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THE RELATIONSHIPS BETWEEN GROSS MOTOR COORDINATION AND SPORT-SPECIFIC SKILLS IN ADOLESCENT NON-ATHLETES

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ABSTRACT

Purpose. While the usefulness of gross motor coordination score as predictor of sports performance in young athletes has been demonstrated, practical applications in the settings where the focus is not on elite performance is limited. Further, little is known about the extent to which gross motor coordination score is associated with sport-specific skills among adolescent non-athletes. The aim of this study was to analyse the relationship between the degree of gross motor coordination and execution in specific volleyball tests among adolescent non-athletes.

Methods. The total of 34 students (27 females and 7 males) aged 13–14 years who regularly participated in volleyball during physical education classes were randomly recruited. Gross motor coordination was assessed with the Körperkoordinationstest für Kinder. Motor performance on volley-specific skills was indicated by two product-oriented tasks: volleyball under service and service reception. Correlation and linear regression analyses were applied to examine the associations between motor coordination scores and motor performance in volley-specific skills.

Results. Motor coordination score was positively correlated with motor performance on specific skills ($r = 0.503$, $p = 0.02$). Linear regression analysis revealed that motor coordination score accounted for 23% of the variance in the motor performance on volleyball skills ($R^2 = 0.253$, R^2 adjusted = 0.230, $F = 10.836$, $p = 0.02$).

Conclusions. The degree of gross motor coordination seems to play a significant role in the execution of specific volleyball tasks.

Key words: motor skills, adolescents, volleyball, physical education, school sports

Introduction

There are several standardized assessment tools which have been used by physical education and physical therapy professionals in order to estimate the degree of motor coordination in children and adolescents, as well as to classify their motor competence. On the basis of the assumption that the inability to efficiently coordinate body segments in motor tasks might be indicative of a neurodevelopmental disorder, motor coordination tests have been used as auxiliary tools in screening for child developmental delays and/or neurological disorders throughout several years [1].

Overall, motor coordination tests applied to children and adolescents assess performance on different types of locomotion, manipulation, and stability skills. In other words, motor coordination tests examine fundamental movement skills, which are suggested to be foundational for more complex physical and sporting activities [2]. Furthermore, motor coordination might be considered an underlying component of fundamental movement skills [2]. However, the usefulness of measures obtained from motor coordination tests is not restricted to solely assessing the neurological and functional status in children [3]. For instance, emerging evidence supports associations between the degree of motor coordination and a range of health outcomes among boys and girls [4, 5], such as levels of physical activity, physical fitness, and weight status [6].

Among the correlates of the degree of motor coordination in children and adolescents, sport-related attributes have been increasingly examined. There are several studies which have analysed associations between the degree of motor coordination and sports participation [7–10]. In general, these previous findings have indicated a positive correlation between motor coordination and sports participation.

In addition, the relationship has also been investigated between the degree of motor coordination and performance in different sports [11], such as tennis [12, 13],

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table tennis [14], soccer [15], gymnastic [16, 17], judo [18], and volleyball [19]. Overall, these findings have suggested that the degree of motor coordination is an important predictor of sports performance in youth athletes. Most of these previous studies [12–15, 17, 19] used the Körperkoordinationstest für Kinder (KTK) as a tool to assess gross motor coordination.

While the usefulness of the degree of motor coordination as a predictor of sports performance in young athletes has been demonstrated, practical applications in the settings where the focus is not on elite performance is limited. Further, little is known about the extent to which the degree of gross motor coordination is associated with sport-specific skills among adolescent non-athletes.

The aim of this study was to analyse the relationship between the degree of gross motor coordination and motor performance on sport-specific skills among adolescent non-athletes. The investigation assessed volley-specific skills because volleyball is one of the most common disciplines in school-based physical education classes among adolescents [20]. It was hypothesized that the degree of gross motor coordination would be positively and significantly associated with motor performance in volley-specific skills among adolescent non-athletes.

Material and methods

The total of 34 students (27 females and 7 males) aged 13–14 years (mean, 14.4 ± 0.3 years) enrolled in a public school in the city of Rio de Janeiro, Brazil were recruited to participate in the 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. In order to define the participants as non-athletes, students with regular competitive sport participation in volleyball outside of school were excluded. Ethical approval for the study was obtained from the Rio de Janeiro State University's Ethics Committee, and parental consent and child assent were provided prior to participation.

