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Original article

The influence of basketball dribbling on repeated high-intensity intermittent runs

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Abstract

Background/Objective: This research examines whether or not the Yo-Yo testing performance could reflect the repeatability of high-intensity intermittent dribbling in adolescent basketball players.
Methods: Thirty-six teenage basketball players aged 13–18 years were invited to participate in this study.
Results: A test–retest showed that the Yo-Yo intermittent endurance Level 2 (IE2) test with dribbling (intraclass correlation coefficient = 0.92; coefficient of variation = 12.6%; $d = 0.24$) and without dribbling (intraclass correlation coefficient = 0.83; coefficient of variation = 15.0%; $d = 0.37$) had acceptable reliability. The dribbling distance covered was significantly shorter than was the running performance of the Yo-Yo IE2 test in participants younger than 15 years (junior; 1138 ± 417 m vs. 910 ± 299 m, $p < 0.01$; $d = 0.65$), as well as in the entire study sample (1077 ± 398 m vs. 1267 ± 437 m, $p < 0.05$; $d = 0.45$), whereas there was no significant difference in the senior players between the two protocols (1396 ± 436 m vs. 1244 ± 427 m, $p > 0.05$; $d = 0.35$). Moderate to large correlations were found between running and dribbling performances in the senior sample ($r = 0.57$, $p = 0.06$), the junior sample ($r = 0.87$, $p < 0.01$), and the whole ($r = 0.72$, $p < 0.01$) sample, respectively.
Conclusion: The results suggest that the Yo-Yo IE2 test could reflect the repeatability of high-intensity intermittent basketball dribbling performance, while dribbling skills may have different influences on high-intensity intermittent exercise capacity in adolescent players at different ages.

Keywords: basketball; dribbling; repeatability; Yo-Yo IE2 test

Introduction

Basketball, a high-intensity intermittent team sport,[1] involving frequent jumping, accelerating, decelerating, turning, and pivoting, requires a combination of good fitness and repeated high-intensity bouts of exercise interspersed with brief periods of low-intensity movement,[2] in addition to superb skill execution.[3] In ballgames, a good player has the ability to dribble without losing running speed and the better players can distinguish themselves by their running speed while dribbling the ball.[4] Running while dribbling a ball is a fundamental skill in basketball. Previous studies revealed that the dribbling velocity had no significant decrease when compared with the running speed over the same course at maximal intensity in elite young[3] and elderly basketball players.[5] However, maintaining running speed while dribbling is a challenge. Dribbling and controlling the basketball become more complicated when the players face high

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velocities with various multidirectional movements because of extra metabolic and neuromuscular loads during exercise.[6,7] As a consequence, several studies have shown that dribbling could decrease the running speed in submaximal[8,9] and repeated sprint exercises.[6,7,10] Therefore, whether dribbling can cause a reducing impact on running performance needs to be clarified.

Given that basketball players run 4500–5000 m in a 40 minute game with extensive intermittent activity,[1] both aerobic and aerobic metabolic pathways are important in this sport.[11] However, the existing studies comparing dribbling with and without a ball mostly focus on submaximal[9] and repeated sprinting exercises within 10s of seconds.[3,5–7] There is little information examining the influence of dribbling on running performance and physiological indices during repeated high-intensity intermittent exercise, which is closely related to the ability to change direction repeatedly and to maintain high intensity shuffling movements in basketball.[3]

The Yo-Yo tests, including the Yo-Yo intermittent recovery test (Yo-Yo IR)[12–15] and the Yo-Yo intermittent endurance test (Yo-Yo IE),[16,17] are popular field tests that examine the fitness of intermittent exercise for basketball players because they have the advantage of frequently and quickly testing a team at a low cost. The Yo-Yo intermittent exercise tests have two levels—Yo-Yo IR and IE Level 2 tests, which begin at a higher speed with quicker incremental intensities compared with Level 1. The recovery periods between each shuttle run are 10 seconds for the Yo-Yo IR tests and 5 seconds for the Yo-Yo IE tests, respectively.[17,18] At present, the Yo-Yo IR tests have been extensively used in different ballgame populations, such as elite soccer players,[12] nonelite young soccer players,[15] adolescent handball players,[19] junior basketball players,[13] and children.[20] Due to the short recovery time and intense exercise intensity, the Yo-Yo IE2 test is used for elite athletes to determine the ability to perform repeated intermittent exercises at a maximal intensity.[17,21] Yet, this test is mainly used in soccer for assessing the fitness of male[21] and female elite soccer athletes,[22] nonelite young soccer players,[15] and even referees.[23] Limited researches concerning this are found for basketball, although the Yo-Yo IE2 test seems appropriate for reflecting the nature of repeated high-intensity intermittent exercises. Hence, it is necessary to determine whether the Yo-Yo IE2 test is a reproducible test for evaluating the high-intensity intermittent exercise capacity of basketball players.

