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Can motor coordination level predict performance on volleyball skills in youth?
¿Puede el nivel de coordinación motora predecir el rendimiento en habilidades específicas de volea en los jóvenes?

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Abstract. Introduction: Motor coordination is an underlying capacity to successful performs sport-specific skills. However, it is unknown whether motor coordination level can predict performance on volleyball skills. The main aim of this study was to verify whether motor coordination level, assessed using a generic test, can predict performance on volleyball skill sin youth. Material and methods: A total of 34 adolescent students (mean 14.4± 0.3 years) were recruited. The *KörperkoordinationtestFür Kinder* (KTK), a generic, non-sport specific test, composed by four tasks (i.e. dynamic balance, hopping, agility and moving sideways skills) was used to assess motor coordination level. Motor performance on volleyball skills was assessed on the basis of two product-oriented tasks: underhand volleyball serve and volleyball serve receiving. A single measure representing the volleyball skills of the participants was adopted. Linear regression models were executed. Results: Regression analysis revealed that dynamic balance, hopping and agility skills accounted for 8.5%, 17.0%and 30.5%, respectively, of the variance in the performance on volleyball skills. In addition, the multiple linear regression model significantly predicted 29.3% of the variance in the performance on volleyball skills. However, only agility skill was a significant predictor of the dependent variable in this multiple model. Discussion: Motor coordination level, assessed using a generic test, can predict performance on volleyball skills in youth. Our findings add to the assumption that KTK test can be a useful motor coordination assessment for supporting making-decisions in different settings, such as school physical education and talent identification programs.
Keywords: motor skills, sports performance, motor coordination, adolescents, physical education.

Resumen. El objetivo principal de este estudio fue verificar si el nivel de coordinación motora, evaluado mediante una prueba genérica, puede predecir el rendimiento en habilidades específicas de volea en adolecentes. Material y métodos: Se reclutó a un total de 34 estudiantes adolescentes (media 14,4 ± 0,3 años). Prueba de coordinación de *KörperkoordinationtestFür Kinder* (KTK), se utilizó para evaluar el nivel de coordinación motora. El rendimiento motor en las habilidades específicas de voleibol se evaluó sobre la base de dos tareas orientadas al producto: servicio de voleibol por debajo del brazo y recepción de servicio de voleibol. Se adoptó una única medida que representa las habilidades de voleibol de los participantes. Se ejecutaron modelos de regresión lineal. Resultados: El análisis de regresión reveló que el equilibrio dinámico, las habilidades de salto y agilidad representaron el 8.5%, 17.0% y 30.5%, respectivamente, de la varianza en el desempeño en las habilidades de volea. Además, el modelo de regresión lineal múltiple predijo significativamente el 29,3% de la varianza en el rendimiento en las habilidades de volea. Sin embargo, solo la habilidad de agilidad fue un predictor significativo de la variable dependiente en este modelo múltiple. Discusión: El nivel de coordinación motora, evaluado mediante una prueba genérica, puede predecir el rendimiento en habilidades específicas de volea en la juventud. Nuestros hallazgos se suman al supuesto de que el KTK es una evaluación de la coordinación motora útil para ayudar a tomar decisiones en diferentes entornos.
Palabras clave: habilidades motoras, rendimiento deportivo, coordinación motora, adolescentes, educación física.

Introduction

Motor coordination can be described as the capacity to efficiently control the degrees of freedom of the different body segments that are involved in the motion (Bernstein, 1967). This capacity is essential to perform a great variety of goal-directed actions throughout span life and that can be developed in physical education classes through activities aimed at increasing motor skills (Rijos et al., 2020). During childhood, children need to move coordinately their bodies in order to reach and grasp objects as well as to perform complex specialized movements (Chagas & Batista, 2017). Finally, the development of motor coordination is also fundamental, as there is an influence not only on physical aspects, but also on psychosocial aspects. (Luis-de Cos et al., 2019)

The specialized movements are formed by fundamental movement skills (i.e. locomotor, stability and manipulative skills) which were refined throughout

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childhood and combined to perform more complex movement abilities (Gallahue et al., 2012; Tompsett et al, 2017). They are on top of children's motor skills acquisition hierarchy and are applied to daily living, recreational, and sport experiences (Clark, 2005; Gallahue et al., 2012).