Anthropometric characteristics of the subjects are presented in Table 1. Body mass was measured to the nearest 0.1 kg with electronic scales in participants wearing their school uniforms. Standing height was determined while unshod with a wall meter to the nearest 0.1 cm.

Gross motor coordination was assessed with the use of the KTK by a single trained assessor. The KTK is a reliable and valid instrument for middle school-aged children and consists of four test items: (1) walking backwards along balance beams of decreasing width; (2) one-legged hopping over an obstacle, formed by an increasing pile of pillows; (3) two-legged jumping sideways across a wooden slat for 15 s as quickly as possible; and (4) moving sideways on wooden boards lasting 20 s as many times as possible. All four scores were gender- and age-adjusted. The degree of gross motor coordination for each participant was derived from the sum of the four age-adjusted scores obtained in the tests.

All the procedures were administered inside the school, on a modified volleyball court (12 × 5 m). The net was placed vertically over the centre line whose top was set at the height of 2.24 m. Motor performance on volley-specific skills was assessed on the basis of two product-oriented tasks: (1) volleyball under service; and (2) volleyball passing. These volley-specific 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.

Through the systematic observation of the participants' performance, it was noted that performance consistency was reached by the fifteenth trial in nearly all subjects. In the first trials, a higher variability in performance was observed, with an unsuccessful rate higher than 0.5. Thus, the participants were familiarized with the tasks by performing each task 20 times consecutively. This amount of previous practice was applied in order to minimize the effects of typical variability present in the first trials of a determined task [21]. All participants had experienced both product-oriented tasks throughout their school year during physical education classes, which they attended 2 times per week, for approximately 12 weeks.

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

In the second task (volleyball passing), the participants were positioned approximately 30 cm behind the attack line, at the middle point, in the 4 × 5 m zone (Figure 1). Their volleyball passing objective was to place the ball in the front zone (2 × 6 m) of the opposite court, in response to an under service performed by an experienced student volleyball player. The height of the pass should be higher than 2.24 m, which was the height of the net. Only those trials in which the participants did not take a step in order to perform the volleyball passing were recorded as successful. The experienced student who had previously demonstrated a success rate of 100% in this specific task performed the under service for all subjects.

The 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

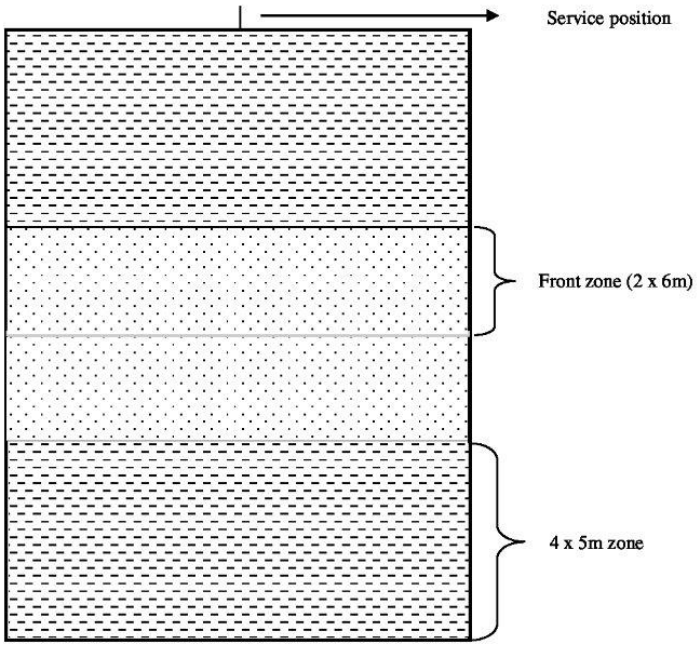

Figure 1. Modified volleyball court (12 × 5 m). Front zones are dotted and the 4 × 5 zones are dashed horizontally

a success rate expressed as percentage (Table 1), i.e. the score representative of the motor performance on specific skills.