With the increasing trend of specializing training at early ages, knowledge of youth training and talent identification and development has been emphasized over recent years. From the viewpoint of practical training, basketball coaches tend to combine fitness training with the practice of sports-specific skills at the same time.[6] If dribbling a ball does not reduce running speed, training with a ball can be an alternative to fitness training because dribbling is one of the most enjoyable basketball fundamentals.[24] By contrast, if the ball has been proven to be the limiting factor for maintaining intensity, physical fitness training should be executed and strengthened without dribbling.

Based on the knowledge of the reliability of the Yo-Yo IE2 test in terms of the high-intensity intermittent exercise in basketball, the purpose of the present study was to examine the influence of dribbling on performance indices using the Yo-Yo IE2 test in adolescent players. It is hypothesized that basketball dribbling can induce different responses in adolescent players at different ages, and running performance is associated with dribbling performance over the same course of high-intensity intermittent exercise.

Methods

Participants

This study enrolled 36 basketball players aged 13–18 years (15.0 ± 1.3 years) with a training history of 2.8 ± 1.4 years. They each trained three to four 90-minute sessions per week. Before participation, all players and their parents were informed of any potential risks of study participation, and all gave their informed consent to participate in accordance with the guidelines established by the Committee of University Research Ethics according to the Helsinki Declaration.

The players underwent the Yo-Yo IE1 test during training in the previous season. To investigate the reproducibility of the Yo-Yo IE2 test with and without dribbling, 24 and 12 of the enrolled players were randomly selected to perform a test–retest of the Yo-Yo IE2 test with and without a basketball. In addition, 22 players accomplished the Yo-Yo IE2 run with and without dribbling and performed graded exercise testing on a treadmill to determine maximal oxygen uptake ($\dot{V}O_{2max}$). For those who completed the Yo-Yo IE2 test with or without dribbling twice, the first measures were used as performances of these two protocols to examine the influence of dribbling on repeated high-intensity intermittent exercise performance.

Procedures

As outdoor courts are more common than are indoor courts, the Yo-Yo IE2 tests with and without dribbling were conducted on the same field basketball outdoor court. The participants were instructed to maintain consistent dietary and sleeping patterns, to avoid caffeine and alcohol consumption for 12 hours before testing, and to perform no strenuous exercise the day before each trial. All trials were performed with the participants wearing the same sports shoes and sportswear, and at the same time of day to reduce the influence of diurnal variation. Field tests were completed between 4:00 PM and 6:00 PM and laboratory tests between 5:00 PM and 8:00 PM

In regard to the responses of dribbling on repeated high-interment exercise, the Yo-Yo IE2 test was completed first, followed by the $\dot{V}O_{2max}$ test, and finally the dribbling test. The different tests were separated by up to 7 days, with the total duration of study participation not exceeding 3 weeks for any player. The same verbal encouragements were delivered for every test. All players were familiar with the testing

procedures and underwent at least a preliminary trial prior to testing.

Yo-Yo IE2 test with and without dribbling

The procedure of the Yo-Yo IE2 test without dribbling has been described elsewhere in the literature.[21,25] The players ran back and forth, completing two 20-m shuttle runs in time with the "beep" sounds from a CD player. Following each shuttle run, the players walked or slowly jogged the 2.5 m behind the marking cone, getting back to the starting point within 5 seconds. The shuttle run speed progressively increased, and the test was terminated when the participant was unable to match the set pace of the "beeps" twice. When the player completed the last shuttle, the total distance covered was recorded. Heart rate (HR) was continuously recorded (Zephyr BioHarness Team System, Zephyr Technology, Annapolis, MD, USA) during the test.

The Yo-Yo IE2 test with dribbling was identical to the Yo-Yo IE2 test except that the participants dribbled a basketball during the shuttle run. Based on the Yo-Yo IE2 distance and the results of the preliminary dribbling Yo-Yo IE2, the shuttle dribbling run distance was reduced from 20 m (× 2) to 17.5 m (× 2) so that completion time would be similar.

