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Validity and reliability of the V-cut dribbling test in young basketball players

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Keywords:	testing, technical skill, performance, somatic maturity, team sports

ABSTRACT

PURPOSE: Change-of-direction (COD) while dribbling appears to be of interest for on-court performance in basketball. The study aim was to assess the validity and reliability of the V-cut dribbling test (VcutBk) in young basketball players.

METHODS: Ninety-two young basketball players from 8 to 21 years old (74% male) were classified in relation to Peak High Velocity (PHV) offset. To examine validity and test-retest reliability, VcutBk test was performed in two identical sessions separated by one week. Participants also performed Vcut test and lineal sprint test with and without dribbling to analyse correlations between tests in different somatic maturity stages.

RESULTS: The relationships between the VcutBk with the other tests and skill-time-related deficits were interpreted from large (r>0.51) to very large (r>0.71). The comparisons between pre-PHV and post-PHV groups of basketball players show significant and large effect in the VcutBk (d=2.04, mean difference=2.59, 95% confidence interval [1.86, 3.32]). Also, significant main effects when comparing PHV groups were reported in all skill-time-related deficits ($p<0.001$, $\eta^2_p=0.13$ to 0.28, moderate-to-large effect size). Test-retest reliability and signal to noise ratio analysis do not show substantial between-trial differences in VcutBk. Reliability scores showed high intraclass correlation coefficient (ICC=0.95) and low coefficient of variation (CV=0.23%).

CONCLUSIONS: The VcutBk seems to be a valid and reliable test to assess COD while dribbling performance. VcutBk performance and skill-time-related deficits seems to be sensitive to somatic maturity. Basketball coaches should consider the VcutBk test to assess young basketball players.

Keywords

Testing, Technical Skill, Performance, Somatic maturity, Team sports

INTRODUCTION

Change-of-direction (COD) speed skill appears to be of interest for on-court physical performance in basketball players[1–3]. It has been observed that in some basketball situations COD skill constitutes 20.7% of sprinting activity[4]. Thus, Sugiyama[2] reported several studies that have assessed the reliability and validity of basketball-specific COD tests, and showed three categorized test types to assess specific COD performances: defensive, 180º-turn, and cutting. However, these tests do not consider other basketball-specific skills like dribbling, passing, shooting, or defending.

In the offensive phase of the game, dribbling performance has been considered as an important skill in basketball, particularly at key game stages[5]. During the basketball match, semi-professional backcourt players spend 9–11% of their playing time dribbling or in the possession of the ball[6,7]. Nevertheless, limited previous literature exists regarding basketball dribbling activities. Previous basketball research found that dribbling skill is strongly influenced by linear running and sprinting ability[8,9]. Similar findings were observed for sprints with COD in a test with slalom manoeuvres[5]. As V-cut manoeuvre is frequently involved in offensive techniques in basketball, it may be interesting to assess the COD skill while dribbling in a V-cutting situation in order to train and improve performance in this phase of the game. Furthermore, identifying COD deficit[10] and dribbling deficit[5] during COD skill while dribbling, may be a good strategy to better understand some specific features of the basketball-players' behaviour in the offensive phase of the game.

In team sport setting, it is common to assess associations between physical aspects and motor skill performance[11]. Somatic maturity is a concept used to describe the degree of biological maturation[12] which indicates the growth rate of body dimensions (height is commonly used) expressed by the age at peak height velocity (PHV)[13]. COD performance while dribbling may be influenced by somatic maturation through the hormone changes related to power in change of direction, and neuromuscular control of skills implied in change of direction and dribbling[14].

To consider these aspects, a new basketball specific test able to evaluate change of direction while dribbling was created: V-cut dribbling test (VcutBk). Therefore, the main objective of this study was to assess the validity and reliability of the VcutBk test in young basketball players.

MATERIALS AND METHODS

Subjects

The original sample included 104 young basketball players from 8 to 21 years of age. Twelve participants were dropped from analysis because of missing data. The final sample consisted of 92 players (53 males and 39 females) recruited from an amateur basketball club (Foment Deportiu Cassanenc). The sample was divided in relation to PHVoffset as an individual somatic maturity indicator according to Moore et al.[13] (Table 1). All players carried out 2-3 90-min training sessions and a game per week. Exclusion criteria were being injured or recovering from an injury.

The Institutional Review Board of Consell Català de l'Esport approved the research, which conformed to the recommendations of the Declaration of Helsinki. Informed consent and assent were obtained from all subjects and their parents.

INSERT Table 1. Subject characteristics.

Study design

This observational research was developed in an amateur basketball club from Girona (Spain). VcutBk test design was based on the Vcut test protocol[3]. Dribbling was added to the execution of the test to assess basketball dribbling while changing direction.

