MOTOR TALENT AND BIOLOGICAL MATURATION IN MILITARY COLLEGE STUDENTS

TALENTO MOTOR E MATURAÇÃO BIOLÓGICA EM ESCOLARES DE UM COLÉGIO MILITAR

TALENTO MOTOR Y MADURACIÓN BIOLÓGICA EN ESCOLARES DE UN COLEGIO MILITAR

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ABSTRACT

Introduction: The assessment of motor performance in students has been used to identify sports talents. However, there are few studies on this topic, and none in the Sistema Colégio Militar do Brasil (Brazilian Military College System). Objective: To evaluate anthropometric, physical motor and maturational indicators, investigate the proportion of motor talents, analyze the relationship between motor talent diagnosis and maturational stage, and compare the profile of student-athletes and non-athlete students of a military college. Methods: We assessed 1490 students of both sexes aged 11 to 17 years. A multidimensional battery of tests was applied to assess body size and composition, flexibility, handgrip strength, upper and lower limb explosive strength, velocity, aerobic endurance, and somatic maturation. Data were analyzed using the Chi-square test and analysis of covariance. Results: Students showed greater body size, higher motor performance and slightly advanced biological maturation in comparison to data available in the literature. In addition, cut-off points were created for eight sports-related tests to identify students with significantly above-average results, with 11% of motor talents being found. It was also found that motor talents were more frequent in biologically advanced students, and that student-athletes had significant differences in comparison to non-athletes, mainly in terms of motor performance. Conclusion: The military school students are larger, stronger, more resistant and more biologically mature when compared to the reference values in the literature, and these characteristics are accentuated in student-athletes. In addition, approximately 1 in 10 of the military college students can be considered a motor talent, and this diagnosis is more frequent in students with early maturation. ***Level of Evidence II; Diagnostic Study.***

Keywords: Students; Aptitude; Athletic performance.

RESUMO

Introdução: A avaliação do desempenho motor em escolares tem sido utilizada na identificação de talentos esportivos. Porém, existem poucos estudos, sobre esta temática, e nenhum no Sistema Colégio Militar do Brasil. Objetivo: Avaliar indicadores antropométricos, fisicomotores e maturacionais; investigar a proporção de talentos motores; analisar a relação entre o diagnóstico de talento motor e o estágio maturacional; e comparar o perfil de alunos-atletas e não atletas de um colégio militar. Métodos: Foram avaliados 1.490 escolares de ambos os sexos, de 11 a 17 anos. Aplicou-se uma bateria de testes multidimensional para avaliação do tamanho e da composição corporal, flexibilidade, força de preensão manual, força explosiva de membros superiores e inferiores, velocidade, resistência aeróbica e maturação somática. Os dados foram analisados por meio do teste qui-quadrado e análise de covariância. Resultados: Os escolares apresentaram maior tamanho corporal, maior desempenho motor e maturação biológica discretamente avançada em relação aos dados disponíveis na literatura. Além disso, foram criados pontos de corte para oito testes relacionados com a prática esportiva, para identificar escolares com resultados muito acima da média, sendo encontrados 11% de talentos motores. Constatou-se ainda que os talentos motores foram mais frequentes nos escolares avançados biologicamente, e que os alunos-atletas apresentaram diferenças significativas em relação aos não atletas, principalmente quanto ao desempenho motor. Conclusão: Os escolares do colégio militar são maiores, mais fortes, mais resistentes e mais maduros biologicamente quando comparados aos valores de referência da literatura, e tais características acentuam-se nos alunos-atletas. Além disso, aproximadamente um em cada dez escolares do colégio militar pode ser considerado um talento motor, e este diagnóstico é mais frequente nos escolares com maturação precoce. ***Nível de evidência II; Estudo diagnóstico.***

Descritores: *Estudantes; Aptidão; Desempenho atlético.*

RESUMEN

Introducción: La evaluación de desempeño motor en escolares ha sido utilizada en la identificación de talentos deportivos. Sin embargo, existen pocos estudios sobre esa temática, y ninguno en el Sistema del Colegio Militar de Brasil. Objetivo: Evaluar indicadores antropométricos, físico-motores y maduracionales, investigar la proporción de talentos motores, analizar la relación entre el diagnóstico de talento motor y la fase de maduración y comparar el perfil de alumnos-atletas y no atletas de un colegio militar. Métodos: Fueron evaluados 1490 estudiantes de ambos sexos, de 11 a 17 años. Se les aplicó una serie de tests multidimensional para evaluación del tamaño y composición corporal, flexibilidad, fuerza de aprehensión manual, fuerza explosiva de miembros superiores e inferiores, velocidad, resistencia aeróbica y maduración somática. Los datos fueron analizados a través del test chi-cuadrado y Análisis de

Covarianza. Resultados: Los estudiantes presentaron mayor tamaño corporal, mayor desempeño motor y maduración biológica discretamente avanzada con relación a los datos disponibles en la literatura. Además, fueron creados puntos de corte para ocho tests relacionados con la práctica deportiva, para identificar estudiantes con resultados muy superiores al promedio, siendo encontrados 11% de talentos motores. Se constató además que los talentos motores fueron más frecuentes en los estudiantes avanzados biológicamente y que los alumnos atletas presentaron diferencias significativas con relación a los no atletas, principalmente en referencia al desempeño motor. Conclusión: Los estudiantes del colegio militar son más grandes, más fuertes, más resistentes y más maduros biológicamente cuando comparados a los valores de referencia de la literatura, y tales características se acentúan en los alumnos atletas. Además, aproximadamente uno en cada 10 estudiantes del colegio militar puede ser considerado un talento motor, y este diagnóstico es más frecuente en los escolares con maduración precoz. ***Nivel de evidencia II; Estudio diagnóstico*** .