In sport setting, specialized movements are composed by sport-specific skills (Gallahue et al., 2012). Therefore, it is expected that motor coordination level displayed by children and adolescents is associated with performance on sport-specific skills (Pion et al., 2015), because specialized movements ability depend on capacity to efficiently control the body segments involved in the motion (Bernstein, 1967). In other words, youth players who display poor motor coordination tend to have low performance on sport-specific skills. Also, it seems plausible to consider that young people with good motor coordination show adequate performance on sport skills.

Among youth athletes, evidence has suggested that motor coordination level is moderate to good (Sogut,2016), varies across different sporting o mains (Jaakkola et al., 2017; Pion et al., 2014), can discriminate competitive level (di Cagno et al., 2014; Opstoel et al., 2015) and predicts competition results (Faber et al., 2016; Pion et al., 2014). However, little is known regarding the relationship between motor coordination level and motor performance on sport-specific skills in youth. In addition, some sports, like volleyball, have been neglected in this field of research (Johnston et al., 2018)

Two retrospective studies (Mostaert et al., 2020; Pion et al., 2015) found that youth volleyball players who achieved elite level tended to have better motor coordination than those who did not achieve elite level. Both investigations (Mostaert et al., 2020; Pion et al., 2015) assessed motor coordination at time of baseline, (respectively 5 and 4-8 years earlier). As such, these studies have suggested that motor coordinations an important factor in determining inclusion into the elite level in volleyball. However, these previous studies did not analyze the association between motor coordination level and performance on volleyball skills.

To our best knowledge, only one study (Chagas & Batista, 2017) assessed the relationship between motor coordination level and performance on volley-specific skills in youth. Using a generic motor coordination test, involving dynamic balance, agility, hopping and moving sideways skill stasks, (Chagas & Batista, 2017) confirmed that global motor coordination level accounted for 23%of the variance in the motor performance on volley-specific skills. However, it was not explored how much each motor skill explained the performance on volleyball skills. Furthermore, it is unknown whether all motor skills of a generic test, separately and together, can explain the variance in the performance on sport-specific skills. This advance in research can provide a better model to predict performance on volleyball skills in youth and to give valuable information for talent identification programs.

The purposes of this study were: 1) to verify whether motor coordination level can predict performance on volleyball skills; 2) to analyze how much different measures of motor coordination level, separately and together, can explain the variance in the motor performance on volleyball skills in youth.

Material and methods

The total of 34 adolescent students (27 females and 7 males) aged 13-14 years (mean 14.4± 0.3 years) enrolled in a public school were recruited to participate in this study. The sample was randomly selected from the population of 106 students who had regularly practiced volleyball at school during physical education classes and free-time activities. The inclusion criteria required students to be under 15 years old, with no history of injury or disease that could affect motor performance. Exclusion criteria consisted of students with regular training or competitive sport participation in volleyball outside of school. Ethical approval for the study was obtained from University's Ethics Committee (CAAE:35534514.5.0000.5259), and parental consent and child assent were provided prior to participation.

Anthropometrics characteristics of the subjects are provided in Table 1.Body mass was measured to the nearest 0.1 kg using an electronic scale (Body Fit; Relax Medic®, São Paulo, Brazil) with participants wearing their school uniform. Stature was measured while unshod with a stadiometer (2-m tape measure attached to wall) to the nearest 0.1 cm and a set-square (with the smaller side leaning on the wall, and the larger side on the vertex and positioned perpendicularly to the floor).

The level of motor coordination was evaluated by *Körperkoordinationstestfür Kinder* (KTK) test using a single trained evaluator. KTK is a reliable and valid assay (Kiphard & Schilling, 2007) for school-age children and is composed by four test items, involving, respectively, dynamic balance, jumping, agility and lateral movement