$\dot{V}O_{2max}$ test

In a preliminary test, all participants were familiarized with the progressively incremental treadmill test in the laboratory. After stretching exercises and running for 3 minutes at 5 km/h on a motorized treadmill (H/P/Cosmos Sports and Medical GmbH, Pulsar 3P, Nussdorf-Traunstein, Germany), the $\dot{V}O_{2max}$ test commenced with 2 minutes of running at 6.3 km/h at a slope of 0%, followed by an increase of 2 km/h every 2 minutes until reaching 12.3 km/h. Subsequently, the gradient was systematically increased by 2.0% every 2 minutes until exhaustion. Cardiorespiratory variables were measured using a calibrated breath-by-breath analysis system (MetaMax 3X, Cortex Biophysik, Leipzig, Germany) and HR was measured using a portable monitor (Polar F4, Polar Electro, Kempele, Finland). The test was stopped when three of the following criteria were met: respiratory exchange ratio $\geq$ 1.0, HR $\geq$ 90% (220 − age) bpm, rated perceived exertion (RPE) $\geq$ 18, no increase in parameters with increasing workload or levelling off of the $\dot{V}O_{2max}$ curve, and subjective discontinuity (uncoordinated running, hyperventilating, and/or clear signs of unwillingness to continue).[20] $\dot{V}O_{2max}$ was determined as either submaximal oxygen uptake value or peak $\dot{V}O_{2max}$ value appearing more than twice.

Statistical analysis

Data are expressed as mean ± standard deviation. Before using parametric tests, the Shapiro–Wilk test was used to test the data for the assumption of normality. The relative reliability of the test was assessed by calculating the intraclass correlation coefficient (ICC), for which a value of 0.70–0.90 is considered moderate and >0.90 is considered high.[26] Absolute reliability measures indicate the expected within-participant trial-to-trial noise (absolute error), independent of the between-participant differences.[27,28] The coefficient of variation (CV) and the standard error of measurements (SEM) were assessed. A CV of $\leq$10% indicates high reproducibility, $\geq$25% indicates poor reproducibility, and moderate reproducibility is indicated by a CV value of around 15%.[29] The smallest worthwhile change (SWC) was calculated to show the capacity to detect the test–retest change.[30] Reliability is considered to be good or satisfactory when SEM $\leq$ SWC, while SEM $\geq$ SWC indicates marginal reliability.[28] The paired *t*-test was applied to examine systematic biases between the test–retest trials.

A two-way repeated measures analysis of variance was used to determine differences in the variables between repeated trials (dribbling vs. running) of the Yo-Yo test and cross groups (junior vs. senior). Following a simple main effect of the trials, paired-samples *t*-test was applied to compare the difference of running and dribbling results. An independent-samples *t*-test was used to compare the difference between the junior and senior players. The effect size of the difference between variables is considered small if Cohen's *d* is between 0.2 and 0.3, large if *d* is > 0.8, while a *d* value around 0.5 indicates a medium effect size.[31] The relationships between the Yo-Yo test with and without dribbling were examined using a simple linear regression analysis in the junior, senior, and entire group of players groups. An alpha level of $p < 0.05$ was considered to indicate statistical significance.

Results

Reliability of the Yo-Yo IE2 test with and without dribbling

No significant difference was found between the test and retest performances of the Yo-Yo IE2 test without dribbling ($p > 0.05$, $d = 0.37$). Although there was a significant increase between the test and retest performances in the Yo-Yo test with dribbling ($p < 0.05$, $d = 0.24$), the effect size was small.[31]

The ICC values were 0.83 for the Yo-Yo IE2 test without dribbling ($p < 0.01$; 95% confidence interval: 0.39–0.95) and 0.92 for the Yo-Yo IE2 dribbling test ($p < 0.001$; 95% confidence interval: 0.74–0.95). The CV values for test–retest performance were 12.6% and 15.0% for the Yo-Yo IE2 test with and without dribbling, respectively (Table 1). For Yo-Yo IE2 performance with and without dribbling, the values of the SEM were smaller and larger compared with the SWC values for these two types of tests (dribbling, 63.0 m; without dribbling, 64.8 m).