For the validation purpose, the relationships between the VcutBk test and other basketball specific tests were determined. Participants also completed the Vcut[3], 25m linear Sprint and 25m Sprint while dribbling (SprintBk) tests. Test-derived scores were used for the analysis and the following variables were calculated: dribbling deficit, SprintBK – Sprint[5]; COD deficit, Vcut –Sprint[10]; dribbling while COD deficit, VcutBk – Vcut; and COD while dribbling deficit, VcutBk – SprintBk.

To examine test-retest reliability, VcutBk test was performed in two identical sessions separated by 6±1 days. Test reliability was assessed through absolute (typical error of measurement [TEM] calculated as coefficients of variation in percentage) and relative (intra-class correlation coefficient [ICC]) reliability.

Procedures

A week before the commencement of the study, anthropometric data were collected and familiarization with test procedures was developed. Subjects were allowed to perform only two trials of each test to avoid any learning effect. Prior to each testing session players were informed not to take any stimulant substance (e.g., caffeine), to maintain their nutritional habits and to avoid any vigorous exercise 24h before the testing session.

Anthropometric examinations were performed in the afternoon, four hours after eating. Body mass was measured with bioelectric impedance (Portable TANITA; 240MA), height was measured with a Harpenden stadiometer (SECA SE206) and sitting height was measured with the same stadiometer adopting the short-sitting position on an anthropometric box (40 cm x 50 cm x 30 cm) with feet supported on the floor.

Birth date and sex were self-reported. Maturity offset was estimated using the equation created by Moore et al.[13] to predict PHV for basketball players under 18 years old. Early maturing (pre-PHV) was defined as preceding the average age of PHV by 1 year; average maturing (PHV), ±1 year from PHV; and late maturing, greater than 1 year after PHV (post-PHV). Players older than 18 years-old were considered post-PHV.

All tests were performed on the same indoor basketball court. Before testing, the subjects completed a warm-up consisting of jogging (3 min), jogging while dribbling (3 min), lower limb dynamic stretches (3 min) and 4x20m sprint progressions (2 trials with dribbling). Additionally, before each test, two submaximal effort trials of the test were performed. Subjects completed each test twice with at least 3 min of rest between trials and 5 min between tests. Vcut, VcutBk, Sprint and SprintBk were randomly performed, with the same player performing the tests in the same order during the two testing sessions. The time of each test was recorded with timing gates (Microgate Witty Wireless Training Timer, Bolzano, Italy). Timing sensors were placed facing each other at the start and finish line; 0.75m in height and 1.5m apart. Players started each test 0.5m behind the starting line. The time of the fastest trial was retained.

Vcut test. In the Vcut test, the Gonzalo-Skok et al., (2015) protocol was applied[3]. Players performed a 25m sprint with 4 COD of 45° each 5 m. For the trial to be valid, players had to pass the line, drawn on the floor, with one foot completely at every turn. If the trial was considered as failed, a new trial was allowed. The distance between each pair of cones was 0.7 m.

VcutBk test. The same procedures of the Vcut test were applied but dribbling was added to the execution of the test. Subjects had to start the test holding the ball with both hands and dribbling hand was not determined. Travelling or double dribbling violations were not allowed. Players had to execute a crossover dribble during COD, when player did not accomplish these criteria or lost the ball, a new trial was allowed.

INSERT Figure 1. Schematic Illustration of VcutBk test

Sprint. All players were assessed in a 25-m linear sprint. The starting position was standardized with the non-dominant toe 1 m back from the start.

SprintBk. Same procedure as Sprint was applied but dribbling was added to the execution of the test. Subjects had to start the test holding the ball with both hands and dribbling hand was not determined. Travelling, double dribbling violations were not allowed. Players had to control the ball during the test.

Statistical Analysis

Data are presented as mean ± standard deviation (SD). Construct validity and relationships between VcutBk test and the other tests and score test-related were assessed using a Pearson's product moment correlation coefficient (r). The correlation coefficients were interpreted as follows: $r =$ 0.0–0.1 trivial; 0.11–0.3 small; 0.31–0.5 moderate; 0.51–0.7 large; 0.71–0.9 very large and 0.91–1.00 nearly perfect[17]. To compare the tests scores and test-derivate scores of somatic maturity status (pre-PHV, PHV and post-HPV groups) a one-way analysis of variance (ANOVA) was used. The assumption of normality was verified exploring the Q-Q plots and histogram of residuals. The mean, SD, and 95% confidence intervals (CIs) were used after data normality was verified. Assumptions of homogeneity were evaluated using Levene's test. Where homogeneity was violated ($p \leq$ 0.05), the Welch correction factor was applied. When significant between-groups effects were reported, post-hoc comparisons were performed with the Bonferroni correction. Effect sizes (ES) were evaluated using a partial eta squared (η^2_p), with 0.06, 0.06–0.14, and .0.14 indicating a small, moderate, and large effect, respectively. Mean difference (MD) and between-group difference Cohen's d were calculated for each pairwise group comparison[18]. The Cohen's d result was qualitatively interpreted as follows: ES< 0.2 trivial; 0.20–0.59 small; 0.60–1.19 moderate; ≥ 1.2 large[17].

