COD, thus showing the differences between performances. The CMJ tested before and after the RSA protocols also showed no differences in jumping performance, thus suggesting that protocol with COD not elicits an increase the effects of fatigue. For that reason, the use of RSA with COD and double COD may be more appropriate to simulate the specificity of the basketball demands. The use of RSA should be also used to test the fitness levels of players and monitor the effects of training process.

A limitation of this study was the small size of the sample that did not allow finding statistical significant differences despite some promising effect sizes. Although a larger number of participants volunteered initially for this study (n=34), only 14 completed successfully all testing sessions. It should also be highlighted that the experimental design was set to quantify the load of three selected RSA exercises and not to establish validity and reliability of exercise tests. Despite of these limitations, this study contributed to propose a new protocol for young basketball players, using COD and short distances to characterize the specificity of players. Future studies may also compare the effects of use and no use the dribbling skill.

Conclusion

In conclusion, these findings showed that performing RSA in-line or with COD resulted in different acute physiological responses for the cardiovascular and neuromuscular systems of 9-year-old basketball. Although all RSA protocols elicited similar HR responses, adding two COD induced larger fatigue. Therefore, coaches and fitness trainers should consider the unique physiological responses to RSA exercises. Especially those working with very young basketball players should consider using no COD in order to reduce the physiological load. Practical ways to reduce this load might be either to use submaximal instead of maximal running speed during RSA with CODs or to perform the COD slowly or to manipulate other exercise parameters (e.g. decrease number of sprints or increase rest duration among sprints).

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Conflict of Interest

All authors disclose that there was no conflict of interest.

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