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The reliability and minimal detectable change of various physical performance tests among youth basketball players

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Original article

Abstract

During basketball game players frequently perform sporting movements such as running in various directions and jumping. Wherefore, these movements should be considered as a main part of physical performance batteries in basketball. The reliability and ability to detect the minimal detectable changes (MDC) of performance tests in basketball was rarely reported. The objective of our study was to evaluate reliability and MDC for physical performance tests often used among basketball players in Cadet category. Fourteen (14.) youth basketball players (mean age was: 15.3 ±1.04) were participated in the study. The jumping, sprint running and change of directions tests were conducted. The reactive strength index (RSI), sprint momentum (MOM) and eccentric utilization ratio (EUR) were also calculated. The results have shown the highest reliability for averaged values of second and third trials. Except of EUR, the ability for detect minimal change was acceptable for all physical performance tests. This study provides important measurement considerations to assess changes in physical performance among youth basketball players.

Keywords

- ¾ Court Test
- Lane Agility Test
- Countermovement Jump
- Drop Jump
- physical performance
- youth basketball

Contribution

A – the preparation of the research project
B – the assembly of data for the research undertaken
C – the conducting of statistical analysis
D – interpretation of results
E – manuscript preparation
F – literature review
G – revising the manuscript

Approval of ethics committee

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Introduction

Basketball is the discipline which the motor skills associated with ability to produce power are of great importance.[1] During basketball game, players have to cover distances from 4400 to 7500 meters. The most common sporting movements were jumping, sprint running and changing of direction.[2] The research shown that during game, mean sprint velocity could reach 7 m/s, moreover players perform 42 to 56 various jumps.[3] Above description pointed a most important motor features in basketball, and show which sporting movements should be involved during physical performance testing. Also, it was highlighted in recent reviews papers.[1,4–5] These studies indicated the Countermovement Jump, Squat Jump, Sargent Jump, Drop Jump as a most commonly used jumping ability tests conducted among basketball players. Sprint running performance have usually been tested via sprint running at 5, 10 and 20-meter distance. Lastly, for change of direction ability testing researchers and practitioners often have used a Lane Agility Test, 505 Test and / or *T*-test. In summary, recently published papers by[1,4] proposed a physical performance test batteries dedicated to basketball involving a sprint running, jumping and change of direction tests.

Nevertheless, Morrison et al.[4] and Wen et al.[1] pointed out need for creating a new batteries of physical performance tests. The new battery of tests should involve a reliability analysis as well as evaluating of MDC ability. It can be in particular of importance because the reliability and MDC was often not reported in the research papers.[4] For example, there is lack of scientific data about the reliability and MDC data of two tests used in NBA Combine Test[6]: ¾ Court Test and Lane Agility Test. Scientific literature review revealed data about the reliability data and MDC only for Lane Agility Test.[7–8]

Taking into account the above considerations, the main objective of this study was an attempt to evaluate of reliability and MDC of battery of tests contains a jumping, sprint running and change of direction ability tests for youth basketball players. The results and procedures from this study can be used by strength and conditioning practitioners during testing of physical performance among youth basketball players.

Methods

Fourteen youth male basketball players (mean age = 15.3 ±1.04 years) participated in this study. Their average body height and body mass were 182.21 ±5.41 cm and 70.17 ±6.93 kg, respectively. All participants were free from injuries that could affect their performance. All measurements were taken in their usual sporting clothes. The somatic measurements were carried out according to the ISAK standards.[9] The following physical performance measurements were conduct: Lane Agility Test (LAT),[7] ¾ Court Test (¾ CT),[10] Squat Jump (SJ) and Countermovement Jump (CMJ),[11] Drop Jump (DJ) from 30 cm box.[12] Based on these measurements the reactive strength index (RSI = DJ height : DJ contact time),[13] eccentric utilization ratio (EUR = CMJ : SJ,[14] and sprint momentum (MOM = ¾ Court Test · body mass)[15] were calculated. The MOM is a product of velocity and body mass. It is important when a player has overcome the physical contact from an opponent during offensive and defensive maneuvers such as high speed transition opportunities to attack the basket. Greater MOM creates difficulties for opponents to intervene.[15] All participants performed 3 trials of each performance test, with 2 minutes recovery between them. Running and jumping performance were measured via Witty photocells (Microgate, Bolzano, Italy) and Optojump Next System (Microgate, Bolzano, Italy), respectively.