Relative reliability analysis was examined by the ICC. The ICC was interpreted as follows: ICC <0.50 poor, 0.5–0.74 moderate, 0.75–0.9 good and, >0.9 excellent[16]. To examine absolute reliability, pairwise comparisons were first applied. The magnitude of between-session differences was also expressed as standardized mean difference ES. The criteria to interpret the magnitude of the ES were as follows: ES < 0.2 trivial, 0.20–0.59 small; 0.60–1.19 moderate; ≥ 1.2 large[17]. The Hopkins spreadsheet (Consecutive pairwise analysis of trials for reliability, in Internet: www.sportsci.org) was also used to determine the change in the mean between trials and the TEM, expressed as a coefficient of variation (CV) calculated as percentage. A CV of less than 5% was set as the a priori criterion for reliability[17]. The signal to noise ratio of the test was determined by comparing TEM and smallest worthwhile change (SWC). In team sports, it has been suggested that the SWC can be calculated as 0.2 multiplied by the between-subject SD ($SWC_{0.2}$) of the particular test, based on Cohen's ES principle[17]. Furthermore, the SWC to detect a moderate or large effect was determined by multiplying the between-subject standard deviation by 0.6 ($SWC_{0.6}$) and 1.2 ($SWC_{1.2}$), respectively [TEM<SWC good; TEM similar to SWC Ok; TEM>SWC marginal][17].

All statistical analyses were performed using JASP (version 0.11.2; JASP Team (2019), University of Amsterdam, the Netherlands). Level of significance was set at 0.05 for all tests.

RESULTS

Validity of the test

Related to construct validity, the relationship between the VcutBk and the Vcut was very large [r (90% CL) = 0.85]. The relationships between the VcutBk with the other tests and test-derivate scores (skill-time-related deficits) were interpreted from large to very large (r range: 0.51-0.71), see Table 2. VcutBk performance was highly correlated with skills-time-related deficits, as COD while dribbling deficit (r = 0.88) and dribbling while COD deficit (r = 0.83).

INSERT Table 2. Measures of relationships between VcutBK test and the other tests and test-derivate scores (skill-time-related deficits)

The scores of the different variables analyzed divided by the different PHV groups are shown in Table 3. Significant main effects between groups were reported in all variables ($p < 0.001$): VcutBk, dribbling deficit, dribbling while COD deficit and COD while dribbling deficit showed large effects ($\eta^2_p > 0.14$) whereas COD deficit variable showed moderate effects ($\eta^2_p = 0.13$).

The post-hoc comparisons of the VcutBK variable revealed significant differences between all pairwise comparisons (pre-PHV vs. PHV: $d = 1.16$ '*large*', *MD* = 1.39 95% CI [0.60, 2.19]; pre-PHV vs. post-PHV: $d = 2.15$ '*large*', *MD* = 2.59 95% CI [1.86, 3.32]; PHV vs. post-PHV: $d = 0.99$ '*moderate*', *MD* = 1.20 95% CI [0.34, 2.05]). See Table 3.

The post-hoc comparisons of the dribbling deficit variable revealed significant differences between pre-PHV and PHV ($d = 0.91$ '*moderate*', *MD* = 0.30 95% CI [0.08, 0.52]) and between pre-PHV and post-PHV ($d = 1.24$ '*large*', *MD* = 0.41 95% CI [0.21, 0.61]. See Table 3.

The post-hoc comparisons of the COD deficit variable revealed significant differences between pre-PHV and post-PHV ($d = 0.81$ '*moderate*', *MD* = 0.39 95% CI [0.10, 0.69]) and between PHV and post-PHV ($d = 0.80$ '*moderate*', *MD* = 0.39 95% CI [0.04, 0.74]. See Table 3.

The post-hoc comparisons of the dribbling while COD deficit variable revealed significant differences between pre-PHV and PHV ($d = 1.04$ '*moderate*', *MD* = 0.85 95%

CI [0.31, 1.38]) and between pre-PHV and post-PHV (d = 1.33 '*large*', MD = 1.08 95% CI [0.59, 1.58]. See Table 3.

