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Original Article

MULTIDIMENSIONAL INDICATORS OF SPORTING POTENTIAL OF BRAZILIAN TRAMPOLINE GYMNASTS

INDICADORES MULTIDIMENSIONAIS DO POTENCIAL ESPORTIVO DE GINASTAS DE TRAMPOLIM BRASILEIROS

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RESUMO
A evidência científica sobre o perfil de atletas de ginástica de trampolim é escassa. Considerando que o trampolim individual é uma modalidade olímpica, torna-se importante investigar as características desses atletas na realidade brasileira. O objetivo deste estudo foi avaliar indicadores antropométricos, físico-motores, maturacionais, socioambientais e o potencial esportivo de ginastas de trampolim brasileiros, investigando diferenças entre as categorias etárias. Participaram 147 atletas que disputaram o Campeonato Estadual e Brasileiro de Ginástica de Trampolim por Idades em 2017-2018. Foi realizada uma bateria de testes multidimensional, comparando os indicadores coletados entre as categorias 9-10 anos, 11-12 anos, 13-14 anos, 15-16 anos e 17 anos ou mais. Os treinadores (n = 20) avaliaram o potencial esportivo dos seus ginastas, em relação a expectativa de sucesso no futuro. Os resultados mostraram diferenças estatisticamente significantes no tamanho e composição corporal, somatotipo, força de preensão manual, salto contramovimento, flexibilidade e no potencial esportivo entre os atletas de diferentes categorias etárias, em ambos os sexos. Além disso, 30% dos ginastas apresentaram elevado potencial esportivo, segundo a opinião dos treinadores. Conclui-se que os indicadores multidimensionais relacionados ao potencial esportivo dos ginastas de trampolim brasileiros variam em função da categoria etária. Este estudo é pioneiro na caracterização do perfil do ginasta de trampolim brasileiro de elite, utilizando uma abordagem dinâmica relacionada ao talento esportivo.
Palavras-chave: Ginástica. Identificação de talentos. Desempenho. Jovem atleta.

ABSTRACT
The scientific evidence on the profile of trampoline gymnastic athletes is scarce. Considering that the individual trampoline is an Olympic sport, it is important to investigate the characteristics of these athletes in Brazil. The aim of this study was to evaluate anthropometric, physical-motor, maturational, socio-environmental indicators and the sporting potential of Brazilian trampoline gymnasts, investigating differences between age categories. There were 147 athletes participating who competed in the State and Brazilian Championship of Trampoline Gymnastics by Age Group in 2017-2018. A multidimensional battery of tests was carried out, comparing the indicators collected between the categories 9 to 10 years, 11 to 12 years, 13 to 14 years, 15 to 16 years and 17 years or older. The coaches (n = 20) assessed the sporting potential of their gymnasts, in relation to the expectation of success in the future. The results showed statistically significant differences in body size and composition, somatotype, handgrip strength, countermovement jump, flexibility and sporting potential among athletes of different age categories, in both sexes. In addition, 30% of gymnasts showed high sporting potential, according to the perspectives of the coaches. It is concluded that the multidimensional indicators related to the sporting potential of Brazilian trampoline gymnasts vary according to the age category. This study is a pioneer in characterizing the profile of the elite Brazilian trampoline gymnast, using a dynamic approach related to the sporting talent.
Keywords: Gymnastic, Talent identification, Performance, Young athlete.

Introduction

The trampoline gymnastics (TG) is composed of four events: individual trampoline, synchronized trampoline, double mini trampoline, and tumbling. On the individual trampoline, the gymnasts perform sequences of ten acrobatic jumps, combining aspects such as height, body control, posture, and speed, aiming for the highest possible accuracy, following the guidelines of the International Gymnastics[1] Federation scoring code. In Brazil, the highest authority of the TG is the Brazilian Gymnastics Confederation, which divides the age categories into: 9 to 10 years old, 11 to 12 years old, 13 to 14 years old, 15 to 16 years old, 17 years old and older)[2].

Individual trampoline is an Olympic sport. Although its practice is still very restricted in our country, Brazil has been present since 1990 in the world championships and in 2016 in the Olympic Games[3,4].

In gymnastics, generally, in order to obtain a good performance, sports initiation begins at a young age so as to enable and enhance the development of capacities that meet the demands of competitive gymnastics[5]. In this sense, the search for talent and the preparation of high-performance gymnasts begins with programs to detect and select children who present great sporting potential for the modality[6]. The profile of a gymnastics athlete is very specific, which implies different performance determinants and, consequently, different methods to identify and develop sporting talents.