Statistical analysis were conduct according to the guidelines for reliability studies.[16] Repeated measures ANOVA with Bonferroni post hoc contrasts were used to check for differences between trials. The level of significance was set at $p < 0.05$. Data of each trial was presented by mean and standard deviation (X ± SD). Subjects within trial reliability for each test were assessed using coefficient of variation (CV = SD/X · 100).[17–18] The CV results were averaged. The relative reliability was assessed using intraclass correlation coefficient (ICC).[19–20] Calculations were made using a custom-made spreadsheet available online.[21] The intra-day CV and ICC were calculated for averaged trials: trial 1–2, trial 2–3 and trial 1–3 with 95% confidence intervals (95 CI).

The thresholds for interpreting ICC and CV results were: ICC > 0.75 i CV < 10% = acceptable; ICC < 0.75 or CV > 10% = moderate; ICC < 0.75 and CV > 10% = poor.[21–22] The smallest worthwhile change (SWC) was calculated as 0.2 multiplied by the between – subject standard deviation for each condition (trials: 1–2, 2–3 and 1–3). The standard error of measurement (SEM) was calculated according to the following formula: SD · (1 – ICC). The SEM was also calculated for each condition. The ability to detect the minimal change (MDC) was interpreted as follows: 1) if SEM ≤ SWC than MDC was good; 2) if SEM = SWC than MDC was moderate; 3) if SEM > SWC than MDC was poor.[23]

It should be noted that during preparation of this study the sample size estimation wasn't conduct. Before measurements, authors had information that sample size will be of 14 to 16 subjects. Hopkins[21] suggested that for reliability study, the sample size could be between 10 and 20 subjects (assuming that ICC values will be high). In such circumstances, the sample size estimation was carried out in post hoc conditions. In this analysis the online sample size calculator using the ICC values was used.[24] The results of this analysis shown that in this study the sample size for statistical power criterion was met (depending on ICC values, the required sample size was between 10–12 subjects for almost all variables). Only EUR variable didn't meet this criterion.

Results

The mean, standard deviation, coefficient of variation and small worthwhile change for each trial and for averaged trials were presented in Table 1.

Table 1. The descriptive statistics with CV and SWC for all and averaged trials

Variable	Trial 1 X ± SD	Trial 2 X ± SD	Trial 3 X ± SD	Average trials X ± SD	CV (95 CI)	SWC
3/4 CT (s)	3.61 ±0.18	3.62 ±0.19	3.61 ±0.23	3.61 ±0.20	1.6 (1.1–2.1)	0.04
LAT (s)	13.30 ±0.79	13.03 ±0.53	12.93 ±0.56	13.09 ±0.64	2.3 (1.8–2.8)	0.13
SJ (cm)	32.20 ±3.98	32.50 ±4.43	33.31 ±4.17	32.67 ±4.12	3.9 (2.7–5.1)	0.82
CMJ (cm)	42.89 ±5.13	43.30 ±5.86	43.98 ±5.52	43.39 ±5.39	3.0 (2.0–4.0)	1.08
DJ (cm)	36.96 ±6.63	40.71 ±6.65	41.14 ±6.20	40.60 ±6.35	4.6 (3.3–5.9)	1.27
Contact time (s)	0.30 ±0.06	0.29 ±0.07	0.29 ±0.06	0.29 ±0.06	8.2 (5.2–10.2)	0.01
RSI	1.41 ±0.39	1.50 ±0.43	1.50 ±0.42	1.47 ±0.41	6.9 (3.8–10.0)	0.08
EUR	1.34 ±0.12	1.34 ±0.13	1.32 ±0.10	1.33 ±0.11	5.5 (3.9–7.1)	0.02
MOM (kg · s)	286.69 ±13.34	269.33 ±14.08	268.21 ±17.32	268.74 ±14.65	1.6 (1.1–2.1)	2.93