Descriptores: *Estudiantes; Aptitud; Rendimiento atlético.*

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INTRODUCTION

Identifying and developing young individuals with potential for high performance sport is a major challenge.[1-3] Several countries developed systematic structures to identify talented athletes as early as possible and to develop their skill in a specific sport.[4,5] The identification and development of sporting talent is crucial for international sporting success,[6] and this process must be integrated in the school system.[7]

In schools, students with high motor performance or talents must be identified and properly nurtured in physical education classes.[8] For this, several tests are used as a scientific method to evaluate the motor performance of students[9-12] and young athletes.[13-15] In general, tests are used to evaluate sporting potential, guide young individuals to modalities that best suit their profile, monitor the effects of training, and predict future success, provided that they are integrated in a systematic and longitudinal process of development.[2,16]

Young athletes are a select group and are generally taller, heavier, stronger, faster, more resistant, and more mature than non-athletes.[15,17,18] Individuals with motor talents are those with atypically higher performance, usually equal to or higher than the 98th percentile, in one or more tests of speed, strength, agility, and endurance.[8,19] Using the criteria adopted by the Brazil Sports Project (PROESP-BR), Brandão et al.,[20] Mello et al.,[10] and Mello et al.[11] stated that 0.5%–4.3% of Brazilian students have motor talents.

However, such studies did not investigate the data related to biological maturation, which is an important variable in the selection of young athletes.[18,21] To date, physical fitness related to motor performance has not been described and the proportion of Brazilian military college students with motor talents remains unknown. In this context, this study aimed to evaluate the anthropometric, psychomotor, and maturational indicators; investigate the proportion of motor talents; analyze the relationship between motor talent and maturational stage; and compare the profiles of student athletes and non-athletes from the military college of Juiz de Fora (CMJF), Minas Gerais, Brazil.

MATERIALS AND METHODS

This study is an integral part of the "Projeto Atletas de Ouro: Avaliação Multidimensional e Longitudinal do Potencial Esportivo de Jovens Atletas" (Golden Athletes Project: Multidimensional and Longitudinal Evaluation of the Sport Potential of Young Athletes),[22] which was approved by the Research Ethics Committee of the Federal University of Ouro Preto (CAAE: 32959814.4.1001.5150).

The target population consisted of Brazilian military college students. For convenience, the study was conducted at the CMJF, which serves approximately 900 students from middle school (6th–9th grade) and high school. The parents of most of these students are in the armed forces military. There are also students with non-military parents who are admitted through a public contest. All students enrolled between 2015 and 2017 at the CMJF (n=2,690) were invited to participate in the study. The sample consisted of 1,490 students (830 boys and 660 girls), aged 11–17 years, evaluated from August 2015 to June 2017, and divided into two groups: 1) young athletes (n=307), those who practice sports at least three times a week as part of their extracurricular activities and participate in regular competitions, and 2) non-athletes (n=1,183), those who only participate in physical education classes at school. The inclusion criteria were as follows: students who enrolled in CMJF, who regularly attend classes at CMJF, and who were present on the data collection day. Students who did not submit the informed consent form (ICF) or refused to participate and those who had any physical or clinical condition that interfered with the tests were excluded from this study. The consent of the legal guardians and the consent of the students were provided before participation in the study.

The tests were performed during the physical education classes, which lasted approximately 90 minutes, on three different days. The data were collected from Monday to Friday between 9:00 and 12:30. The evaluation was performed by trained professionals, and there were specific evaluators for each test.

On the first day, a lecture was held in the CMJF auditorium to explain the nature and objective of the tests and to obtain the sociodemographic information and sports experience of students, under the supervision of physical education teachers. On the second day, anthropometric measurements were collected and psychomotor tests were performed in the gym using circuit training routines. On the third day, a 20-meter shuttle run test was performed to assess cardiorespiratory resistance. In this test, each evaluator was responsible for monitoring the distance, physical condition, and motivation of three students. The reliability of the tests was assessed by test-retest performed on 20 randomly selected students. Intraclass correlation coefficient values >0.85 were obtained.

The students were classified according to motor talent (yes or no) based on their height measurement and scores on arm span, handgrip strength, medicine ball throwing, countermovement vertical jump, 20-meter running speed, and endurance running. The cut-off point at the 98th percentile was adopted according to age and gender.

Body mass (digital anthropometric scale accurate to 0.05 kg; Welmy, São Paulo, Brazil), height (wall-mounted tape measure accurate to 0.20 cm; Sany, São Paulo, Brazil), arm span, sitting height (portable stadiometer attached to a bench; Sany, São Paulo, Brazil), and three skinfolds (triceps, subscapular, and thigh – scientific adipometer; Sany, São Paulo, Brazil) were measured according to the procedures indicated in Norton and Olds's study.[23] Lower limb length was estimated from the difference between height and sitting height. The body mass index was calculated using the following equation: body mass (kg)/square of body height (m^2). The percentage of body fat was estimated using the equation indicated

in Slaughter et al.'s study.[24] These measurements were obtained while the students were barefoot and wearing physical education clothing.