In artistic gymnastics (AG), for example, the tests used by coaches to analyze the profile and detect a sporting talent are: chronological age, anthropometric assessment, physical-motor tests (coordination, flexibility, and balance), and empirical assessment[7]. In general, the profile of young athletes is differentiated, since they are taller, heavier, stronger, faster, more resistant and, due to selective processes, present advanced maturation[8]. However, the profile of gymnasts differs in most sports. In rhythmic gymnastics (RG), the gymnasts have long legs, low body fat, a lean and less defined body shape, while in AG they are shorter, stronger, have broader shoulders, and are more flexible[6-10]. In relation to maturation, gymnasts show late skeletal maturity 11, and due to selective processes, they would have more advantages in female AG[5].

The preparation of high-level gymnasts begins with programs to detect and select children who show great potential for gymnastics, which requires a very specific profile. There are many studies on the profile of Brazilian gymnasts intended for AG[7,9,11]and for RG[6,10], however, the scientific collection related to TG is still scarce. Until this moment, no indicators of anthropometric, physical-motor, and maturational profiles of Brazilian gymnasts in TG are known. The data obtained from this study will allow us to know the profile of trampoline gymnasts of different age groups, enabling a sporting potential diagnosis of the athletes, with implications for their development, through systematic training, so that they can reach the highest level of performance possible.

The TG is a very rich modality in ludic aspects, motor development and stimulus to the practice of physical activity, which justifies the realization of research in order to reveal its importance and relevance, not only for the knowledge of the athlete profiles and to help the coaches in the process of sportive formation, but also to awake the interest of the academics of the graduation courses in Physical Education. Therefore, the objective of the present study was to evaluate anthropometric, physical-motor, maturational and socio-environmental indicators, as well as the sporting potential of Brazilian trampoline gymnasts, investigating differences between age groups.

Methods

Participants

In this study there were 147 TG gymnasts (89 female, 58 male), aged 8 to 24 years, who competed in the State and Brazilian Championships of Trampoline Gymnastics by Age Group, in the town of Ouro Preto-MG, in 2017 and 2018. This sample of elite athletes represents nine teams from the states of Minas Gerais, Rio de Janeiro, São Paulo, and Santa Catarina. The inclusion criterion was: to be registered in the competition and to be an athlete in the individual trampoline test. Athletes who presented some type of injury or health condition on the day of the evaluation that made it impossible for the series of tests to be conducted, and team of athletes who refused to participate in the research were excluded. This study is an integral part of the Projeto Atletas de Ouro®: multidimensional and longitudinal assessment of young athletes, approved by the UFOP Research Ethics Committee (CAAE: 20383013.7.0000.5150). The

participation of the athletes and coaches was voluntary, following the guidelines of the Brazilian legislation for studies with human beings, having the consent of the Mineira Gymnastics Federation and the Brazilian Gymnastics Confederation.

Procedures

For the evaluation of the indicators related to sporting potential the following set of tests was applied, in the following order: a questionnaire containing demographic data and the sporting experience of the athletes, anthropometry and physical-motor tests on the athletes, followed by the evaluation of the sporting potential made by the coaches. The series of tests were performed during the training day of the gymnasts at the State Championships and at the Brazilian Trampoline Gymnast Championships by Age Group. The evaluation was done by members of the team from the Laboratory for Exercise and Sports Studies and Research (LABESPEE), all properly trained and qualified in the test application procedures. The data collection took place over two days and was carried out at the Physical Education School of the Federal University of Ouro Preto (EEF-UFOP). The tests were performed as a circuit, where each testing station was composed of one test, one evaluator, and one record-keeper.

Anthropometric Indicators

Measurements of body mass, height, wingspan, sitting height, arm and leg circumference, and skinfolds (calf, subscapular, and triceps) were taken. Three repeated measurements were made in each skinfold, using the mean value, according to standardized procedures [12]. The body mass was measured using a digital anthropometric scale, graduated from 0 to 150 kg, with a precision of 0.05 kg. The height was measured using a tape measure fixed to the wall, graduating from 0 to 200 cm, with an accuracy of 0.20 cm. In order to read the height, a device in the shape of a set-square was used, so that one side of the set square was fixed to the wall and the lower perpendicular side was close to the head of the evaluated individual. A device with two vertical movable rulers fixed to the wall was used to read the wingspan. The body mass index was calculated using the equation: body mass (kg)/square height (m^2). The somatotype was calculated in an electronic spreadsheet, using the validated formulas for calculating the components of endomorphy, mesomorphy and ectomorphy[12]. For the measurement of sitting height, a portable stadiometer (Sanny®, Brazil) with attached bench was used, in such a way that the assessed person kept the hips flexed forming a 90º angle and the head oriented according to the Frankfurt plan, parallel to the ground. The lower limb length was estimated from the difference between height and sitting height. The skinfold measurements were obtained using a calibrated scientific adipometer (Sanny®, Brazil). During these measurements, the gymnasts were in training attire and barefoot.