Table 2. The reliability values for all conditions (trials: 1–2, 2–3 and 1–3)

	Trial 1–2					
	X	CV	SWC	Df T1–T2	ICC (95 CI)	SEM
3/4 Court Test (s)	3.62	1.4 (0.7–2.1)	0.04	0.01	0.86 (0.63–0.95)	0.03
LAT (s)	13.16	2.3 (1.6–3.0)	0.13	−0.26*	0.81 (0.52–0.94)	0.12
SJ (cm)	32.35	3.2 (1.2–5.2)	0.81	0.30	0.85 (0.60–0.95)	0.62
CMJ (cm)	43.10	2.9 (1.7–4.1)	1.08	0.41	0.92 (0.78–0.97)	0.43
DJ (cm)	40.34	4.3 (2.2–6.4)	1.29	0.74	0.89 (0.69-0.96)	0.70
Contact time (s)	0.29	9.4 (5.1–13.7)	0.01	−0.01	0.73 (0.34–0.90)	0.02
RSI	1.46	8.2 (4.1–12.3)	0.08	0.09	0.87 (0.64–0.96)	0.05
EUR	1.34	4.9 (2.3–7.5)	0.02	0.00	0.39 (−0.15–0.75)	0.07
MOM (kg · s)	269.01	1.4 (0.7–2.1)	2.63	0.64	0.86 (0.63–0.95)	2.05

	Trial 2–3					
	X	CV	SWC	Df T2–T3	ICC (95 CI)	SEM
3/4 Court Test (s)	3.61	1.4 (0.9–1.9)	0.04	−0.02	0.93 (0.79–0.98)	0.01
LAT (s)	12.98	1.0 (0.6–1.4)	0.11	−0.10	0.93 (0.80–0.98)	0.04
SJ (cm)	32.90	3.5 (1.0–5.0)	0.84	0.81	0.92 (0.77–0.97)	0.33
CMJ (cm)	43.64	1.8 (1.0–2.6)	1.13	0.68	0.98 (0.94–0.99)	0.11
DJ (cm)	40.93	4.2 (2.9–5.5)	1.26	0.44	0.92 (0.76–0.97)	0.51
Contact time (s)	0.29	6.2 (3.9–8.5)	0.01	0.00	0.89 (0.70–0.96)	0.01
RSI	1.50	5.3 (2.7–7.9)	0.08	0.00	0.94 (0.84–0.98)	0.02
EUR	1.33	4.0 (2.6–5.4)	0.02	−0.01	0.69 (0.27–0.89)	0.03
MOM (kg · s)	268.77	1.4 (0.9–1.9)	3.09	−1.12	0.93 (0.79–0.98)	1.03
	Trial 1–3					
	X	CV	SWC	Df T1–T3	ICC (95 CI)	SEM
3/4 Court Test (s)	3.61	0.4 (0.3–0.5)	0.04	−0.01	0.90 (0.71–0.97)	0.02
LAT (s)	13.09	2.3 (1.8–2.8)	0.12	−0.36*	0.81 (0.51–0.94)	0.12
SJ (cm)	32.67	3.9 (2.7–5.1)	0.81	1.11	0.92 (0.78–0.97)	0.33
CMJ (cm)	43.39	3.0 (2.0–4.0)	1.07	1.09	0.91 (0.74–0.97)	0.49
DJ (cm)	40.60	4.6 (3.3–5.9)	1.26	1.18	0.93 (0.79–0.98)	0.44
Contact time (s)	0.29	8.2 (5.2–11.2)	0.01	−0.01	0.86 (0.63–0.95)	0.01
RSI	1.47	6.9 (3.8–10.0)	0.08	0.09	0.92 (0.78–0.97)	0.03
EUR	1.33	5.5 (3.9–7.1)	0.02	−0.01	0.25 (−0.30–0.68)	0.08
MOM (kg · s)	268.74	1.6 (1.1–2.1)	2.88	−0.48	0.90 (0.71–0.97)	1.47