Flexibility was assessed by performing the sit-and-reach test using a Wells' bench (Sany, (Sany, São Paulo, Brazil) with a 23-cm box at the level of the feet according to the procedure of Gaya and Gaya.[19] The lower limb explosive power was assessed by performing a countermovement vertical jump test (CMJ) using a contact mat (Multi-Sprint Full®, Hidrofit, Belo Horizonte, Brazil) following the procedures of Rodrigues and Marins.[25] The upper limbs explosive power was assessed by performing a medicine ball throw test using a 2-kg ball according to the procedures of Gaya and Gaya.[19] The maximal isometric handgrip strength was evaluated by performing a handgrip strength test using a manual dynamometer (Jamar®, São Paulo, Brazil) following the procedures of Fernandes and Marins.[26] The speed was evaluated by performing a 20-meter run test considering the maximum sprinting speed measured with a photoelectric cell system ((Multi-Sprint Full®, Hidrofit, Belo Horizonte, Brazil) following the procedures of Gaya and Gaya.[19] Aerobic endurance was assessed by performing a 20-meter shuttle run test.[27] The pace of the race is set by a beep and has an initial speed of 8.5 km/h, and 0.5 km/h is added at 1-minute intervals. The relative VO_{2max} (mL/kg/min) was estimated using the following equation: 31.025 + 3.238×S – 3.248×A + 0.1536×S×A, where S is speed in km/h of the last stage reached and A is age in years.

The biological maturation was evaluated based on the percentage of the predicted adult height (%PAH) and the predicted age of the peak height velocity (PHV). The %PAH was estimated using the Khamis and Roche method,[28] which uses the chronological age, height, and body mass of the individual evaluated and the height of the biological parents. Using the reference data, maturational stage classifications (delayed, normal, or advanced) were obtained by age and gender. The predicted age of PHV was estimated using the method proposed by Mirwald et al.[29] based on the maturity offset (MO), which represents the time in years before and after PHV.

Statistical analysis

The data were described as mean±standard deviation. The cut-off points for motor talent were defined by the 98th percentile. Differences between young athletes and non-athletes were tested using analysis of covariance, controlling the effect of chronological age. The chi-square test was used to test the association between qualitative variables. When comparing means, the magnitude of the effect was evaluated by Cohen's *d* and Cramer's *V*, and the classification proposed by Cohen was adopted.[30] The test-retest reliability was assessed using the intraclass correlation coefficient. All analyses were performed using the IBM SPSS version 24.0 software (IBM Corp., Armonk, NY). The value of $p \leq 0.05$ was adopted for statistical significance.

RESULTS

Table 1 shows the descriptive values by age and gender in each of the tests and measurements performed. The mean age was 14.5±1.8 and 14.0±1.7 years for boys and girls, respectively ($p<0.001$; $d=0.28$). The results showed that body size and motor performance increased with age, especially in boys who showed higher results than girls.

Table 2 shows the absolute values corresponding to the 98th percentile, which were used as criteria for the motor talent classification of students (yes or no). The proportion of motor talents found in the sample was 10.8% (n=161), taking into account the finding of motor talent (yes) in at least one of the tests/measurements performed. There were no significant differences in the proportion of motor talents between boys (10.2%; n=85) and girls (11.5%; n=76) ($X^2=0.619$; $p=0.43$; $V=0.02$). Based on the values shown in Table 2, the students were classified according to motor talent (yes or no) and the percentage of motor talent (yes) was determined for each test and measurement performed (Figure 1).

Table 1. Mean±standard deviation of anthropometric, psychomotor, and maturational indicators in students of the military college of Juiz de Fora by age and gender (n=1,490).

