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On Wall Drop Punt Kick & Catch Test, who wins: foot inner part or instep?
En la prueba Wall Drop Punt Kick & Catch, ¿quién gana: la parte interna del pie o el empeine?

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Abstract: WDPK&C test requires the manipulation of a ball with both the upper (releasing and catching) and the lower (kicking) limbs. The present study aimed to: i) identify which (if any) of two different foot parts (inner part or instep) would imply a better performance on WDPK&C; ii) verify if a significant correlation between both foot parts' test performance could be found, and iii) search for differences between early (10-13 years-old) and middle (14-17 years-old) adolescents on the afore mentioned variables. Thirty-four young male basketball players (14.59 ± 1.93 years-old) participated in this study. Considering the global sample, as well as for the early adolescents' group alone, using the instep revealed to have greater efficacy than using the inner part of the foot. Besides, very strong (global sample and middle adolescents) and strong (early adolescents) correlations between both foot parts performance were found. However, considering the middle adolescents exclusively, no foot part performance supremacy was found. It seems that the greater efficacy on WDPK&C test using instep disappears when passing from early adolescence to middle adolescence, on male basketball players, probably due to a rise in maturation and years of practice.
Keywords: motor competence, gross motor coordination, assessment

Resumen: El test WDPK&C requiere la manipulación de un balón tanto con las extremidades superiores (soltar y atrapar) como con las inferiores (chutar). El presente estudio tuvo como objetivos: i) identificar cuál de las dos partes del pie (parte interna o empeine) implicaría un mejor rendimiento en el WDPK&C; ii) verificar si existe una correlación significativa entre el rendimiento de ambas partes del pie en el test, y iii) buscar diferencias entre adolescentes de edad temprana (10-13 años) y media (14-17 años) en las variables mencionadas. Treinta y cuatro jóvenes jugadores de baloncesto (14,59 ± 1,93 años) participaron en este estudio. Considerando la muestra global, así como sólo para el grupo de adolescentes precoces, la utilización del empeine reveló tener mayor eficacia que la utilización de la parte interna del pie. Además, se encontraron correlaciones muy fuertes (muestra global y adolescentes medios) y fuertes (adolescentes tempranos) entre el rendimiento de ambas partes del pie. Sin embargo, considerando exclusivamente a los adolescentes medios, no se encontró ninguna supremacía en el rendimiento de la parte del pie. Parece que la mayor eficacia en el test WDPK&C utilizando el empeine desaparece al pasar de la adolescencia temprana a la adolescencia media, en jugadores de baloncesto masculinos, probablemente debido a un aumento de la maduración y de los años de práctica.
Palabras clave: competencia motora, coordinación motora gruesa, evaluación

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Introduction

As stressed on several studies (Cohen et al., 2014; Vlahov et al., 2014), manipulative gross motor skills (e.g., kicking, throwing), even more than locomotor ones, are associated with greater participation in physical activity (PA) and the positive health-related consequences from activities that need manipulative gross motor skill (Cattuzzo et al., 2016; Garcia-Marin et al., 2020; Khodaverdi et al., 2016; Lopes et al., 2023; Pranoto et al., 2024; Robinson et al., 2015). Besides, to be competent in a range of fundamental movement skills may serve as a protective factor against decline in PA levels, either during childhood (Lopes et al., 2011) or adolescence (Chan et al., 2019). Furthermore, as important as to engage into activities that may have the potential to enhance motor coordination and motor competence will be to have adequate instruments to measure this competence. Among several tests and batteries where the manipulative component of gross motor skills is assessed, as are the cases of KTK3+ (Platvoet et al., 2018), MCA (Luz et al., 2016) or TGMD-2 (Ulrich, 2000), the WDPK&C test (Matos et al., 2022) is a gross motor test undergoing validation that requires the manipulation of a ball with both the upper (releasing and catching) and the lower (kicking) limbs. This unique characteristic is challenging from the motor coordination point of view as it requires the manipulation of an object (ball) with the upper and lower limbs and not just by one or another, differently from other coordination tests.

As stressed by several authors (Naito et al., 2010; Shan & Westerhoff, 2005), the drop punt (kicking a ball in the air that has been released from the own hands) is a complex and multidimensional kicking action which implies whole body interactions and coordination to be successful. Several studies have looked at the effectiveness of passing as a function of the point of bodily contact with the ball, whether in Australian football (Peacock & Ball, 2018), rugby (Ford & Sayers, 2015) or football (Sakamoto et al., 2012). According to the same authors, the orientation of the supporting foot, the distance from the contact point of the foot to the centre of gravity of the ball and the variability in the swing of the leg that causes the impact on the ball have been identified as some of the most important variables that condition the accuracy of sending the ball with this technical gesture.