The post-hoc comparisons of the COD while dribbling deficit variable revealed significant differences between pre-PHV and post-PHV (d = 1.30 '*large*', MD = 0.98 95% CI [0.52, 1.44]) and between PHV and post-PHV (d = 0.72 '*moderate*', MD = 0.55 95% CI [0.00, 1.09]. See Table 3.

INSERT Table 3. Test-derived scores (skill-time-related deficits) of the different PHV groups.

Reliability of the test

Test-retest reliability and the signal to noise ratio analysis do not show substantial between-trial differences in VcutBk (i. e., ES = -0.14). All the other measures of reliability of VcutBk tests are considered small, moderate and large (Table 4). The signal to noise ratio is ok [TEM (0.35)<$SWC_{0.6}$ (0.94)], see Table 4.

INSERT Table 4. Measures of reliability of the VcutBK test.

DISCUSSION

The purpose of this study was to assess the validity and reliability of the VcutBk test in young basketball players. The test showed construct validity since test results demonstrated large to very large relationship with the other tests and skill-time-related deficits included in this study. Moreover, VcutBk test results were representative of somatic maturation. Finally, high level of test-retest reliability was found for the VcutBk test. Therefore, the present study is the first to report the VcutBk as a reliable and valid test to assess change of direction while dribbling in basketball players.

Owing to the importance of dribbling skill on basketball performance, previous research has examined the influencing factors of linear running speed with dribbling. Dribbling has demonstrated a negative effect on the sprint in soccer and hockey players[9,19]. Nevertheless, some studies with basketball players found that dribbling does not reduce sprint speed[20,21]. The differences in dribbling deficit may depend on the sport-specific dribbling skill[5]. All these studies measured only the running linear sprint or the COD skill in slalom manoeuvres with and without dribbling, and there is a paucity of studies that examined how dribbling can affect performance on COD performance in V-cut manoeuvres. For this reason, VcutBk test, a novel basketball specific test able to evaluate change of direction while dribbling, was created. Also, change of direction with dribbling in the time-related situations is a determinant skill in offensive basketball key stages[5], in this line, our results seem to indicate that VcutBk is a good test to assess skill-time-related deficits as dribbling deficit and COD deficit.

As there is no gold standard for COD tests, Vcut test was used to construct validity. The large correlation coefficients between Vcut test and VcutBk test indicate that both tests have a predominant skill in common: COD, even if they include different constraints like dribbling. Additionally, VcutBk correlated larger when skill-time-related deficits were shown in a COD while dribbling situation as it has been indicated in COD while dribbling deficit and dribbling while COD deficit results. The influence of biological maturity status on specific-skills basketball performance such as dribbling, passing, shooting, and defensive movements is not conclusive[22]. More evidence is needed during adolescence when the influence of hormonal changes on neuromuscular, anthropometric and metabolic adaptations is relevant to increased motor performance[14], and change of direction while dribbling. In this regard, the study analyses VcutBk test performance relative to somatic maturity which is categorized in three groups: pre-PHV, PHV and post-PHV[13]. Although the Moore et al.[13] formula has a weakness in predicting biological maturity, specifically in early and late maturing boys and girls[23], it is the most currently used by coaches and physical education teachers because of the non-invasive, low-cost and easy-to-use characteristics, in contrast to other indicators like: skeletal bone age measured by X-ray, sexual maturity determinates by genitals, breasts and pubic hair, and percentage of adult height related to average height of biological parents. Our results show that performance in the VcutBK and in skill-time-related deficits seems to be sensitive to somatic maturation. It is worth noting that for basketball players between pre-PHV and post-PHV, the dribbling while COD deficit is the skill-time-related deficit with the largest ES. Also, dribbling deficit and COD while dribbling deficit have shown a large ES. Losing running speed during COD with dribbling was previously reported only in pre-adolescents[25] and under-15-year-old players[8]. In this line, increased dribbling deficit during COD tasks compared to the dribbling deficit in linear sprint were found in semi-professional basketball players[5]. Analysing these differences between PHV groups, results possibly display that COD while dribbling performance is influenced by dribbling mastery in specific and simultaneous skills situation (COD simultaneous with change of direction and time constraint). The influence of dribbling performance in COD and linear speed seems to be most strongly related to less experience in practice[26–28], because dribbling deficit during change of direction is the most determinant skill-time-related deficit in VcutBk. In the post-PHV group, COD during dribbling performance could also be influenced by large anthropometry[29,30] and power[14,31] in lower-body limbs to execute sprint COD skill. These results are similar in other studies with young soccer[32], tennis[33] and basketball[14] players. In contrast to previous studies in adolescent basketball players[24], our findings revealed that change of direction while dribbling in basketball players is sensitive to somatic maturity status. The use of a heterogeneous sample of different ages and experience in basketball training may explain the opposite findings from the studies which used homogeneous samples[22].