Indicators	11 years		12 years		13 years		14 years		15 years		16 years		17 years	
	M (n=85)	F (n=90)	M (n=129)	F (n=127)	M (n=125)	F (n=120)	M (n=153)	F (n=121)	M (n=142)	F (n=106)	M (n=113)	F (n=66)	M (n=83)	F (n=30)
Body mass (kg)	44.1±9.2	45.3±11.5	48.9±8.9	49.8±11.3	56.3±13.5	52.8±10.7	59.9±12.5	54.7±11.2	64.9±13.0	56.1±9.8	68.6±15.3	57.2±9.8	69.5±11.3	56.5±14.9
Height (cm)	149.5±7.3	150.2±7.2	155.9±7.5	155.0±5.9	163.6±8.1	158.9±5.8	169.5±7.5	161.2±5.1	172.4±6.9	161.7±5.3	174.5±8.0	163.0±6.4	176.6±8.1	162.0±8.7
Sitting height (cm)	77.1±3.9	78.8±3.7	79.8±4.0	81.4±3.5	84.4±4.7	83.9±3.0	87.5±4.2	84.6±3.9	89.6±4.3	85.5±3.1	91.5±3.5	86.8±3.1	92.0±4.1	86.5±3.9
Lower limb length (cm)	72.3±4.6	71.8±4.3	75.9±4.3	73.6±3.8	79.2±4.7	75.0±4.6	82.0±4.9	76.4±4.9	82.8±4.8	76.1±4.5	83.0±6.0	76.2±4.6	84.6±5.2	75.5±6.4
Arm span (cm)	153.1±8.1	153.0±9.4	159.3±9.3	158.1±7.7	168.1±9.7	161.1±6.9	173.2±9.1	163.9±6.4	176.4±7.9	164.2±7.0	179.0±9.2	164.3±7.8	180.7±9.0	162.7±10.1
BMI (kg/m^2)	19.6±3.3	19.9±3.8	20.1±3.1	20.6±3.9	20.9±4.3	20.8±3.6	20.8±3.6	21.0±3.6	21.8±3.6	21.4±3.3	22.4±4.1	21.5±3.2	22.2±3.2	21.4±4.4
Sum SF (mm)	35.8±15.9	39.8±15.4	35.7±13.6	42.5±15.6	33.8±18.1	42.3±15.0	30.0±13.0	43.1±15.4	30.4±12.1	42.3±11.6	30.3±13.8	44.1±12.0	28.6±10.9	40.3±12.4
Body fat percentage (%)	20.2±8.0	22.1±6.0	20.0±6.8	23.0±5.9	18.3±8.9	22.9±6.1	16.0±6.3	23.2±6.2	15.8±6.0	22.9±4.4	15.4±6.5	23.8±4.6	14.4±5.3	21.6±4.7
Flexibility (cm)	21.0±5.5	25.1±8.6	23.2±7.1	26.5±7.7	22.8±9.1	28.8±8.3	23.8±8.5	30.0±8.9	25.8±8.5	30.0±8.3	25.4±9.7	28.1±7.8	26.5±9.5	30.4±6.80
Handgrip strength (kgf)	22.4±5.3	21.8±4.1	25.7±6.0	25.0±4.5	31.1±6.4	26.3±3.9	36.5±7.4	27.7±4.8	39.6±7.3	28.7±5.0	42.8±8.5	27.8±4.6	43.4±8.4	27.1±5.0
Medicine ball throw (m)	3.20±0.58	2.82±0.44	3.57±0.68	3.12±0.43	4.14±0.68	3.36±0.40	4.66±0.88	3.41±0.53	5.13±0.91	3.48±0.51	5.46±1.00	3.59±0.63	5.64±1.14	3.57±0.70
CVJ (cm)	23.0±4.6	20.5±4.8	24.1±5.2	21.7±4.8	25.8±5.4	22.0±4.6	29.2±6.1	22.1±4.6	31.8±6.5	22.9±4.7	32.2±7.2	22.1±3.9	34.1±6.2	25.0±4.0
Speed 20 m (s)	3.84±0.26	4.06±0.39	3.82±0.31	3.97±0.35	3.63±0.32	3.90±0.30	3.47±0.29	3.92±0.34	3.38±0.26	3.91±0.31	3.34±0.27	3.90±0.30	3.26±0.21	3.74±0.27
Speed shuttle 20 m (m)	862±302	601±227	918±335	693±246	1002±356	732±258	1204 ±414	752±265	1299±451	744±270	1375±501	785±294	1483±422	788±287
VO_{2pico} (ml/kg/min)	47.5±4.0	44.0±3.3	46.9±4.4	43.7±3.6	46.5±4.9	42.7±3.9	47.5±5.4	41.4±4.1	47.4±6.2	39.8±4.1	47.0±6.8	38.9±4.5	47.2±5.8	37.1±4.6
Predicted adult height (cm)	178.6±6.2	164.8±4.2	179.4±6.2	164.6±4.8	180.2±6.4	164.2±4.5	179.4±5.4	163.7±4.1	177.3±5.9	163.3±5.3	177.0±6.5	164.0±6.6	176.2±8.1	162.8±8.5
%PAH	83.6±2.4	90.8±3.2	86.8±2.5	94.3±2.7	90.8±2.5	96.7±1.9	94.6±2.1	98.2±1.0	97.3±1.5	99.0±0.5	98.9±1.1	99.4±0.2	99.9±0.6	99.5±0.3
MO (years)	-1.99±0.52	-0.25±0.54	-1.26±0.55	0.53±0.47	-0.19±0.70	1.29±0.44	0.71±0.66	1.97±0.40	1.52±0.68	2.53±0.36	2.33±0.62	3.14±0.42	2.90±0.70	3.61±0.55
Age PHV (years)	13.6±0.5	11.8±0.5	13.7±0.5	12.0±0.4	13.7±0.6	12.2±0.4	13.8±0.6	12.6±0.4	14.0±0.7	12.9±0.4	14.2±0.6	13.3±0.4	14.5±0.6	13.8±0.5

M: male; F: female; BMI: body mass index; SF: skinfolds – triceps, subscapular, and thigh; CVJ: countermovement vertical jump; %PAH: percentage of predicted adult height; MO: maturity offset; PHV: peak height velocity.