skills. The first test consists of balance movements, in which the child walks on a balance beam three meters long on descending width of 6, 4.5 and 3 cm. Each beam was crossed three times where a maximum of eight steps per attempt were allowed (72 steps in total); the total of steps across all attempts determined Motor Quotient 1 (MQ1). The second test involved balance in which the child jumped an obstacle formed by a pile of pillows, in ascending order (pillow measured 60 cm × 20 cm × 5 cm; the maximum height was constituted by 12 pillows or 60cm). Only 3 attempts were allowed for each obstacle and 3, 2 or 1 point(s) were/was respectively awarded for good performance in the first, second or third tests. Thus, a maximum of 39 points (including a single level test) could be scored for each leg; the scores were added to determine the Motor Quotient 2 (MQ2). The third task consisted of the activity in which the child jumped on a wooden batten (60 cm × 4 cm × 2 cm) in an area (60 cm × 100 cm) for 15 seconds at maximum speed, using both legs. For this task the participant must: land in the inner area, with both feet simultaneously, without touching the wooden batten when jumping. The number of jumps performed correctly was added in 2 trials to determine the Motor Quotient 3 (MQ3). The final task involved moving laterally on wooden boards (25 cm × 25 cm × 5.7 cm) as many times as possible in 20 seconds. One point was awarded for each time the batten was passed and one more for stepping on it. The number of relocations were counted and summed and two attempts were made to determine Quotient 4 (MQ4). All four scores were age-adjusted.

All the procedures were administered inside the school, on a modified volleyball court (Figure 1), according to strategies previously adopted in a previous study (Chagas & Batista, 2017). The net was placed vertically over the center line whose top was set at the height of 2.24m. Motor performance on volleyball skills was assessed on the basis of two product-oriented tasks: (one) underhand volleyball serve; and (two) volleyball serve receiving. These volleyball skills were selected owing to their importance for pupils to be able to participate in and enjoy a proper volleyball game. Furthermore, the students had not experienced other specialized movement skills as teaching contents during physical education classes.

The participants were familiarized with the tasks by performing each task 20 times consecutively (Chagas & Batista,2017). All participants had experienced both product-oriented tasks throughout their school year during physical education classes, which they attended two times per week, for approximately 12 weeks.

In the first task (underhand volleyball serve) the participants were positioned immediately behind the end line, at the middle point, in the 'serve position' (Figure 1). The subjects were required to hit the ball with the upper limb in an ascendant way, aiming to place the ball inside the 4 x 5m zone in the opposite court, located between the attack and end lines (Figure 1).

In the second task (volleyball service receiving) the participants were positioned approximately 30cm behind the attack line at the middle point in the 4 x 5m zone ('service receiving position', Figure 1). Their volleyball serve receiving objective was to place the ball inside the front zone (2 x 5m), of the opposite court, in response to an underhand volleyball serve performed by an experienced student volleyball player. Only those trials in which the participants did not take a step in order to perform the volleyball passing were recorded as successful. The same experienced student, who previously had demonstrated a success rate of 100% in this specific task, performed the underhand serve (i.e. from 'serve position', Figure 1) for all subjects. Participants performed 10 trials for each task (i.e. 20 trials in total). The ratio between the number of successful trials (i.e. when they reached the goal) and the number of total trials was acquired and formed a success rate express as percentage (Table 1), i.e. the score representative of the motor performance on volleyball skills.

A single measure representing the volleyball skills of the participants was adopted. As such, the algorithm for the total score of the performance on volleyball skills was:

Success rate = (successful trials on task 1 + successful trials on task 2) / 20.

Descriptive statistics were determined for all variables. The Kolmogorov-Smirnov test confirmed acceptable normality of the data distribution. Pearson correlation was used to examine the associations between motor coordination level and motor performance on volleyball skills. The following categories were adopted for classifying the strength of the correlation coefficient: little or inexistent (r d» 0.25), low (0.25 <r < 0.50), moderate (0.50<r < 0.70), high (0.70d»r < 0.90), and very high (r e» 0.90). Pearson correlation coefficients were calculated to identify potential predictors (i.e. motor quotients) of volleyball skills. Simple and multiple regression analysis were performed to verify the variance in the performance on volleyball skills explained

from motor quotients variables, respectively, separately and together. Only those motor quotient variables that significantly correlated with performance on volleyball skills were included in the regressions models. A significance level of 5% ($á = 0.05$) was adopted in all statistical tests. Data analysis was executed using IBM SPSS (ver. 22.0, USA).