Williams (1983) states that after the establishment of the mature kicking pattern, the child begins to make appropriate adjustments to kick a ball that rolls or that has been dropped. However, studies that identify which part of the foot is preferentially used, in situations of greater or lesser precision, are scarce. Yet, the performance of the drop punt kick was studied (Dichiera et al., 2006; Millar, 2004;

Young et al., 2003), despite the fact that the conditions of kicking are diverse from WDPK&C test, namely because the ball is quite different. Nevertheless, one of the features that is commonly referred to as being effective on a well-performed punt kick is the stabilisation of the ankle – keeping a taut instep - in plantar flexion (Millar, 2004; Orchard et al., 1999).

Something that has captured researchers' attention while observing participants performing the WDPK&C test, was the part of the foot used to kick the ball to the wall. In fact, although the protocol states that no demonstration should be performed (so that no researcher' personal influence should arise, namely on the part of the foot to use or speed or height on the wall where to kick the ball to), an apparent majority of participants uses the instep. Even so, others use the inner part.

Thus, the present study aims to identify which (if any) of these different foot parts (inner part or instep) will imply a better performance (higher number of catched balls following a drop punt kicked gesture and a rebound from a wall in 30 seconds) on the WDPK&C Test. Besides, it is also an objective of the present study to verify if a significant correlation between both foot parts' test performance can be found. Finally, the present study also aims to identify possible differences between early and middle adolescents on the afore mentioned variables, as several studies have showed that, with age, motor coordination and competence develops (Barnett et al., 2026; Matos et al., 2022; Platvoet et al., 2018; Rodrigues et al., 2019).

Materials and Methods

Participants

A non-probabilistic sample of thirty-four male basketball players (14 early adolescents – 10-13 years-old, 20 middle adolescents – 14-17 years-old) with a mean age of 14.59 (SD = 1.93) years were recruited and participated in this study. All participants presented no motor or perceptual limitations. Sample characteristics are reported in Table 1.

Table 1.
Sample characteristics.

Participants	Decimal age (years)	Competitive seasons (#)	Height (cm)	Weight (kg)
Total Sample (n=34)	14.59 ± 1.93	3.76±2.34	170.99±11.95	64.93±20.63
Early adolescents (n=14)	12.59 ± 0.98	2.50±1.51	156.70±11.57	50.67±14.85
Middle adolescents (n=20)	15.99 ± 0.92	4.65±2.43	181.31±8.15	75.23±18.10

Procedures

The study was conducted in accordance with the Declaration of Helsinki for research involving human participants (World Medical Association, 2013). Before data collection, ethical approval for the study was obtained (n. º EA06.2022.CIEQV). After obtaining approval from the ethics committee, a local basketball club was contacted for convenience. The first author explained the study's objectives, and after obtaining authorization from the club administration, club' coaches were contacted regarding the study objectives. Subsequently, considering the participants' ages, parents were contacted, and the study's objectives were also explained to them. Anonymity, data confidentiality, and voluntary participation were emphasized. Parents or legal tutors who authorized their adolescent to participate in this study signed informed consent for, with the mediation of the adolescents' coaches. Assessments were performed during a regular session of basketball training. All participants engaged in a light warm-up involving both upper and lower body movements. Participants would come in pairs to perform the tests, and, after the testing, they would return to their training session. Verbal explanation of each test was provided before each test assessment. Examiners instructed all participants to perform each task with their maximum effort.

Measures and instruments

Height and weight

A portable stadiometer scale, specifically model SECA (Hamburg, Germany), was utilized to measure both body weight and height. Participants were instructed to stand barefoot on the platform of the stadiometer, leaning against the pole of the device, maintaining a conventional positioning their arms alongside their body. Weight measurements were obtained from participants while wearing sport clothing and without shoes, using a digital scale (Tanita BC-50, Arlington Heights, IL, USA). These measurements took place as participants arrived for the basketball training session.

Wall Drop Punt Kick &Catch test (WDPK&C)

Participants were required to perform, with a drop punt kick movement pattern, as many ball impacts on a wall as possible, with subsequent catches, in 30 seconds, following Matos et al. (2022) protocol. Specifically, subjects should drop the ball and kick it to wall without any ground rebound moment. Only wall ball impacts with subsequent successful ball catching should be considered as a successful attempt. A line marked on the ground two meters apart from the front wall should not be stepped or surpassed during the kicking action so that an impact could be considered valid. Participants could enter the 2-meter zone if the ball was retained there. Each performer was entitled to five warming up repetitions before two consecutive 30 seconds' trials with 30 seconds recovery between them, so that the best performance with a specific part of the foot (instep or inner part, at the researcher request) could be registered. After these two trials, participants were required to perform another two trials, this time with the part of the foot they had not use before. This

procedure was taken in a balanced way, so that an equal number of participants of each age group would perform the trials beginning either with the inner part or with the instep, diminishing a possible order bias. The test was performed with a size 5 football ball, 69 cm perimeter, to a wall that had a clean valid zone of 5 meters wide and over 4 meters high.