Figure 2 shows a statistically significant correlation between the maturational stage and motor talent classification both for boys (X^2=26.504; p<0.001; *V*=0.19) and girls (X^2=11.578; p=0.003; *V*=0.14). For boys, the proportion of motor talents was higher among biologically advanced students than among delayed and normal students. For girls, the proportion of motor talents was higher among biologically advanced students than among delayed students. For boys, motor talents showed higher %PAH than non-motor talents (95.1±2.0 *vs.* 93.3±2.0; $F_{1,726}$=51.763;

Table 2. Cut-off points for motor talent classification based on the 98th percentile obtained for students from the military college of Juiz de Fora by age and gender (n=1,490).

Indicators	Male						
	11 years (n=85)	12 years (n=129)	13 years (n=125)	14 years (n=153)	15 years (n=142)	16 years (n=113)	17 years (n=83)
Height (cm)	169	174	180	183	187	189	194
Arm span (cm)	172	182	186	194	192	195	198
Flexibility (cm)	31	38	40	42	42	44	46
Handgrip strength (kgf)	37	38	45	54	55	63	60
Medicine ball throw (m)	4.90	5.25	5.93	6.88	7.82	8.37	8.49
Countermovement vertical jump (cm)	37	36	37	41	48	47	50
Speed 20 m (s)	3.40	3.22	3.09	3.04	2.90	2.97	2.87
Speed shuttle 20 m (m)	1530	1663	1824	2241	2255	2561	2459
Indicadores	**Female**						
	11 years (n=90)	12 years (n=127)	13 years (n=120)	14 years (n=121)	15 years (n=106)	16 years (n=66)	17 years (n=30)
Height (cm)	166	170	172	174	173	177	177
Arm span (cm)	176	181	175	180	179	182	182
Flexibility (cm)	45	41	47	45	44	44	44
Handgrip strength (kgf)	33	37	36	39	39	43	43
Medicine ball throw (m)	3.81	4.07	4.31	4.63	4.52	5.84	5.84
Countermovement vertical jump (cm)	30	32	31	30	34	32	32
Speed 20 m (s)	3.22	3.44	3.32	3.40	3.31	3.33	3.00
Speed shuttle 20 m (m)	1096	1262	1294	1333	1446	1652	1652

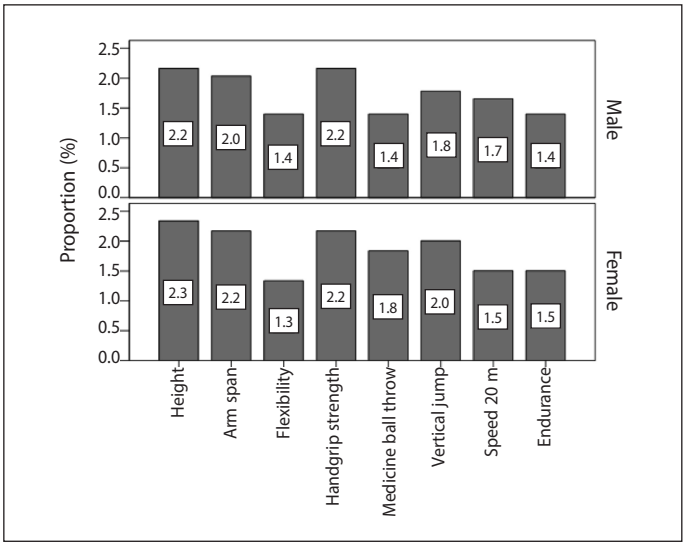

Figure 1. Proportion of motor talent among students of the military college of Juiz de Fora, aged 11–17 years, male and female, based on the 98th percentile of each test.

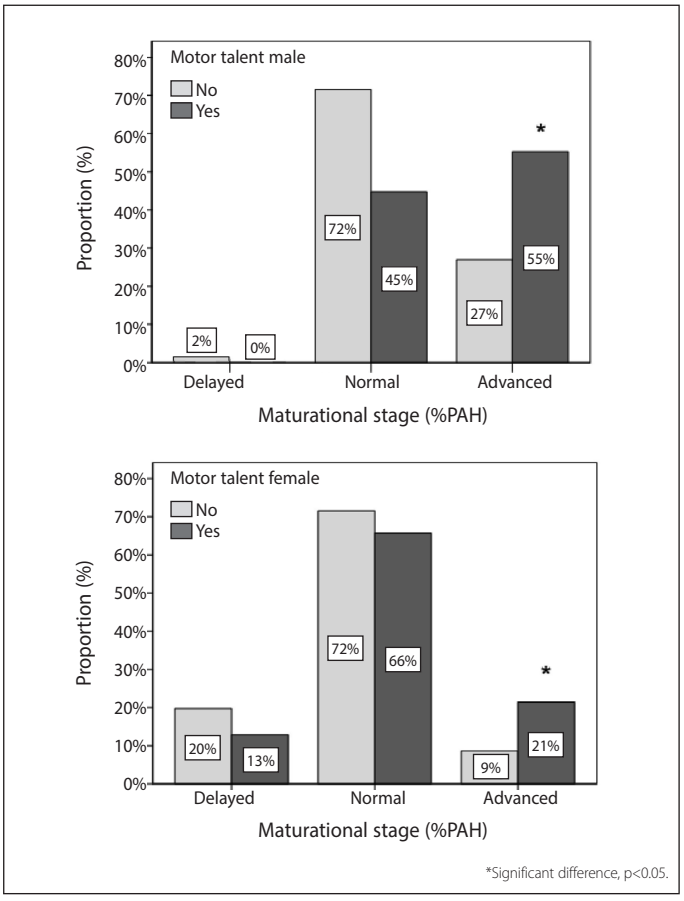

Figure 2. Classification of the students of the military college of Juiz de Fora according to motor talent and maturational stage criteria, which were assessed by the percentage of predicted adult height (%PAH).

p<0.001; *d*=0.90). This difference was of high magnitude. A similar result was observed for girls (97.3±2.1 *vs.* 96.4±2.1; $F_{1,573}$=11.062; p=0.001; *d*=0.43), but the magnitude of the effect was low.