Note: Df T1–T2, Df T2–T3, Df T1–T3 – averaged difference between trials; * – significant difference between the mean results in the consecutive averaged tests ($p < 0.05$)

In Table 2 were presented all data regarding reliability and MDC (for trials: 1–2, 2–3 and 1–3). When trial 2 and 3 were averaged the highest ICC values and the lowest CV values were observed. The only exception was SJ (the lowest CV values were observed for averaged 1–2 trials). The repeated measures ANOVA shown a potential habituation trend for execution LAT test (significance differences between trails 1–2 and 1–3). There was SWC the highest than SEM for all variables at each condition, except: 1) contact time (for trial 1–2 SEM > SWC, for rest conditions SEM = SWC; and 2) EUR, where for all conditions SEM > SWC.

Discussion

The main objective of the present study was to evaluate reliability and MDC of the proposed physical performance battery of tests dedicated for youth basketball players. The battery involved three jumping tests (SJ, CMJ and DJ), two running tests (3/4 CT and LAT) and indicators of the RSI, MOM and EUR. The study has shown that except of EUR and contact time during DJ, all tests have acceptable reliability and MDC. This meant that battery has a high practical value and in consequence can be used by strength and conditioning coaches, particularly for monitoring of training process. Also, in practice, coaches can choose a some of those tests or use all of them. However, coaches should take into account a potential habituation phenomenon, especially for LAT test.

With habituation phenomenon in mind and the fact that results revealed the highest reliability on averaged trial 2–3, it can be suggested that during examination of players there is need to perform at least 3 trials, and average two of them for further analysis. Our study suggest that the trial second and third should be averaged. Finally, the main advantage of this set of tests is high ecological value of them (sprint running, change of direction with lateral movement and jumping ability). Yet, as Morrison et al.[4] presented, the reliability data for physical performance tests among basketball players was rarely shown. In this light, results of our study are some kind of novel and could be an inspiration for future scientific exploration.

Stojanović et al.[8] have made a similar study, but they focused only on change of direction tests. One of the tests was the Lane Agility Test. They noted a similar value of ICC (0.88) and CV (7.3%). In other study, Brown[7] noted a ICC = 0.97 and CV = 5.47% for LAT test. Our results were in agreement with above-mentioned studies, however in our study the habituation phenomenon was detected. So it is important to indicate that during performance testing coaches should take into account this phenomenon and increase the number of trials, especially among youth basketball players. Moreover, this conclusion can be highlighted in front of results of studies conducted by Stojanović et al. and Brown, where the participants were adults players, probably with longer training experience, what potentially might be a factor could influence on the reliability. Nevertheless, comparing the reliability data for LAT among adult and youth basketball players, it can be assumed that LAT is highly reliable tests regardless of the age category or sports level.

The analysis of literature revealed that in case of ¾ CT, which is often used in research, there was no reliability and MDC data reported.[10,25–26] This makes a some difficulties for interpreting our results. However, there is possibility to compare our results with other sprint running test's performed at similar distances. The distance of ¾ CT was 22.86 meters. Then, it is possible to compare our results with reliability data for 20-meter sprint test which was often used in research and in practice among team sports (e.g. soccer).[27] For example, Sporis et al.[28] in 20-meter sprint test among professional soccer players noted somewhat high ICC values (0.81). Zois et al.[29] among amateur soccer players noted CV at the 0.8%. Thus, comparing our data with above-mentioned results, it can be assumed that ¾ CT is a reliable test for monitoring sprint performance among youth basketball players.