The results of the test-retest reliability of the VcutBk test showed that there were no differences in between-trial differences. The ICC was 0.95, indicating a high level of reliability. Also, a CV of 0.23% supported this result. The CV value for the VcutBk was slightly lower than those reported in young team sport players for the Vcut test without dribbling (1.4%)[3]. This was also the case for COD slalom manoeuvres with dribbling in semi-professional (2.7%)[5] and preadolescent (2.4%)[25] male basketball players. Differences in sample sizes, subjects' ages or test characteristics might explain these differences between studies in test-retest reliability.

PRACTICAL APPLICATIONS

Basketball coaches should consider the VcutBk test when assessing skills involved in the COD while dribbling in young basketball players. VcutBk test used and analysed with the results of Vcut and 25m sprint test with and without dribbling would be useful to calculate different skill-time-related deficits such as dribbling deficit, COD deficit, dribbling while COD deficit and COD while dribbling deficit. Identifying those deficits during COD skill while dribbling, could be a good strategy to better understand some specific features of the basketball-players' skill development. Finally, status of somatic maturity must be taken into consideration as it seems to influence COD while dribbling performance and skill-time-related deficits. Therefore, the effect of maturity in the deficits should be considered for planning the longitudinal learning process to achieve mastery of this skill. Even though, somatic maturity influence should be further explored.

CONCLUSION

In conclusion, the present study demonstrates that VcutBk test is a reliable and valid test to assess change of direction while dribbling in basketball players. Furthermore, findings revealed that VcutBk correlated more strongly with skill-time-related deficits in a COD while dribbling tests compared to linear sprinting or COD without dribbling tests. Finally, VcutBk performance and skill-time-related deficits seems to be sensitive to somatic maturity.

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Authors' contributions: AJ-P, MM-P, DR-R, OG-S and RF-LL conceived and carried out experiments, AJ-P, JVB-G and RF-LL conceived experiments and analysed data. AJ-P, MM-P, DR-R, and RF-LL carried out experiments. AJ-P, MM-P and RF-LL acquired data. GS reviewed the English-language. All authors were involved in writing the paper and had final approval of the submitted and published versions.

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REFERENCES

1. Stojanović E, Aksović N, Stojiljković N, Stanković R, Scanlan AT, Milanović Z. Reliability, Usefulness, and Factorial Validity of Change-of-direction Speed Tests in Adolescent Basketball Players. *J Strength Cond Res*. 2019;33(11):3162-3173. doi:10.1519/JSC.0000000000002666

2. Sugiyama T, Maeo S, Kurihara T, Kanehisa H, Isaka T. Change of Direction Speed Tests in Basketball Players: A Brief Review of Test Varieties and Recent Trends. *Front Sports Act Living*. 2021;3. doi:10.3389/fspor.2021.645350

3. Gonzalo-Skok O, Tous-Fajardo J, Suarez-Arrones L, Arjol-Serrano JL, Casajús JA, Mendez-Villanueva A. Validity of the V-cut Test for Young Basketball Players. *Int J Sports Med*. 2015;36(11):893-899. doi:10.1055/s-0035-1554635

4. Conte D, Favero TG, Lupo C, Francioni FM, Capranica L, Tessitore A. Time-motion analysis of italian elite women's basketball games: Individual and team analyses. *J Strength Cond Res*. 2015;29(1):144-150. doi:10.1519/JSC.0000000000000633

5. Scanlan AT, Wen N, Spiteri T, et al. Dribble Deficit: A novel method to measure dribbling speed independent of sprinting speed in basketball players. *J Sports Sci*. 2018;36(22):2596-2602. doi:10.1080/02640414.2018.1470217

6. Scanlan AT, Dascombe BJ, Kidcaff AP, Peucker JL, Dalbo VJ. Gender-specific activity demands experienced during semiprofessional basketball game play. *Int J Sports Physiol Perform*. 2015;10(5):618-625. doi:10.1123/ijspp.2014-0407

7. Ferioli D, Rampinini E, Martin M, et al. Influence of ball possession and playing position on the physical demands encountered during professional basketball games. *Biol Sport*. 2020;37(3):269-276. doi:10.5114/biolsport.2020.95638

8. Kong Z, Qi F, Shi Q. The influence of basketball dribbling on repeated high-intensity intermittent runs. *J Exerc Sci Fit*. 2015;13(2):117-122. doi:10.1016/j.jesf.2015.10.001

9. Meckel Y, Geva A, Eliakim A, Cairns S, Macrae H. *The Influence of Dribbling on Repeated Sprints in Young Soccer Players*. Vol 7.; 2012.