Statistical analysis

The analyses were conducted in IBM SPSS STATISTICS (v.29 for Windows, SPSS Inc., Chicago, IL). First, the database was checked for outliers and missing values. Presence of extreme values or missing data were not found. Second, a normality analysis was performed using the Kolmogorov-Smirnov test ($n > 50$) as suggested by Ho (2014). The data indicated a non-normal distribution ($p < .05$). Thus, subsequent inference analysis was performed with non-parametric tests.

To compare the variables considering part of the foot used, the Wilcoxon test was used. To compare either inner part or instep performances between early and middle adolescents, the Mann-Whitney test was used. The significance level for rejecting the null hypothesis was set at 5%. To examine associations among variables, for total and samples split according to age group (early vs middle adolescence), Spearman correlation coefficients were calculated, assuming a $p < .05$ value to reject the null hypothesis (Ho, 2014). In case of statistical significance, the effect sizes based on partial eta-square for both tests were calculated (Fritz et al., 2021), considering the following cutoff values: $\eta 2 < 0.01$ no effect, 0.01-0.04 small effect, 0.06-0.11 intermediate effect and 0.14-0.20 large effect (Cohen, 1988, 1992).

Results

Descriptive statistics, mean comparison and bivariate correlations of the WDPK&C test are displayed in Table 2. In respect to foot part, instep performance was significantly better than inner part with the total sample ($p<0.05$, with an intermediate effect size) and in the group of early adolescents ($p<0.05$, with a large effect size). However, in the eldest group (middle adolescents), there were no significant differences between instep and inner part performances. Furthermore, middle adolescent performance was significantly better than early adolescents' one, either with instep ($p<0.05$) or with inner part ($p<0.001$), both with a large effect size).

Relative to correlations, significant bivariate correlations (<0.001) were noted between instep and inner part WDPK&C' performances. These were very strong with the total sample (0.915) and considering just the middle adolescent group (0.954) and strong on the early adolescent group (0.851).

Table 2.
Differences and correlations of WDPK&C performance with instep and inner part.

	WDPK&C instep (repetitions)	WDPK&C inner part (repetitions)	Differences (p-value)	Effect size $\eta 2$	Correlation ρ (p-value)
Total Sample (n= 34)	17.85±4.49	16.91±4.88	<0.05	0.063	0.915 (<0.001)
Early adolescents (EA) (n= 14)	15.71±3.63	13.71±3.29	<0.05	0.23	0.851 (<0.001)
Middle adolescents (MA) (n= 20)	19.35±4.50	19.15±4.60	0.709	-	0.954 (<0.001)
Differences EA vs MA (p-value)	<0.05	<0.001	-		-
Effect size (EA vs MA) ($\eta 2$)	0.169	0.332			

Notes: values reported in mean and standard-deviations; p-value = significance level at 95%.

Discussion

The WDPK&C protocol doesn't define which part of the foot should be used. Likewise, to avoid any personal influence on the part of the foot to be used or on the speed or height of the wall to kick the ball towards, the protocol states that no demonstration by the researcher should take place. Therefore, it remains, till now, unknown which, if any, part of the foot results in better performance on the test. Thus, the present study aimed to investigate whether the performance on WDPK&C test would be different when using two alternative foot parts (inner part or instep). Besides, it is also an objective of the present study to verify if a significant correlation between both foot parts' test performance could be found. Additionally, differences between early and middle adolescents on the afore mentioned variables were also to be investigated.

The performance of the middle-aged adolescents was significantly better with both the instep and the with inner part. In the former group, while performing the test technical difficulties using the inner part of the foot became very evident. It might be that participants couldn't keep yet a steady foot position while kicking with this foot inner part, as Orchard et al. (1999) and Millar (2004) said it was important when performing punt kick, although this was referred to instep use. It is possible that with an increased motor coordination and competence this issue was overcome, with both parts' performance becoming highly similar on middle adolescents' group. In fact, age is a well-identified correlate of most aspects of motor competence, as stressed by Barnett et al. (2016) in their systematic review. Nevertheless, unlike childhood motor development, which is more influenced by biological maturation, adolescence motor competence has greater influence of practice. This means that the (positive) correlation of these two variables (age and motor competence) will depend upon opportunities to practice. In the present case, all participants were basketball players (with an average of 3.76 years in the sport) and the older had significantly more years of practice

than the younger ones ($p<0.01$, value not reported on tables), which may have helped to reach the present results.

