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Original Article

Performance of upper limb velocity at different maturation stages in young sports practitioners

Desempenho da velocidade de membros superiores nos diferentes estágios maturacionais em jovens praticantes de esporte

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ABSTRACT

Introduction: Test batteries have become indispensable for the assessment of performance, maintenance of health, and motor condition, as this also represents a requirement for learning specific skills.
Objective: Comparing the performance in different stages of the upper limb velocity test at different maturation stages in children and adolescents.
Methods: 91 children and adolescents of both sexes, aged 8 to 14 years, participated in the study. Bone age, anthropometric, and upper limb velocity assessments were executed. A Mixed Repeated Measures ANOVA was used to verify the interaction effect [3 (conditions) x 3 (times)] on the upper limb velocity test phases at different maturation stages.
Results: The accelerated stage showed the best performance in all stages of the upper limb velocity test, while for the total performance the delayed group had the lowest achievement.
Conclusion: The data indicate that individuals who are in an accelerated maturation stage perform better in the upper limb velocity test than their peers in regular and delayed stages, although the test development curve is similar for all stages.

Key-words: Anthropometry, Child, Adolescent, Exercise.

RESUMO

Introdução: As baterias de testes têm se tornado indispensáveis para a avaliação de desempenho, manutenção da saúde e da condição motora, pois essa também representa um requisito para a aprendizagem de habilidades específicas.
Objetivo: Comparar o desempenho em diferentes etapas do teste de velocidade de membros superiores nos diferentes estágios maturacionais em crianças e adolescentes.
Métodos: 91 crianças e adolescentes de ambos os sexos com idade entre 8 e 14 anos participaram do estudo. Foram realizadas avaliações da idade óssea, antropométricas e velocidade de membro superior. Foi utilizado uma ANOVA Mista de Medidas Repetidas com objetivo de verificar o efeito de interação [3 (condições) x 3 (tempos)] sobre as fases do teste de velocidade de membros superiores nos diferentes estágios maturacionais.
Resultados: O estágio acelerado apresentou melhor desempenho em todas as fases do teste de velocidade de membros superiores, enquanto para o desempenho total o grupo atrasado apresentou o menor desempenho.
Conclusão: Os dados apontam que indivíduos que estão em estágio de maturação acelerada apresentam melhor desempenho no teste de velocidade de membros superiores do que os seus pares em estágio normal e atrasado, embora a curva de desenvolvimento do teste seja similar para todos os estágios.

Palavras-chave: Antropometria, Criança, Adolescente, Exercício.

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Introduction

Test batteries have become indispensable for the assessment of performance, maintenance of health, and motor condition, as this also represents a requirement for learning specific skills. The upper limb velocity test (ULV) is part of the *Eurofit* test battery [1] and has the purpose of evaluating the velocity of a given upper limb through a continuous and closed motor task [2]. Our group recently proposed the use of an automated device (AATT) for the assessment of ULV, which has intrinsic advantages to the test that are unverified in the original standardization. The broader analysis of the test allows us to highlight three distinct phases of performance: the initial one is called adaptation, followed by an optimized phase, and, finally, the moment of performance decline [3,4].

It is widely accepted that the biological development process interferes with physical capacities and the precociousness of the process can provide significant advantages for sport [5]. Therefore, the correct identification of the maturation stage gives vital information for the sports scientist who works with the pediatric population. The gold standard in the literature for identifying maturation is the X-ray of the hand and wrist, though, the high cost of the evaluation motivated the development of an equation for the estimation of bone age in children and adolescents using a mathematical model [6]. From the estimate of biological age and chronological age, it is possible to classify it in a late, regular, and accelerated state of maturation [7].

However, the implications of maturation for performance measures still need further investigation in sport. The literature has shown a moderate-strong relationship between the capacity to produce maximum, explosive, strength, velocity, and maturation [6,8]. When it comes to ULV, a study on the theme suggests that there is no relationship with maturation [9]. However, the general test performance was the only used for the analysis. It is supposed that if the execution is fragmented, the group with accelerated maturation will present a superior result in the optimized performance phase, after adapting to the task. Given the above, there is a need to study parameters that reduce errors in the selection and sports orientation process concerning instruments for assessing physical capabilities and their relationship with maturation stages [10,11]. Thus, the present study aimed to compare the performance in different stages of the upper limb velocity test at different maturation stages in children and adolescents.