10. Nimphius S, Callaghan SJ, Spiteri T, Lockie RG. Change of Direction Deficit: A More Isolated Measure of Change of Direction Performance Than Total 505 Time. *J Strength Cond Res*. 2016;30(11):3024-3032. doi:10.1519/JSC.0000000000001421

11. Lloyd RS, Oliver JL, Faigenbaum AD, Myer GD, de Ste Croix MBA. Chronological age vs. biological maturation: Implications for exercise programming in youth. *J Strength Cond Res*. 2014;28(5):1454-1464. doi:10.1519/JSC.0000000000000391

12. Olivares LAF, de León LG, Fragoso MI. Skeletal age prediction model from percentage of adult height in children and adolescents. *Sci Rep*. 2020;10(1). doi:10.1038/s41598-020-72835-5

13. Moore SA, McKay HA, Macdonald H, et al. Enhancing a somatic maturity prediction model. *Med Sci Sports Exerc*. 2015;47(8):1755-1764. doi:10.1249/MSS.0000000000000588

14. Arede J, Ferreira AP, Gonzalo-Skok O, Leite N. Maturational development as a key aspect in physiological performance and national-team selection in elite Male basketball players. *Int J Sports Physiol Perform*. 2019;14(7):902-910. doi:10.1123/ijspp.2018-0681

15. Gonzalo-Skok O, Tous-Fajardo J, Suarez-Arrones L, Arjol-Serrano JL, Casaj??s JA, Mendez-Villanueva A. Validity of the V-cut Test for Young Basketball Players. *Int J Sports Med*. 2015;36(11):893-899. doi:10.1055/s-0035-1554635

16. Koo TK, Li MY. A Guideline of Selecting and Reporting Intraclass Correlation Coefficients for Reliability Research. *J Chiropr Med*. 2016;15(2):155-163. doi:10.1016/j.jcm.2016.02.012

17. Hopkins WG, Marshall SW, Batterham AM, Hanin J. Progressive statistics for studies in sports medicine and exercise science. *Med Sci Sports Exerc*. 2009;41(1):3-12. doi:10.1249/MSS.0b013e31818cb278

18. Dankel SJ, Mouser JG, Mattocks KT, et al. The widespread misuse of effect sizes. *J Sci Med Sport*. 2017;20(5):446-450. doi:10.1016/j.jsams.2016.10.003

19. Lemmink KAPM, Elferink-Gemser MT, Visscher C. Evaluation of the reliability of two field hockey specific sprint and dribble tests in young field hockey players. *Br J Sports Med*. 2004;38(2):138-142. doi:10.1136/bjsm.2002.001446

20. Apostolidis N, Nassis GP, Bolatoglou T, Geladas ND. Physiological and technical characteristics of elite young basketball players. *Journal of Sports Medicine and Physical Fitness*. 2004;44(2).

21. Tessitore A, Tiberi M, Cortis C, Rapisarda E, Meeusen R, Capranica L. Aerobic-anaerobic profiles, heart rate and match analysis in old basketball players. *Gerontology*. 2006;52(4):214-222. doi:10.1159/000093653

22. Coelho E Silva MJ, Moreira Carvalho H, Gonçalves CE, et al. Growth, maturation, functional capacities and sport-specific skills in 12-13 year-old- basketball players. *J Sports Med Phys Fitness*. 2010;50(2):174-181. http://www.ncbi.nlm.nih.gov/pubmed/20585295

23. Kozieł SM, Malina RM. Modified Maturity Offset Prediction Equations: Validation in Independent Longitudinal Samples of Boys and Girls. *Sports Medicine*. 2018;48(1):221-236. doi:10.1007/s40279-017-0750-y

24. Coelho e Silva MJ, Figueiredo AJ, Moreira Carvalho H, Malina RM. Functional capacities and sport-specific skills of 14- to 15-year-old male basketball players: Size and maturity effects. *Eur J Sport Sci*. 2008;8(5):277-285. doi:10.1080/17461390802117177

25. Conte D, Scanlan AT, Dalbo VJ, et al. Dribble Deficit quantifies dribbling speed independently of sprinting speed and differentiates between age categories in pre-Adolescent basketball players. *Biol Sport*. 2020;37(3):261-267. doi:10.5114/biolsport.2020.95637

26. Rinaldo N, Toselli S, Gualdi-Russo E, Zedda N, Zaccagni L. Effects of anthropometric growth and basketball experience on physical performance in pre-adolescent male players. *Int J Environ Res Public Health*. 2020;17(7). doi:10.3390/ijerph17072196