The influence of basketball dribbling on repeated high-intensity intermittent runs

Junior and senior players had different ages and training histories but consistent height, weight, body composition, and $\dot{V}O_{2max}$ values (Table 2). Regarding performances of the Yo-

Table 1
Reliability for performance to the Yo-Yo intermittent endurance test Level 2 with and without dribbling.

	N	Test	Retest	ICC	CV (%)	SEM
Yo-Yo IE2 running	12					
Distance (m)		1210 ± 395	1363 ± 442	0.83	15.0	79.7
Peak HR (bpm)		191 ± 8	190 ± 9	0.91	1.7	1.0
Yo-Yo IE2 dribbling	24					
Distance (m)		1175 ± 438	1286 ± 479[a,*]	0.92	12.6	43.8
Peak HR (bpm)		189 ± 10	190 ± 11	0.88	2.3	1.6

*$p < 0.05$.
CV = coefficient of variation; HR = heart rate; ICC = interclass correlation; SEM = standard error of the mean; Yo-Yo IE2 = Yo-Yo intermittent endurance test Level 2.
[a] Comparison with test.

Yo IE2 with and without dribbling, the seniors ran longer than the junior players did ($p < 0.01$). For comparison of the Yo-Yo test with and without dribbling ($p < 0.01$, $d = 0.65$), the juniors and the entire group of players ($p < 0.05$, $d = 0.45$) performed worse in the former compared with the latter, and the seniors covered similar distances (Table 3).

Significant correlations of the Yo-Yo IE2 test with and without dribbling were found in the juniors ($r = 0.87$; $p < 0.01$) and the entire group of players ($r = 0.72$; $p < 0.01$). The performance on the Yo-Yo test with dribbling was moderately correlated with that of the Yo-Yo IE2 test without dribbling ($r = 0.57$; $p = 0.06$; Figure 1).

Discussion

To our knowledge, this is the first study to evaluate the influence of basketball dribbling on repeated high-intensity intermittent runs in basketball players. The study showed that the Yo-Yo IE2 test with or without dribbling had acceptable reliability in adolescent basketball players. Running speed while dribbling during repeated high-intensity intermittent exercise decreased in the junior adolescents (younger than 15 years) but not in the senior adolescents, whereas there were similar responses in maximal HR and RPE

Table 2
Physiological characteristics of the participants.

	Junior ($n = 11$, 5F, 5G, & 1C)	Senior ($n = 11$, 7F, 2G, & 2C)	All ($n = 22$)
Age (y)	13.6 ± 0.5	16.0 ± 0.8[a,**]	14.8 ± 1.5
Height (cm)	167.0 ± 5.0	169.9 ± 4.8	168.5 ± 5.0
Weight (kg)	58.0 ± 11.8	62.3 ± 11.7	60.1 ± 11.4
Fat free mass (kg)	47.6 ± 5.7	51.0 ± 5.3	49.3 ± 5.7
Fat mass (kg)	10.4 ± 7.2	11.2 ± 7.0	10.8 ± 6.9
Body fat (%)	16.7 ± 7.7	17.1 ± 6.6	16.9 ± 7.0
Training history (y)	1.9 ± 1.1	3.5 ± 1.4[a,*]	2.7 ± 1.5
$\dot{V}O_{2max}$ (mL/kg/min)	55.8 ± 6.4	56.1 ± 4.1	56.0 ± 5.2

*$p < 0.05$.
**$p < 0.01$.
B = guard; C = center; F = forward.
[a] Comparison with juniors.

Table 3
Performance and physiological responses to the Yo-Yo intermittent endurance test Level 2 with and without dribbling.

	Junior ($n = 11$)	Senior ($n = 11$)	All ($n = 22$)	Effect size (d)
Running distance (m)	1138 ± 417[a,**]	1396 ± 436[b,**]	1267 ± 437[a,*]	$d_j = 0.65$, $d_s = 0.35$,
Dribbling distance (m)	910 ± 299	1244 ± 427[b,**]	1077 ± 398	$d_{all} = 0.45$
Running peak HR (bpm)	190 ± 10	191 ± 7	190 ± 9	$d_j = 0.22$, $d_s = 0.10$,
Dribbling peak HR (bpm)	193 ± 16	189 ± 8	191 ± 12	$d_{all} = 0.09$
Running peak RPE	17.7 ± 2.5	17.5 ± 2.1	17.6 ± 2.3	$d_j = 0.10$, $d_s = 0.46$,
Dribbling peak RPE	17.5 ± 1.4	18.4 ± 1.8	17.9 ± 1.6	$d_{all} = 0.15$

*$p < 0.05$.
**$p < 0.01$.
HR = heart rate; j = junior; RPE = rating of perceived exertion; s = senior.
[a] Comparison with dribbling.
[b] Comparison with juniors.

when running with and without dribbling. In addition, high correlations ($r = 0.87$, $p < 0.01$) and moderate correlations ($r = 0.57$, $p = 0.06$) were found between the two protocols of the Yo-Yo test in the junior and senior basketball adolescents, respectively.