Results

Descriptive statistics of body weight, height, MQ1, MQ2,MQ3,MQ4 and PVS is provided in Table 1. Correlational analyses showed that performance on volley skills was significantly and positively correlated with MQ1, MQ2 and MQ3,but not with MQ4 (Table 2).Thus, only MQ1, MQ2 and MQ3 were included in the regressions models. Significant correlations were low-to-moderate, with Pearson coefficient (r) ranging between 0.34and 0.57.

Linear regression analyses revealed that MQ1, MQ2and MQ3accounted for 8.5%, 17.0% and 30.5%, respectively, of the variance in the performance on volley skills. All of these linear regressions were statistically significant (Table 3).

The multiple linear regression model significantly predicted 29.3% of the variance in the performance on volley skills (Table 4).However, the only independent variable that was significant predictor of the dependent variable in this model was MQ3.

Table 1
Descriptive statistics of anthropometric characteristics, levels of motor coordination, and performance (success rate) on volley skills (n=34)

	Mean(± SD)	CI (95%)
Body Weight (kg)	56.7(± 16.7)	50.8 – 62.5
Height (m)	1.62(±0.1)	1.59 – 1.64
MQ1	98.6(±19.6)	91.7 – 105.4
MQ2	76.2(±26.0)	67.9 – 84.2
MQ3	76.1(±23.3)	67.9 – 84.2
MQ4	83.1(±15.8)	77.6 – 88.6
PVS	0.69(± 0.2)	0.63 – 0.75

SD: standard deviation; CI: confidence interval; PVS: performance on volley skills.

Table 2
Pearson correlation coefficients between motor coordination level (MQ1-MQ4) and performance on volley skills

	PVS	Significance Level
MQ1	$r = 0.34$	$p = 0.05$
MQ2	$r = 0.44$	$p = 0.009$
MQ3	$r = 0.57$	$p = 0.0004$
MQ4	$r = 0.09$	$p = 0.597$

PVS: performance on volley skills.

Table 3
Linear regression models of the performance on volley skills

Independent variables	Adjusted R^2	*f*-test	β (Unadjusted)	β (SE)	Significance of β (*t* Test)
MQ1	0.085	4.085	0.003	0.001	0.05
MQ2	0.170	7.740	0.003	0.001	0.009
MQ3	0.305	15.500	0.004	0.001	0.0002

SE: standard error.

Table 4
Multiple linear regression model of the performance on volley skills*

Independent variables	β (Unadjusted)	β (SE)	Significance of β (*t* Test)
MQ1	0.001	0.001	0.596
MQ2	0.001	0.001	0.304
MQ3	0.003	0.001	0.029

*Results of the whole model: adjusted R^2=0.293, *f*-test=5.553, significance level=0.004.
SE means standard error.

Discussion

This study provides evidence that motor coordination level can predict performance on volleyball skills in youth. Our investigation showed that measures of a generic motor coordination test (i.e. KTK), separately and together, can explain the motor performance on volleyball skills among adolescent students. Overall, our findings add to the assumption that KTK test can be a useful motor coordination assessment for supporting making-decisions in different settings, such as school physical education and talent identification programs. Its great utility has been shown to be essential and growing in investigations on the levels of motor coordination (Arjona, Vargas & Buendía, 2020).

Motor coordination is an underlying capacity to successful performs sport-specific skills, which are highly specialized movements (Latash,2013). Previous studies found global motor coordination is positively correlated with performance on sport-specific skills in karate (Bozanic & Beslija,2010), soccer (Kokstejn et al., 2019) and basketball (Kamandulis et al., 2013) among young people. In volleyball, a previous study provided evidence that global motor coordination level is also positively correlated with volleyball skills in adolescents (Chagas & Batista,2017). Consistent with literature, our findings found that dynamic balance (MQ1), hopping (MQ2) and agility (MQ3) skills were positively correlated with performance on volley skills in youth.These results were expected because both kinds of skills, generic and sport-specific, depend of adequate levels of motor coordination in order to be properly executed.