Methods

Participants

A descriptive study with a cross-sectional design, conducted with 91 young people between the ages of 8 and 14 years old, of both sexes and practicing sports in a sports initiation program. The selection of the sample was conducted in a non-probabilistic manner, with the exclusion of those subjects who had some psychomotor impairment that would make the collection impossible, as well as those who refused to participate in any study procedure. Anthropometry, bone age, and upper limb velocity were checked. The study was approved by the Research Ethics Committee of the Federal University of Rio Grande do Norte (CAAE: 1249937/2015), following the guidelines for conducting studies involving human beings, according to resolution 466/12 of the National Health Council.

Procedures

Anthropometry

The anthropometric measurements involved body mass and height, utilizing a Filizola® 110 digital scale with a capacity of 150kg and a 100g resolution; and a stadiometer (Sanny® ES2020) with a 0.1 cm resolution, respectively. The corrected perimeter of the arm; the tricipital skinfold (Harpenden® adipometer (John Bull Indicators Ltd); the Biepicondylar bone diameters of the humerus and the Bicondylar of the Femur were also measured. A single evaluator performed all procedures strictly following the guidelines of the International Society for Advancement in Kinanthropometry – ISAK [12].

Bone age

To assess the bone age, the mathematical model proposed for young people aged 8 to 14 years [13] was used, in which the bone age is defined by using the following equation:

Bone Age = -11.620 + 7.004 x (stature) + 1.226 x (Dsex) + 0.749 x (age) – 0.068 x (Tr) + 0.214 x (ACP) – 0.588 x (HD) + 0.388 x (FD).

Note: stature (m); for the male sex: Dsex = 0; for the female sex: Dsex = 1; chronological age (years); Tr = tricipital skinfold; ACP = arm corrected perimeter (cm); HD = humeral diameter (cm), FD = femoral diameter (cm).
Figure 1 - Mathematical model for the evaluation of bone age.

Maturation

To estimate maturation, bone age was subtracted from the chronological age in years (sum of the months of life divided by 12), with the result stratified taking into account the respective cut off points: Delayed (over 12 negative months); Regular (up to 12 positive months) and; Accelerated (over 12 positive months) [14].

Upper limb velocity (ULV)

For checking the velocity of the upper limbs, the plate strike test inserted in the *Eurofit* test battery [1] was used, with the application of the automated tapping test (AATT) device [15]. The test was conducted with the presence of an evaluator, who registered the test participant and adjusted the protocol in the software for the test initiation. The test participant stood upright, in front of the AATT, with height adjusted at the waist level, waiting for the sound/light signal from the device to start the test. The AATT performed the entire measurement procedure. The device has all the dimensions proposed by the original *Eurofit* test [1], consisting of two metal disks fixed horizontally and separated by a distance of 80 centimeters within a rectangle. The tested participant's non-dominant hand remained motionless over the rectangle, and the dominant hand in the circle on the opposite side. At the audible/luminous signal, without moving the hand of the rectangle, the test participant performed 25 cycles touching with the dominant hand in the other circle and returning to the original with the highest possible speed. The device's software counts the total time and the 50 touches provided by *Eurofit* [1], besides automatically tabulating the data collected in a spreadsheet in Microsoft Office Excel®. For analysis, it was considered the best test performance after two tests separated by an interval of thirty minutes. All subjects were acquainted with the test and the device before the evaluation itself.