Due to similar physiological requirements of a basketball game, the Yo-Yo IE2 test has been used in ballgames as a tool to examine physical fitness; however, no study has examined the reliability of the Yo-Yo IE2 test performances with and without dribbling in basketball. In general, reliability is usually examined as relative reliability and absolute reliability.[27] In accordance with previously reported ICC criteria,[28] the Yo-Yo IE2 test with and without dribbling were considered to be moderately and highly reliable measures, suggesting that both tests have acceptable relative reliability for use in youth basketball players. The test–retest CVs were 15.0% and 12.6%, respectively, for the performances of the Yo-Yo IE2 running with and without a basketball. These determined variations are consistent with the high variance of the Yo-Yo IR1 performance in young children (CV = 13.0–26.0%),[20] young soccer players (CV = 16.7–17.3%),[15] and junior basketball players (CV = 9.4–19.4%).[14] However, the presently determined variations were larger than that reported for Yo-Yo IE2 in elite male soccer players (CV = 3.9%).[21] Furthermore, the SEM value for the Yo-Yo IE2 was larger than its SWC, while the Yo-Yo IE2 dribbling test had a smaller SEM compared to its SWC. This difference accounted for the corresponding "marginal" and "satisfactory" detection of performance changes in these young basketball players. The statistical powers of the differences for the Yo-Yo IE2 tests were 0.37 and 0.24, respectively, representing small effect sizes. Additionally, the CV values in the present study are not high when compared with the wide range of performances, ranging from 385 m to 2100 m and 600 m to 2120 m in the Yo-Yo IE2 test performances with and without dribbling.

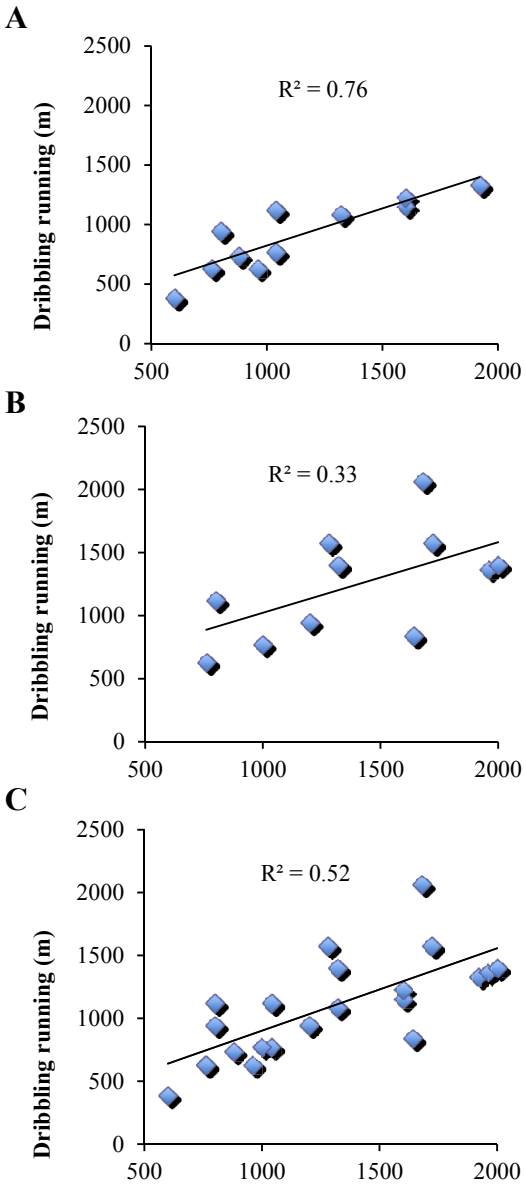

Figure 1. Regressions between the Yo-Yo intermittent endurance Level 2 test performance with dribbling (Y-axis) and without dribbling (X-axis) in the: (A) juniors; (B) seniors; and (C) the entire group.