The proportion of motor talents was higher among young athletes (18.6%; n=57) than among non-athletes (8.8%; n=104) (X^2=24.168; p<0.001; *V*=0.13). Student athletes were chronologically older than non-athletes (15.0±1.7 *vs.* 14.3±1.8 years, p<0.001). Controlling the effect of chronological age, student athletes showed greater arm span, had lower body fat percentage, and were more flexible, stronger, faster, and more resistant than non-athletes; the magnitude of the observed differences was low (Table 3). By contrast, there was no difference in chronological age between athletes and non-athletes for girls (14.3±1.6 *vs.* 14.0±1.7 years, p=0.12). Young athletes showed higher values for height, sitting height, and arm span, and were stronger, faster, and more resistant than non-athletes; the magnitude of these differences was small to moderate (Table 4). In addition, these athletes showed greater maturity offset and lower predicted age at PHV.

DISCUSSION

This study aimed to evaluate the anthropometric, psychomotor, and maturational indicators; investigate the proportion of motor talents; analyze the relationship between motor talent and maturational stage; and compare the profile of student athletes and non-athletes of the CMJF, Minas Gerais, Brazil. The study showed that the students of CMJF had larger body sizes, higher motor performances, and slightly advanced biological maturation those reported in the literature. In addition, cut-off points were created for eight sport-related tests to identify students with scores well above average, and 11% of motor talents were found. Moreover, motor talents were more frequently identified in the group of

Table 3. Comparison of anthropometric, psychomotor, and maturational indicators in male student athletes and non-athletes of the military college of Juiz de Fora.

Indicators	Athletes (n = 209)	Non-athletes (n = 621)	p-value	*d*
Body mass (kg)	60.4 ± 12.6	59.0 ± 12.6	0.16	0.11
Height (cm)	167.4 ± 7.9	166.3 ± 7.9	0.08	0.13
Sitting height (cm)	86.6 ± 4.3	86.2 ± 4.3	0.30	0.09
Lower limb length (cm)	80.9 ± 5.1	80.1 ± 5.1	0.06	0.15
Arm span (cm)	172.0 ± 9.2	170.0 ± 9.3	0.01*	0.21
BMI (kg/m2)	21.2 ± 3.8	21.1 ± 3.8	0.67	0.02
Sum SF (mm)	30.2 ± 14.3	32.6 ± 14.3	0.04*	0.16
Body fat percentage (%)	16.1 ± 7.1	17.4 ± 7.1	0.02*	0.18
Flexibility (cm)	25.9 ± 10.5	23.6 ± 9.8	0.01*	0.23
Handgrip strength (kgf)	36.4 ± 7.2	34.4 ± 7.2	0.001*	0.28
Medicine ball throw (m)	4.86 ± 0.86	4.49 ± 0.86	<0.001*	0.43
Countermovement vertical jump (cm)	30.5 ± 6.0	28.1 ± 6.1	<0.001*	0.39
Speed 20 m (s)	3.45 ± 0.29	3.56 ± 0.29	<0.001*	0.37
Distance (m)	1298.1 ± 402.3	1105.1 ± 416.1	<0.001*	0.46
$VO_{2máx}$ (ml/kg/min)	49.0 ± 5.5	46.5 ± 5.6	<0.001*	0.44
Predicted adult height (m)	179.1 ± 6.7	178.1 ± 6.9	0.07	0.14
%PAH (%)	93.6 ± 2.2	93.5 ± 2.2	0.44	0.04
Maturity offset (years)	0.66 ± 0.62	0.61 ± 0.62	0.27	0.08
Predicted age at PHV (years)	13.9 ± 0.6	13.9 ± 0.6	0.27	0.00

*Significant difference, p<0.05; chronological age as covariate = 14.5 years; BMI: body mass index; SF: triceps, subscapular, and thigh skinfolds; %PAH: percentage of predicted adult height; PHV: peak height velocity; *d*: magnitude of the effect.

Table 4. Comparison of anthropometric, psychomotor, and maturational indicators in female student athletes and non-athletes of the military college of Juiz de Fora.