27. Ramos S, Volossovitch A, Ferreira AP, Fragoso I, Massuça LM. Training Experience and Maturational, Morphological, and Fitness Attributes as Individual Performance Predictors in Male and Female Under-14 Portuguese Elite Basketball Players. *J Strength Cond Res*. Published online February 6, 2019. doi:10.1519/JSC.0000000000003042

28. Guimarães E, Ramos A, Janeira MA, Baxter-Jones ADG, Maia J. How Does Biological Maturation and Training Experience Impact the Physical and Technical Performance of 11–14-Year-Old Male Basketball Players? *Sports*. 2019;7(12):243. doi:10.3390/sports7120243

29. Carvalho HM, Gonçalves CE, Collins D, Paes RR. Growth, functional capacities and motivation for achievement and competitiveness in youth basketball: an interdisciplinary approach. *J Sports Sci*. 2018;36(7):742-748. doi:10.1080/02640414.2017.1340654

30. Garcia-Gil M, Torres-Unda J, Esain I, et al. Anthropometric parameters, age, and agility as performance predictors in elite female basketball players. *J Strength Cond Res*. 2018;32(6):1723-1730. doi:10.1519/jsc.0000000000002043

31. Pichardo AW, Oliver JL, Harrison CB, Maulder PS, Lloyd RS, Kandoi R. The influence of maturity offset, strength, and movement competency on motor skill performance in adolescent males. *Sports*. 2019;7(7). doi:10.3390/sports7070168

32. Read PJ, Oliver JL, Myer GD, de Ste Croix MBA, Lloyd RS. The effects of maturation on measures of asymmetry during neuromuscular control tests in elite male youth soccer players. *Pediatr Exerc Sci*. 2018;30(1):168-175. doi:10.1123/pes.2017-0081

33. Madruga-Parera M, Romero-Rodríguez D, Bishop C, et al. Effects of maturation on lower limb neuromuscular asymmetries in elite youth tennis players. *Sports*. 2019;7(5). doi:10.3390/sports7050106

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Table 1. Subject characteristics.

	Pre-PHV	PHV	Post-PHV
n	41	20	31
Sex (M/F)	24 / 17	10 / 10	19 / 12
Age (y)	9.7 ± 1.8	12.8 ± 1.3	18.5 ± 3.6
Stature (cm)	138 ± 10	161 ± 9	174 ± 11
Body mass (kg)	32.8 ± 7.2	51.5 ± 11.6	64 ± 10
Federated years (y)	1.8 ± 1.5	3.2 ± 1.4	8.8 ± 5.7
Dominance (R/L)	36 / 5	19 / 1	28 / 3
Wingspan (cm)	136.5 ± 11.3	162.2 ± 10.2	167.9 ± 18

Values of n, sex and dominance are presented as absolute frequencies. Values of age, federated years and wingspan are presented as mean ± SD. M: male; F: female; R: right-handed; L: left-handed. Pre-PHV: greater than 1 year before the PHV; PHV: ±1 year from PHV; Post-PHV: greater than 1 year after PHV.

Table 2. Measures of relationships between VcutBK test and the other tests and test-derivate scores (skill-time-related deficits)

Pairwise comparison	**Pearson's r (90% CL)**
Tests	
VcutBk – Vcut	0.85 (0.79, 0.89) VL
VcutBk – Sprint	0.84 (0.77, 0.88) VL
VcutBk – SprintBk	0.87 (0.81, 0.91) VL
Test-derived scores: Skill-time-related deficits	
VcutBk – Dribbling deficit	0.72 (0.62, 0.80) VL
VcutBk – COD deficit	0.59 (0.46, 0.70) L
VcutBk – Dribbling while COD deficit	0.83 (0.76, 0.88) VL
VcutBk – COD while dribbling deficit	0.88 (0.83, 0.91) VL

CL: confidence limits; Vcut: traditional Vcut test; VcutBk: Vcut test performed with a basketball; Sprint: 25 m linear sprint test; SprintBk: 25 m linear sprint test performed with a basketball.
Dribbling deficit=SprintBK–Sprint; COD deficit =Vcut–Sprint; Dribbling while COD deficit =VcutBK–Vcut; COD while dribbling deficit =VcutBK– SprintBK
VL: very large effect size; L: large effect size;

Table 3. Test-derived scores (skill-time-related deficits) of the different PHV groups.