In this study, we decided to adopt a single measure that could represent the volleyball skills of the participants. Taking into account their low or none experience in performing other volley specific skills, we only used two skills (i.e. volleyball under service and passing) to compose this measure. Thus, the algorithm for the total score of the specific sport 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 coefficient (r) and linear regression analysis were used to examine the association between gross motor coordination and motor performance in volley-specific skills. The following categories were adopted for classifying the strength of the correlation coefficient: little or inexistent ($r \leq 0.25$), low ($0.25 < r < 0.50$), moderate ($0.50 \leq r < 0.70$), high ($0.70 \leq r < 0.90$), and very high ($r \geq 0.90$). The significance level of 5% ($\alpha = 0.05$) was adopted in all statistical tests. Data analysis was executed with the Statistical Package for Social Sciences (SPSS) ver. 22.0 software (IBM, USA).

Ethical approval

The research related to human use has been complied with all the relevant national regulations, institutional policies and in accordance the tenets of the Helsinki Declaration, and has been approved by the authors' institutional review board or equivalent committee.

Table 1. Descriptive statistics of anthropometrics characteristics, degree of gross motor coordination, and success rate on volley-specific skills (n = 34)

	Mean (± *SD*)	95% confidence interval
Body weight (kg)	56.7 (± 16.7)	50.8–62.5
Height (m)	1.62 (± 0.1)	1.59–1.64
Motor coordination	79.2 (± 19.2)	72.4–85.9
Success rate	0.69 (± 0.2)	0.63–0.75

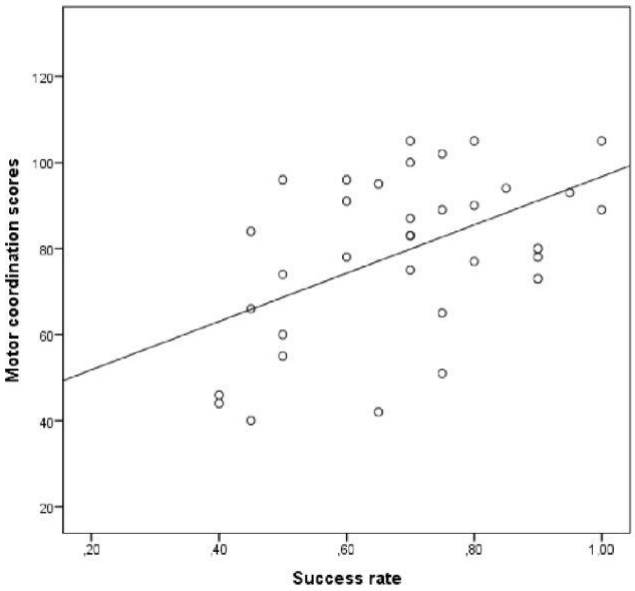

Figure 2. Scatter plot between motor coordination scores and success rate on volley-specific skills (r = 0.503, p = 0.02), with a linear fit (R^2 = 0.253, y = 40.62 + 56.1*x)

Results

The descriptive statistics are provided in Table 1. Body weight and height showed high and low variability, respectively, among participants. Gross motor coordination was moderately and positively correlated (r = 0.503, p = 0.02) with motor performance on volley-specific skills (Figure 2). Linear regression analysis revealed that the degree of motor coordination accounted for 23% of the variance in the motor performance on volleyball skills (R^2 adjusted = 0.230, F = 10.836, p = 0.02).

Discussion

The main aim of the study was to analyse the relationship between the degree of gross motor coordination and motor performance in two volley-specific skills among adolescent non-athletes. On the basis of

motor tasks involving manipulative skills with ball control, the findings of our investigation revealed that the outcomes of a generic, non-specific motor coordination test are moderately and positively associated with motor performance on volley-specific skills among adolescent non-athletes. Additionally, the degree of motor coordination accounted for 23% of the variance in the motor performance on volley-specific skills. These findings support the hypothesis that the degree of gross motor coordination is positively, moderately, and significantly associated with motor performance on selected volley-specific skills among adolescent non-athletes.

Gross motor coordination was moderately and positively associated with motor performance on volley-specific skills among adolescent non-athletes. Because of the paucity of investigations about the topic, it is difficult to compare our results with other studies. While the degree of motor coordination seems to be an important predictor of motor performance in different sports [12–18], little is known about this relationship in volleyball. Specifically in volleyball, Pion et al. [19] found that high-level young female players had better motor coordination compared with their average-level peers. However, in this previous study, the association between the degree of motor coordination and motor performance in volley-specific skills was not analysed. In the context of the direction and strength of the association (i.e. positive and moderate, respectively) found in this study, our results suggest that adolescent non-athletes with good outcomes in gross motor coordination assessments tend to have good performance on volley-specific skills.