On the other hand, moving sideways skill (MQ4) was not significantly correlated with performance on volley skills. This finding might be explained due to variety of postural strategies which can be adopted by individuals during execution of the moving sideways task. In this regard, inter-subjects performance can significantly vary in relation to their body alignments to complete the task, such as a more or less inclined trunk, a more or less forward head, and a lower or higher knee range of motion. These different postural strategies, that is, behavioral constraints (Bardy et al., 2006), will result in alterations in the height of the center of gravity, body stiffness, moment of inertia and mechanical work .In fact, KTK is a product-oriented test(Kiphard & Schilling,2007) where is not assessed the manner by which (i.e. «how») subjects perform the tasks. As such, therefore, our results must be interpreted with caution, and additional studies using

biomechanical analysis should be conducted in order to assess how young people perform these motor tasks.

Consistent with literature (Chagas & Batista,2017), our findings indicated that motor coordination level can predict performance on volley skills in youth. While that previous study (Chagas & Batista,2017) found global motor coordination level accounted for 23% of the variance, our multiple linear regression model was a bit more predictive, explaining 29.3% of the variance in the performance on volley skills in youth. Therefore, beyond its potential to discriminate competitive level (di Cagno et al., 2014; Opstoel et al., 2015)and to predict competition results (Faber et al., 2016; Lech et al., 2011), motor coordination level, assessed using a generic test (i.e. KTK), can predict performance on volley skills in youth.

In addition, our study explored how much each motor skill assessed in the KTK test explained the performance on sport-specific skills. First, moving sideways skill was not included in the model because was not significantly correlated with performance on volley skills. Second, agility skill was the variable with the highest predictive values in both simple and multiple regression models. In simple regression model, agility skill (MQ3) explained 30.5% of variance in the performance on volley skills, while dynamic balance (MQ1) and hopping (MQ2) skills accounted for 8.5% and 17%, respectively. Altogether, these results suggest that a short form of the KTK test, using MQ3 alone or together with MQ1 and MQ2, could be applied with the purpose to predict variance in the performance on volley skills in youth.

With respect to amount of explained variance in the performance on volleyball skills, our models were only slightly better than previous evidence, ranging from 29.3% (multiple models involving MQ1, MQ2 and MQ3) to 30.5% (simple model using agility skill). On the other hand, our findings show that it is possible to save time using a short form of the KTK test. While the complete form of KTK test requires around 20 min to complete, using only one item (MQ3), for instance, it would be necessary less than five min. This study provides evidence that motor coordination level can predict performance on volley skills in youth. In fact, our investigation showed that measures of a generic motor coordination test, separately and together, can explain the motor performance on volley-specific skills among adolescent students. Overall, our findings add to the assumption that KTK test can be a useful motor coordination assessment for supporting making-decisions in different settings, such as school physical education (Chagas & Batista,2017), and talent identification programs (O'Brien Smith et al., 2019).

Talent identification programs are designed to identify athletes who possess extraordinary potential for success in senior elite sport (Vaeyens et al., 2009). To date, there does not seem to be a clear set of variables that predict future success, and research in volleyball is scarce (Johnston et al., 2015). Given that sport is multidimensional in nature (Abbott & Collins,2002; Johnston et al., 2015) this study suggests that motor coordination level, especially agility skill level, can compose a model to predict the sport performance in volleyball. However, our cross-sectional design does not allow making inferences to future success in sport performance.

In addition, our findings suggest that it seems important to focus on the development of adequate levels of motor coordination at young ages since this characteristic is associated with performance on volleyball skills. As such, young people should receive both appropriate instruction and opportunities for practice in order to develop their motor coordination levels. For this, physical education classes are an important setting for young students around the world.

This study had some limitations. First, only two volleyball skills were tested, where as volleyball also involves other specialized movement skills. Second, the sample size is relatively small - although it was large enough to generate significant results -and there was an unbalanced male/female ratio of the sample. Third, our cross-sectional design does not allow to make inferences to future success in sport performance. Instead, our findings only suggest that motor coordination level can compose a model to predict the sport performance in volleyball. Nevertheless, this study adds to the scarce literature on the relationship between motor coordination level and performance on volleyball skills in youth.

Conclusions

Motor coordination level, assessed using a generic test, can predict performance on volleyball skills in youth. Our findings add to the assumption that KTK test can be a useful motor coordination assessment for supporting making-decisions in different settings, such as school physical education and talent identification programs. Moreover, we recommend that young people's hould receive both appropriate instruction and opportunities for practice in order to develop adequate

levels of motor coordination. For this, physical education classes are an important setting for youth around the world.

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