	Pre-PHV	**PHV**	**Post-PHV**	**ANOVA 3x1 (*p*-value)**	η^2_p
VcutBK	10.58 ± 1.57 $^{*L\ \#L}$	9.19 ± 0.95 $^{\#M}$	7.99 ± 0.59	< 0.001	0.47 ^{L}
Skill-time-related deficits					
Dribbling deficit	0.64 ± 0.43 $^{*M\ \#L}$	0.34 ± 0.25	0.23 ± 0.17	< 0.001	0.25 ^{L}
COD deficit	4.00 ± 0.45 $^{\#M}$	3.99 ± 0.69 $^{\#M}$	3.60 ±0.35	< 0.001	0.13 ^{M}
Dribbling while COD deficit	1.50 ± 1.04 $^{*M\ \#L}$	0.65 ± 0.75	0.41 ± 0.34	< 0.001	0.28 ^{L}
COD while dribbling deficit	4.72 ± 1.01 $^{\#L}$	4.28 ± 0.55 $^{\#M}$	3.73 ± 0.32	< 0.001	0.25 ^{L}

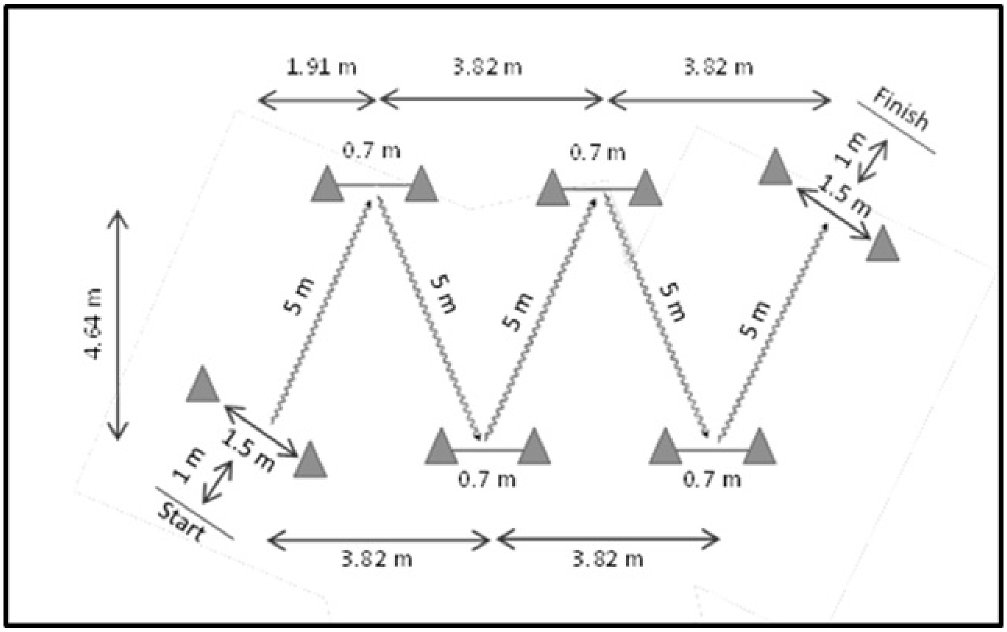
Values are presented as mean ± SD.
Dribbling deficit=SprintBK–Sprint; COD deficit =Vcut–Sprint; Dribbling while COD deficit =VcutBK–Vcut; COD while dribbling deficit =VcutBK– SprintBK
*Statistically significant to PHV ($p_{Bonferroni} \leq 0.05$). # Statistically significant to Post-PHV ($p_{Bonferroni} \leq 0.05$); η^2_p: partial eta squared effect size.
$^{L:}$ large effect size; $^{M:}$ moderate effect size.

Table 4. Measures of reliability of the VcutBK test.

Test-retest reliability						
Baseline	**Retest**	**TEM (90% CL)**	**CV (%) (90% CL)**	**ICC (90% CL)**	**Difference (90% CL)**	**ES (90% CL)**
9.46 ± 1.64	9.38 ± 1.47	0.35 (0.31, 0.42)	0.23 (0.20, 0.27)	0.95 (0.93, 0.97) (Excellent)	-0.21 (-0.32,-0.11)	-0.14 (-0.21 - 0.07) (Trivial)

Signal to noise ratio		
$SWC_{0.2}$ (%) (signal to noise ratio)	**$SWC_{0.6}$ (%) (signal to noise ratio)**	**$SWC_{1.2}$ (%) (signal to noise ratio)**
0.31 (0.28, 0.36) (Ok)	0.94 (0.84, 1.07) (Good)	1.88 (1.68, 2.15) (Good)

TEM: typical error of measurement; CL: confidence limits; CV: coefficient of variation expressed as percentage of TEM; ICC: Intraclass correlation coefficient; Difference: difference in mean between the 2 trials; ES: effect size and ES rating (see Methods); SWC: smallest worthwhile change (0.2 x standard deviation = $SWC_{0.2}$; 0.6 x standard deviation = $SWC_{0.6}$; 1.2 x standard deviation = $SWC_{1.2}$) and signal to noise ratio



Schematic Illustration of V-cut dribbling test

275x172mm (59 x 59 DPI)