The basketball players in this study were well-trained adolescent basketball players whose $\dot{V}O_2$max (56.0 ± 5.2 mL/kg/min) was similar to the levels of youth basketball players at elite levels.[3,13] As hypothesized, dribbling decreased repeated high-intensity intermittent exercise performance in adolescent basketball players despite a decreasing effect that only occurred in junior players, suggesting that the task of basketball dribbling may not be sufficient to induce an additional significant workload in skillful senior adolescents. It seems that age or training level are important factors affecting the results when dribbling a ball during repeated high-intensity exercise. The decrease in running performance while dribbling in the junior is in line with a previous study, which shows that dribbling can cause a decline of running speed during 6 m × 30 m repeated maximal sprints separated by 30 seconds rest in basketball players around 13 years of age.[6]

The correlations between repeated high-intensity intermittent running and dribbling performances in the junior and senior young players demonstrate that dribbling skills have more influence on running results in the younger players. Skillful senior players have comparable running and dribbling, as partially supported by Huijgen et al's[32] study, which shows that youth soccer players' sprinting improves rapidly compared with dribbling, from ages 14 years to 16 years, whereas after age 16 years dribbling improves considerably but sprinting hardly develops. These findings indicate that coaches and trainers may carry out different training modalities in light of the ages of young basketball players. Physical fitness and high-intensity dribbling skills may be trained separately for the junior age group, and more importantly, repeated high-intensity intermittent running capacity should be emphasized in these younger players. For the senior players, it might be better to incorporate dribbling rather than doing high-intensity intermittent runs in regular training sessions.

In contrast to previous studies,[6,7,9] we did not observe that dribbling led to a lower maximal HR and RPE, indicating that additional physiological responses and neuromuscular workloads caused by dribbling did not always happen when performing progressive high-intensity intermittent exercise. As a matter of fact, dribbling is one of the most enjoyable basketball fundamentals,[24] thus it is possible to speculate that for young basketball players, running without dribbling is not as enjoyable as with a ball and is more likely to cause a higher perceived load. The possible reason that dribbling reduces the Yo-Yo test performance in juniors may result from greater lower body rotation due to alternating movements of the two limbs, followed by shortening of the stride length.[8]

Sports disciplines and exercise modality appear to be influencing factors of running speed with a ball. Regardless of exercise modality, almost without exception, dribbling has a negative effect on running speed in soccer[7,9] and hockey players.[4] By contrast, Apostolidis et al[3] and Tessitore et al[5] observed that elite basketball players could run while dribbling at the same speed during a sprint. Given the different dexterity in upper and lower limbs, maneuvering a ball with legs or with hands may result in differences in metabolic and neuromuscular indices, which seems to be an interesting topic. Furthermore, the discrepancy between the present study and the previous studies may result from different exercise modalities. We used high-intensity intermittent tests with speed progression, while most previous studies examined the influences of dribbling on submaximal runs[8,9] or maximal repeated sprints,[6,7,10] which can be viewed as a short run with anticipated high speed. In addition, our findings also differ from some published studies in which dribbling does not reduce running speed because a single sprint was used.[3,5]

There are some limitations in the present study. Firstly, because of limited samples we did not compare the differences of running performance with and without dribbling in the adolescent players according to their playing positions, although no differences in running and dribbling testing results

of repeated sprints between frontline and backline players were reported before in young male basketball players.[6] Secondly, we did not use random order to conduct the repeated high-intensity intermittent running with and without a ball, which may cause order bias and changes to the accuracy of the estimated parameters. Thirdly, for the sake of the purpose of the study, our focus in this study merely concentrated on adolescent basketball players. Further investigations are needed to examine the influences of dribbling on repeated high-intensity intermittent exercise performance for different ballgame players at different competitive levels.

In conclusion, in the present study our main findings suggest that the Yo-Yo IE2 test with or without dribbling is reproducible in adolescent basketball players. Furthermore, losing running speed while dribbling during repeated high-intensity intermittent exercise may occur in junior adolescents (younger than 15 years) but not in senior adolescents, whereas there are similar responses in maximal HR and RPE when running with and without dribbling in the players at different levels. In addition, the high and moderate correlations between the Yo-Yo IE2 running and dribbling distances suggest that dribbling skills play different roles than running does with a basketball in junior and senior adolescent basketball players.

Conflicts of interest

The authors have no conflicts of interest to disclose.

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