Indicators	Athletes (n = 98)	Non-athletes (n = 562)	p-value	d
Body mass (kg)	53,8 ± 11,3	52,6± 11,3	0,30	0,10
Height (cm)	159,8 ± 6,4	158,2± 6,4	0,03*	0,25
Sitting height (cm)	84,5 ± 3,6	83,4± 3,6	0,01*	0,30
Lower limb length (cm)	75,3 ± 4,8	74,9± 4,8	0,41	0,08
Arm span (cm)	162,4 ± 8,1	160,7± 8,0	0,05*	0,21
BMI (kg/m2)	21,0 ± 3,7	20,9± 3,7	0,76	0,02
Sum SF (mm)	41,3 ± 14,8	42,4± 14,7	0,49	0,07
Body fat percentage (%)	22,5 ± 5,8	23,0± 5,8	0,40	0,08
Flexibility (cm)	29,2 ± 9,9	28,2± 10,0	0,34	0,1
Handgrip strength (kgf)	27,1 ± 4,2	26,1± 4,2	0,05*	0,24
Medicine ball throw (m)	3,55 ± 0,51	3,27± 0,51	<0,001*	0,54
Countermovement vertical jump (cm)	24,1 ± 4,7	21,7± 4,7	<0,001*	0,51
Speed 20 m (s)	3,78 ± 0,34	3,96± 0,34	<0,001*	0,52
Distance (m)	860,6 ± 272,3	692,0± 275,8	<0,001*	0,61
$VO_{2máx}$ (ml/kg/min)	43,9 ± 4,1	41,5± 4,1	<0,001*	0,58
Predicted adult height (m)	164,8 ± 5,3	163,9± 5,5	0,14	0,16
%PAH (%)	96,8 ± 2,2	96,5± 2,3	0,26	0,13
Maturity Offset (years)	1,67 ± 0,43	1,56± 0,43	0,02*	0,25
Predicted age at PHV (years)	12,4 ± 0,4	12,5± 0,4	0,02*	0,25

*Significant difference, p<0.05; chronological age as covariate = 14.0 years; BMI: body mass index; SF: triceps, subscapular, and thigh skinfolds; %PAH: percentage of predicted adult height; PHV: peak height velocity; *d*: magnitude of the effect.

biologically advanced students and student athletes showed significant differences compared with non-athletes, especially in motor performance.

To the best of our knowledge, this is the first study to establish the reference values for physical growth, biological maturation, and motor performance of students of a Brazilian military college. There was high prevalence of unsatisfactory physical fitness among Brazilian students, especially in terms of motor performance.[9-11] However, our results showed that both female and male CMJF students are taller and heavier in all age groups, compared with the reference data of the Brazilian population[31], in addition to higher BMI values.[12,31] The students had excellent mean body fat percentage values,[32] That is, the body fat percentage of male students decreased from 20% at the age of 13 years to 16% at the age of 14 years, while that of female students was 23%, with no significant differences with age.

Female CMJF students were slightly more flexible than Brazilian students[12], whereas male CMJF students aged 11 years had low flexibility values. The handgrip muscle strength of CMJF students was higher for ages above 14 years.[9] The medicine ball throw test showed that CMJF students are, on average, stronger than Brazilian students and would be classified as very good (above average) according to the PROESP-BR criteria.[19] Based on the results of the 20-meter speed test, CMJF students would be classified as reasonable or good by the PROESP-BR. However, this comparison should be interpreted cautiously, since this test was performed in our study using an electric photocell system and was performed in the PROESP-BR using a mechanical timer, which can have measurement errors associated with the reaction time of the evaluator. For example, 12-year-old CMJF boys obtained a mean time of 3.82 s in the 20-meter run test, which is similar to the mean times obtained for young athletes practicing team sports.[14] This finding suggests that CMJF students are as fast as or faster than the Brazilian student population.

With regard to aerobic endurance, the results of CMJF students corroborate the mean performance obtained for the 20-meter shuttle run test in 109 studies from 37 different countries.[33] The estimated mean VO_{2peak} was 47 mL/kg/min for boys and 42 mL/kg/min for girls. The mean speed reached in the last stage of the Legér test was 11 km/h for boys aged 11–13 years and 12 km/h for boys aged 14–17 years. For girls, it was 10 km/h for ages 11–12 years and 10.5 km/h for ages 13–17 years.

With regard to maturation, the values for the predicted age of PHV for CMJF students are similar to the values found in the literature, which is, on average, at 12 years for girls and at 14 years for boys.[17,18] With regard to the %PAH, the values obtained in this study were slightly higher for all ages than the reference values,[28] which shows that CMJF students are slightly more biologically advanced. On average, the predicted adult height was 178 cm for boys and 164 cm for girls. According to Pearson et al.,[21] adult height prediction is required to identify talents, while the predicted age of PHV is important to establish training routines.[18]

A total of 11% of CMJF students were categorized as having motor talents; that is, 161 students showed results well above average for body size or performance in at least one of the psychomotor tests. The proportion of motor talent in this population in each test ranged from 1.3% to 2.3%, which partially corroborates with the findings of the PROESP-BR in Brazilian students.[10,11,20] Like the PROESP-BR, this study adopted the same criteria used in the Australian Sports Institute's National Talent Search Program, which considers that individuals with atypical performance are those with results above two standard deviations from the group mean. However, it is important to highlight that the cut-off points (absolute values of the tests) to classify motor talents are specific to the sample used as reference. For example, using the PROESP-BR motor talent criteria, 16% of our CMJF sample have motor talent, 6.3% have higher values for height, 4.9% have higher values for arm span, 2.3% have higher values speed, and 7.3% have higher values for medicine ball throw test. This result shows that CMJF students are, on average, larger and stronger than students from the PROESP-BR database. For the other tests, there are no studies available for comparison.