Considering the purpose of the present study there are several practical implications:

- Coordination, Age and Practice: The study reinforces that coordination evolves with age and motor practice. It suggests that while age is a (well known) factor in the development of motor coordination and competence (Matos et al., 2022; Platvoet et al., 2018; Rodrigues et al., 2019), practice and experience also play significant roles (Barnett et al., 2016; Coppens et al., 2021; Fransen et al., 2014; Henrique et al., 2016; Vandorpe et al., 2012; Wrotniak et al., 2006), particularly during adolescence. This finding underscores the importance of providing ample opportunities for practice and skill development in young athletes to enhance their motor coordination and competence. It suggests that while younger adolescents may struggle with technical difficulties using the inner part of the foot, older adolescents may have overcome these issues due to increased motor coordination and competence.

- Biomechanics of Foot Movement: The study prompts further investigation into the biomechanical aspects of foot movement, particularly in sports-related activities like kicking. Understanding how different parts of the foot affect performance can provide insights into optimal techniques for executing specific movements, which could be applicable in several different sports that use foot-ball contact (Ford & Sayers, 2015; Millar, 2004; Orchard et al., 1999; Peacock & Ball, 2018; Sakamoto et al., 2012).

- Practical Applications in Sports Training: Insights from this study can inform sports training programs aimed at improving kicking skills among adolescent athletes. Coaches and trainers may consider incorporating specific drills targeting different parts of the foot to enhance overall performance. Moreover, understanding biomechanical characteristics associated with each foot part's performance (Dichiera et al., 2006; Millar, 2004; Orchard et al., 1999; Young et al., 2003) could guide the development of more effective training techniques. Furthermore, the indicators also seem to reinforce the assumption that motor patterns change with age, and this may be associated with greater or lower task effectiveness, even when it comes to close ages (as is the case). So perhaps it would be interesting to encourage coaches to monitor the motor pattern adopted by each of their athletes, and how this may be influencing their performance. Although our goal was not to analyse the impact in basketball but, instead, just to use a sample of active adolescents, an interesting informal result has emerged. Talking with the athletes' coaches after the assessments, it was very interesting to notice that, according to them, the list of best basketball players of each of the two age groups was quite coincident with the top performers on WDPK&C, which raises questions about the possibility of using WDPK&C not only as a gross motor coordination test but, also, as a proxy for talent detection on young team players, even if the gesture is not an usual one on any of the traditional team sports.

Although the practical implications of present study, there are, however, several limitations that should be addressed in future:

- Gender Differences and Generalizability: The study's limitation regarding the sample being composed only of male basketball players raises questions about the generalizability of the findings across different demographic groups. Future research should explore whether similar patterns exist among females and individuals participating in different sports or no sports at all. Understanding potential gender differences in motor skill development can inform more tailored training approaches.

- Longitudinal Studies and Maturation Assessment: The study acknowledges limitations such as the lack of longitudinal data and maturation assessment. Longitudinal studies tracking individuals over time could provide deeper insights into the trajectory of motor skill development during adolescence. Additionally, assessing maturation status could help elucidate the role of biological factors in motor competence. In the present study, we have the used the well-accepted classification of adolescence phases that had correspondence with the two recruited age groups basketball players (under 14 and under 18).

Thus, future studies should extend the analysis to participants i) of different age bands and maturation status (children - 6-10 years-old - and adults), ii) that play other sports or no sports at all, as well as to iii) females, which made no part of the present study. It would also be worth to investigate which biomechanical characteristics might differentiate these two-foot parts' performance, namely if, with instep, participants can perform more essays due to a higher ball projection speed.

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Conclusions

Considering the global sample on WDPK&C test, using the instep revealed to have greater efficacy than using the inner part of the foot. A very strong correlation was found between instep and inner part performances. Considering the younger participants sample on WDPK&C test, using the instep revealed to have greater efficacy than using the inner part. A strong correlation was found between instep

and inner part performances. Considering the older participants sample on WDPK&C test, no performance supremacy was found using either the instep or the inner part. A very strong correlation was found between instep and inner part performances. Thus, greater efficacy on WDPK&C test using instep disappears when passing from early adolescence to middle adolescence, on male basketball players.

In conclusion, the study contributes to the understanding of motor skill development during different adolescence phases, particularly in the context of sports performance. Its findings have implications for both theoretical understanding and practical applications in sports training and skill development.

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