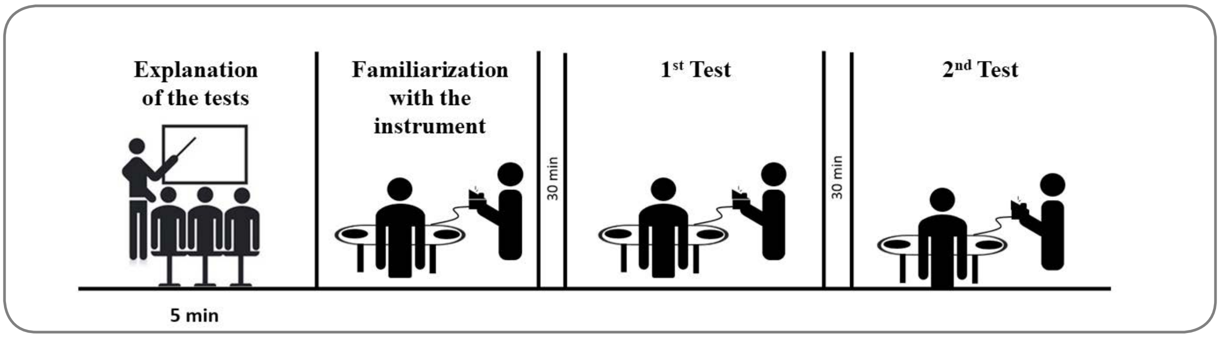

Figure 2 - Study design.

Statistical analysis

The normality of the data was tested using the Kolmogorov Smirnov test, asymmetry, and kurtosis. As the assumption was denied, a logarithmic transformation of the data was performed. Thus, continuous data are reported as mean and standard deviation. One-way ANOVA was used to compare anthropometric and performance variables according to maturation stages. A Mixed Repeated Measures ANOVA was used to verify the effect of the interaction [3 (conditions) x 3 (times)] on the upper limb velocity test phases in different maturation stages. The Mauchly test was adopted to verify the sphericity of the data, and when it was violated, the Huynh-Feldt epsilon correction factor was utilized. To determine the size of the variance effect, Eta to the partial square (η^2p) was used. Bonferroni's post hoc test was applied to find the differences. For all analyzes, the level of significance adopted was $\alpha = 0.05$. The data were analyzed using the Statistical Package for the Social Sciences - SPSS 20.0®.

Results

Table I shows the descriptive analysis of the sample stratified according to maturation stages. No statistically significant difference was found between the groups.

Table I - Sample characteristics stratified by maturation stages.

Variables		N	Mean ± DP	Min - Max	P-value
Age (years)	Delayed	7	11.93 ± 2.11	8.60 – 14.20	0.543
	Regular	31	11.64 ± 1.88	8.40 – 14.90	
	Accelerated	53	12.10 ± 1.78	7.80 – 14.90	
Mass (kg)	Delayed	7	48.46 ± 10.42	35.10 – 68.20	
	Regular	31	47.17 ± 13.19	22.50 – 79.90	0.875
	Accelerated	53	48.88 ± 15.81	22.60 – 85.70	
Stature (m)	Delayed	7	1.49 ± 0.10	1.31 – 1.61	0.310
	Regular	31	1.50 ± 0.12	1.24 – 1.72	
	Accelerated	53	1.54 ± 0.14	1.31 – 1.87	

Table II reports the performance in the 3 stages and the total performance in the upper limb velocity test stratified by sex. There was no effect of interaction between time and maturation [$F_{(3,822;\ 168,180)} = 1,086$; $p = 0.364$; $\eta2 = 0.024$; power = 0.329], but there was an effect of time [$F_{(1,911;\ 168,180)} = 15.129$; $p < 0.0001$; $\eta2 = 0.147$; power = 0.999] and maturation [$F_{(2;\ 88)} = 9,794$; $p < 0.0001$; $\eta2 = 0.182$; power = 0.980]. There was a reduction in the performance of the optimized phase for the fatigue phase in all groups ($p < 0.005$). The accelerated stage showed the best performance in all phases of the upper limb velocity test, while for the total performance the delayed group had the lowest performance.

Table II - Condition and time effect of the maturation stages variables.

	Delayed	Regular	Accelerated	P-value
Adapted	2.49 ± 0.005*	2.41 ± 0.056#	2.37 ± 0.081b	0.364
Optimized	2.47 ± 0.065a*	2.41 ± 0.068a#	2.37 ± 0.075a	
Fatigue	2.52 ± 0.098*	2.44 ± 0.079#	2.39 ± 0.087	
ULV	15.76 ± 2.69*†	12.98 ± 1.71	12.11 ± 1.99	**0.0001**

a = statistical difference between the optimized phase and the fatigue phase; b = statistical difference between the adapted phase and the fatigue phase; * = statistical difference between the delayed and accelerated groups ($p < 0.005$); # = statistical difference between the regular group and the accelerated group ($p < 0.005$); † = difference compared to the regular group ($p < 0.05$); ULV = upper limb velocity.