With regard to the relationship between motor talent and maturational stage, this study showed that students classified as having motor talent are usually biologically advanced. This result agrees with the literature as the maturational timing and status are factors that influence motor performance, which have an impact on the identification and selection

of talents.[18,21,34,35] Body size and psychomotor performance are related to biological maturation, especially in adolescence when significant hormone-mediated changes occur in the body structure and function.[17] Changes observed during puberty can range from 20% to 50% in body size and composition and from 20% to 200% in psychomotor performance.[21] Therefore, maturation can account for most of the variability observed in physical test performance results and is an important covariate to be considered when evaluating young athletes.[15] For example, boys aged 13–15 years who are biologically advanced are larger and heavier and perform better in speed, strength, and muscle power tests than age-matched biologically delayed or normal students.[17,18] This is mainly due to the higher testosterone and growth hormone levels observed during this period. In girls, this maturation-dependent trend is related to body size and handgrip strength, but differences in functional abilities are less pronounced.[18]

The results obtained after comparing the profiles of young athletes and non-athletes agree with the results available in the literature.[13,14,17,25,26,36] Young CMJF athletes showed larger body size, higher psychomotor performance, and more advanced biological maturation than non-athletes. There was a higher proportion of motor talents among young athletes considering height, medicine ball throw test, countermovement vertical jump, and 20-meter speed test. There is growing high-quality evidence showing the importance of anthropometric and physiological factors for sports performance.[2,3,15,17] In young athletes, it is assumed that certain profiles are associated with higher performances, and those who meet more requirements for good performance in a given sport are more likely to succeed.[22]

One possible explanation for the results is that CMJF students have, in most cases, military parents. They underwent a selection process for joining the Armed Forces, which preferentially selects taller and stronger individuals, and this thus constitutes a population with specific features compared with the general population. Moreover, these students are biologically more advanced, which can explain their larger body size and higher psychomotor performance. Lastly, the provision of extracurricular sports training at CMJF could also partly explain these results, since training is a factor that significantly affects body composition and performance.[17]

It is noteworthy that the application of several motor test allows teachers/coaches to diagnose the sports potential of their students. The test results provide important information on nutritional status, health indicators, growth, maturation, and motor performance; these factors directly or indirectly influence the organization of classes and have implications for the selection of activities to be provided, the strategies of health promotion, student orientation for sports, selection of athletes for high school teams, and training of student athletes. From the test reference tables, it is possible to identify students with specific talents for certain sports and thus guide them to modalities that are more compatible with their profile, in addition to identifying potential sports talents.

Sports talent is one of the manifestations of fine motor skills and must be discovered to be developed.[8] Therefore, identifying talents that show high motor performances is a responsibility of the physical education teacher. For example, in the United Kingdom, schools adopt the Model of Talent Development in Physical Education created by Bailey and Morley[7], which aims at increasing psychomotor, interpersonal, intrapersonal, cognitive, and creative skills based on deliberate practice for the development of students' potential. According to the researchers, the process of development should be done holistically to maximize the chances of young people remaining engaged in sports. In this study, 104 students with higher performance in at least one of the tests, but who do not yet systematically practice sports, were identified. These young people have potential that must be developed and trained. It is possible that many of them are unaware of their potential or have not yet been motivated for sports.

From the student's point of view, the test results serve as a starting point for self-awareness and motivation for sports and physical activity. In addition, the information serves as a guide for students' parents, as they often place no or too much expectation on their children about the possibility of being athletes. Generally, parents know whether their child is good in math, Portuguese, or science, but they know nothing about physical education. CMJF students are assessed annually, and each student receives a personalized report containing the test results that indicate their strengths and weaknesses.

This study has several limitations. The height of the biological parents were obtained through a self-assessment report, there was lack of control of the students' motivation during the tests, there was lack of information related to previous motor experiences, and the evaluation was performed only in a limited number of 17-year-old students. Moreover, the cut-off values for motor talent do not consider the students' maturation status. Further studies should investigate the percentage of variance explained by biological maturation in this group of tests, the stability of motor talent diagnosis over time, and the effects of training.

Lastly, identification of motor talents is not enough. The potential talents should be exposed to an environment that favors the development of the skills required for successfully practicing sports in a long-term training process. Longitudinal monitoring through the application of tests is necessary, especially to observe the progress of the students due to their growth and maturation processes and to expose these students to training programs.

The biological maturation should be considered when assessing the sporting potential of young athletes to avoid hasty and/or wrong judgments regarding the expectations of success in students, as differences in performance related to maturation are transient, thus often reflecting a temporary advantage. Teachers are responsible for creating learning pedagogical strategies and providing favorable conditions for the development of their students' sporting potential. Attention should be given both to those who need to improve motor performance and to those with high sport potential, especially those who are not yet involved in sports (training) and those who are biologically delayed. Initiation and training sports programs, such as "Forças no Esporte," which was developed by the Ministry of Sports in partnership with the Ministry of Education, should be encouraged.

CONCLUSION

CMJF students are larger, stronger, more resistant, and more biologically mature than those in the literature, and such features are more pronounced in student athletes. In addition, one in 10 CMJF students can be considered as having a motor talent, either related to body size or higher performance in flexibility, speed, strength, or endurance. This diagnosis is more frequent in biologically advanced students.

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