The jumping tests (SJ, CMJ) are very ecological tests for basketball[1,4] with high reliability.[11] The results of present study revealed high reliability and acceptable MDC in SJ and CMJ for youth basketball players. It is consistent with Rodríguez-Rosell et al.[30] study, which have shown a high CMJ reliability among basketball players in U-15 and U-18 categories. The drop jump test (DJ) is defined as an indicator of using elastic energy efficiency by muscles, an indicator of ability to changing direction during running, maneuvering during basket attacking, efficiency of transitional movements, and ability to perform repeated jumping during rebounds in game.[1]

In this study, DJ test was performed from a 30 cm box. Analysis of the DJ results and MDC has shown an acceptable MDC and high reliability. Our results were in agreement with Markwick et al.,[12] who examined ICC and CV of DJ's performed from 20, 30, 40 and 50 centimeter boxes. The DJ data allows calculating a reactive strength index (RSI). It is an indicator of ability to transition from eccentric to concentric phase contraction.[1] Our data revealed a high reliability and MDC for RSI indicator, and it was consistent with reliability results from Markwick et al.[12] study.

The two issues should be noted here: 1) in Markwick et al.[12] study the CV and ICC confidence intervals for RSI (obtained from DJ 30 cm) were wider in compare to other boxes height, and level of the lower confidence interval for ICC were outside optimal range; and 2) the valid RSI value needs the contact time to be less than 0.2 s,[31] however in our study average contact time was 0.29 s, this suggests a limited validity of test (despite acceptable measurement error). The higher than optimal contact time observed among youth basketball players could be a consequence of their age and / or shorter training experience in compare to adult basketball with longer training background. This allows to conclusion that coaches who works with youth basketball players should take into account these conditions. It may decrease probability to misinterpret the obtained results after performance testing.

The analysis of the SJ and CMJ levels allows evaluating the efficiency of stretch-shortening cycle.[14] In basketball game, the effectiveness of using elastic energy caused by "countermovement" is one of the most important motor feature.[1] The relation between SJ and CMJ can be described by an eccentric utilization ratio (EUR). However, the results of our study shown a moderate reliability and poor MDC level for EUR. Thus, the strength and conditioning coaches should be aware of this limitation using EUR indicator among youth basketball players.

Wen et al.[1] proposed a sprint momentum (MOM) test[15] as a part of battery tests for basketball players. Due to lack of reliability data regarding MOM, the discussion about it was difficult. Still, the results of our study shown an acceptable MDC level and reliability of the MOM. Sprint momentum is a product of body mass and velocity, so it could be assumed that MOM reliability level will be the same (or similar) as reliability of sprint running test. This suggests that coaches can use the sprint running reliability data for estimation of MOM reliability.

The obtained results were valuable from the practical point of view, and suggested a high suitability of the proposed battery. However, at this point, it is also important to highlight some limitations related to this very research. Firstly, the sample size were low, what suggest conducting similar measurements on larger sample. Secondly, the sprint running tests at short distances (e.g. 5 meters or 10 meters) wasn't conduct. Such tests should be part of the physical performance tests battery dedicated for basketball players.[1,4] Thirdly, higher contact time (more than 0.2 s) observed during DJ's, and fact that MOM was designed for shorter distances (up to 10 meters)[15] could be an important limiting factor of validity RSI and MOM.

Conclusions

The proposed battery of physical performance tests for basketball players was highly reliable with ability to detect of minimal detectable performance changes. Some of evaluated tests could have limitations, described in details in this paper. From practical point of view during performance testing among youth basketball players a minimum of three trails need to be performed and for further analysis the averaged of two trails with the highest reliability should be used (based on this study it should be averaged second and third trial).

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