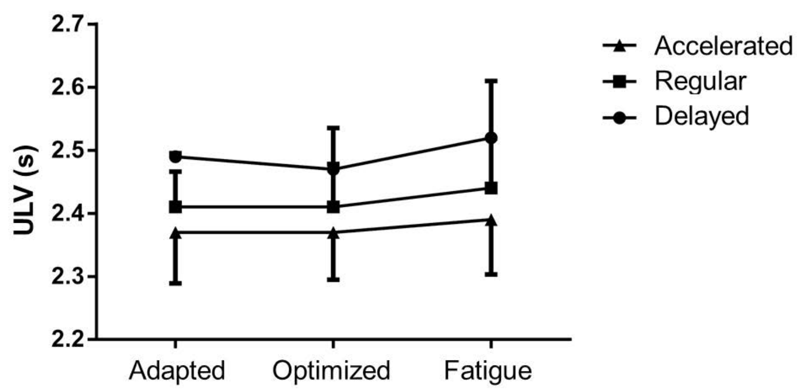

Figure 3 - Performance behavior in the upper limb velocity test.

Discussion

The initial objective of the present study was to analyze the performance of the upper limb velocity test at different stages of maturation. A similar performance curve was verified throughout the test, but with higher performance for subjects in an accelerated stage of maturation compared to their peers in regular and delayed stages.

During the process of selection and promotion of talents, evaluations are essential for the stratification of participants who will proceed to the next stage of training [5]. The maturation process expresses a potential ability to influence the physical components of young people [5,6,16]. However, until now, the results showed that maturation interfered mainly in the capacity to produce strength and power of upper limbs and speed of lower limbs [8]. Previous results reported that there was no association between bone age and upper limb velocity, although the maturation stage showed a moderate relation [6,17]. But the study related bone age to the total performance in the upper limb velocity test. In addition, the authors identified a moderate association ($r = 0.464$; $r^2 = 0.21$) between the maturation stages. However, the test can be stratified into three distinct phases of performance (adaptation to movement, phase of better performance, and process of loss of performance [18]).

Our data indicate that since the adaptation phase, the accelerated stage can print a movement speed similar to the optimized phase and superior to the regular and delayed stages. This fact corroborates the finding that motor control is widely varied during motor development [19]. It is possible that this variability, as well as motor competence and training time, may influence the test results.

These findings potentially imply the process of detecting and selecting sports talents. Coaches must take into account the maturation of young athletes to avoid bias [5,20] since within a selection process, those who are born in the second semester or are "less matured" end up being marginalized or excluded for not having the chance playing on equal terms [21]. In addition to the results, the study has the limitation of not having controlled the motor behavior or the previous experience of each individual, since the age of training can also influence the results.

Conclusion

The data indicate that individuals who are in an accelerated maturation stage perform better in the upper limb velocity test than their peers in normal and delayed stages, although the test development curve is similar for all stages.

Academic link
This article is part of the master dissertation of Leandro Medeiros da Silva, supervised by Professor Doctor Breno Guilherme de Araújo Tinôco Cabral by the Postgraduate Program in Physical Education -PPGEF of the Federal University of Rio Grande do Norte - UFRN, Natal- RN, Brazil.

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Potential conflict of interest
No conflicts of interest with potential for this article have been reported.

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Authors' contributions
Conception and design of the research: Silva LM, Dantas MP, Costa RF, Teixeira RV, Cabral BGAT. **Data collection:** Silva LM, Dantas MP, Teixeira RV. **Analysis and interpretation of data:** Silva LM, Dantas MP, Costa RF, Teixeira RV. **Statistical analysis:** Dantas MP, Teixeira RV. **Obtaining financing:** Not applicable. **Writing of the manuscript:** Silva LM, Dantas MP, Teixeira RV, Dantas PMS, Neto PA, Cabral BGAT. **Critical revision of the manuscript for important intellectual content:** Silva LM, Dantas MP, Costa RF, Teixeira RV, Dantas PMS, Neto PA, Cabral BGAT.

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