A plausible explanation for our findings is based on theoretical aspects. First of all, motor coordination can be defined as the capacity to efficiently control the degrees of freedom of the different body segments that are involved in the motion [22]. With this concept, it seems reasonable to expect that the outcomes of the gross motor coordination assessments are associated with specialized movement skills, regardless of sport. Secondly, the ability to control the movement of the body's limbs and torso with goal-oriented human movement is elementary for both fundamental and specialized movement skills [23]. In this sense, Newell [24] argued that the basic actions of posture, locomotion, and manipulation, such as those performed in the KTK test, allow the subject to engage in a variety of motor skills defined by a wide range of task constraints, such as those found in sports. Finally, the developmental model proposed by Gallahue et al. [23] explains that the onset and extent of skill development within the specialized movement phase depends, among other constraining factors, on motor coordination.

The linear regression analysis carried out in this study revealed that the degree of motor coordination can be a predictor for the quality of execution in two specific volleyball skills. Despite the differences between study designs, it can be considered that this finding is in line with the results of previous researches [14–17, 19]. However, our outcomes indicated that the degree of motor coordination accounted only for 23% of the variance in the performance on volley-specific skills. That is, the degree of motor coordination is a measure that explains only partially the aforementioned variance. Future studies should include other sport-specific skills in volleyball, as well as in other sports in order to improve our understanding of the extent to which gross motor coordination score is associated with sport-specific skills in adolescent non-athletes.

This study shed some light on the usefulness of motor coordination assessments in the teaching of sport skills at school, since physical education teachers often incorporate motor assessments into their program [25]. First, the outcomes of the motor coordination assessments can be applied by physical education teachers in order to drive pedagogic interventions in the teaching of sport skills suitable to the level of the motor coordination of their learners. In other words, motor coordination assessments can be used as screening tools at school. Thereby, students with higher motor coordination scores could experience motor activities with higher level of complexity, likewise those with lower levels of motor coordination could experience motor activities with lower level of complexity. From a practical perspective, designing developmentally appropriate lessons would decrease the risk of students with poor motor performance on sport skills to repeatedly experience unsuccessful performance attempts and a potential decline in self-concept and self-esteem. It is well demonstrated that youth with poor motor skills are often teased [26], bullied [27], subject to ridicule [28], and tend to represent lower physical activity levels [29] and to become isolated in the school playground [30]. Secondly, motor coordination assessments can be employed as an auxiliary tool for the detection and selection of latent talents to participate in school team sports. Finally, it is our point of view that a standardized measure, such as that acquired through KTK, is more comparable across participants, schools, and countries than a direct evaluation of adolescents' sports performance.

Limitations

This study had some limitations. First, only two volley-specific skills were tested. While these specific skills are important for pupils to be able to participate in and enjoy a proper volleyball game, this sport also involves other specialized movement skills, such as spiking, blocking, and overhand service. Owing to low or none experience of the participants in other

specialized movement skills in volleyball, we decided to assess only passing and under service. Second, there was an unbalanced male/female ratio of the sample. Thus, possible differences between genders might have biased the results. Third, the variability concerning the body weight among the participants was also a limitation, since weight status is associated with motor coordination [6]. Nevertheless, the study adds to the underexplored literature on the relationship between motor coordination and sports performance in adolescent non-athletes. To our best knowledge, this study is the first to assess the relationship between gross motor coordination score and volley-specific skills in adolescent non-athletes. We believe that the issue addressed here may be useful to many physical education teachers who teach volleyball in schools around the world. Because physical education classes are taught to a much higher percentage of non-athlete students than athlete students, we recommend that future investigations on the relationship between motor coordination score and sport-specific skills are not restricted to adolescent athletes.

Conclusions

The degree of gross motor coordination seems to play a significant role in the execution of specific volleyball tasks. We suggest that the use of motor coordination tests by physical education teachers should be encouraged in order to drive pedagogic interventions in the teaching of sport skills. Future studies should include other sport-specific skills in volleyball, like spiking, blocking, and overhand serve, in order to improve our knowledge about the relationships between gross motor coordination and motor performance on volley skills.

Disclosure statement
No author has any financial interest or received any financial benefit from this research.

Conflict of interest
Authors state no conflict of interest.

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