Physical-Motor Indicators

The flexibility assessment of the hamstring muscles and lumbar spine was done through the sit and reach test, using the Wells bench (Sanny®, Brazil) with the feet supported at the 23 cm mark, where 3 attempts were performed and the greatest measurement was considered[13]. The muscular power (explosive strength) of the lower limbs was evaluated through the vertical jump test with countermovement (CMJ), using a contact mat (Multi-SprintFull®, Hidrofit, Brazil). The hands were positioned on the hips and the participant was asked, from the standing position, to perform a quick squat and vertical jump in sequence.

Three jumps were performed and the best result was considered[14]. For the evaluation of the maximum isometric hand strength, the handgrip strength test was performed, using a manual dynamometer (Jamar®). The participant performed the test in the sitting position, elbow flexed at 90º and was instructed to perform a maximum contraction for up to three seconds. Three attempts were performed on each hand, and the best result was considered[15].

Maturational Indicators

The biological maturation was assessed through the following somatic maturation indicators: 1) percentage of predicted adult height (%PAH); 2) age at peak height velocity (APHV). The predicted adult height was estimated using the Khamis and Roche method[16], which uses the chronological age, current height, and body mass of the individual assessed, in addition to the height of the biological parents, which was obtained by self-report. The maturational indicator was then calculated by the following equation: %PAH = (current height/predicted adult height)*100. The higher the %PAH, the closer the person assessed will be to the mature (adult) stage. From reference data, by age and sex, the Z score was calculated to obtain the maturational stage classification of the athlete: delayed, normomature or advanced. The APHV was estimated using sex-specific prediction equations[17]. Based on the chronological age of the athlete and anthropometric measurements, the maturity offset (MO) was calculated, which represents the distance in years that the subject is from the PHV. The maturational indicator was then estimated by the equation: APHV = current chronological age - (MO). Negative values indicate that the adolescents have not yet reached PHV, while positive values indicate that the adolescents have already reached PHV. In girls, sexual maturation was assessed by the age at menarche, using the retrospective method.

Socio-environmental Indicators

A questionnaire was applied containing demographic data and sports experience of the athletes - competitive level, age when they started playing the sport, and the year they were federated. The time of practice was estimated from the starting age in the sport and the date of the participation in the study[18].

Evaluation of Sporting Potential by the Coaches

A scale was applied for the coaches to assign a subjective classification regarding the expectation of future success for each of the gymnasts. There were twenty experienced TG coaches (10 women and 10 men) aged 24 to 53 years who participated in the study. They were asked to rate the potential for future performances in each of the gymnasts, adopting the following classification: 1 = Poor; 2 = Fair; 3 = Good; 4 = Very Good; 5 = Excellent[18].

Statistical analysis

The data were described using mean ± standard deviation (quantitative variables) and absolute frequency and percentages (qualitative variables). In order to analyze differences in the multidimensional profile between age groups, analysis of variance (ANOVA) was used, separately by gender. When significant differences were detected, the Bonferroni post hoc test was performed, comparing only the age category with the subsequent one. The Chi-square test was used to test the association between qualitative variables. All analyses were performed in IBM SPSS® version 24.0 software (IBM Corp. Armonk, NY). A value of $p \leq 0.05$ was adopted for statistical significance.

Results

The characteristics of the sample are presented in Table 1. Out of the trampoline gymnasts evaluated, 60.5% were female, with a higher proportion of girls in the 9-10 years, 11-12 years and 15-16 years categories compared to boys. Most of the athletes were from Minas Gerais (74.8%), with experience in national/international competitions (78.2%).

Table 1. Sample characteristics

	Male (n=58)	Female (n=89)	Total (n=147)
Category			
9-10 years	10 (27.8%)	26 (72.2%)	36
11-12 years	7 (21.2%)	26 (78.8%)	33
13-14 years	15 (50%)	15 (50%)	30
15-16 years	7 (43.8%)	9 (56.3%)	16
17+ years	19 (59.4%)	13 (40.6%)	32
State			
MG	36 (32.7%)	74 (67.3%)	110
RJ	13 (59.1%)	9 (40.9%)	22
RS	2 (25%)	6 (75%)	8
SP	7 (100%)	0 (0%)	7
Competitive Level			
State	5 (16.1%)	26 (83.9%)	31
National	26 (37.1%)	44 (62.9%)	70
International	26 (57.8%)	19 (42.2%)	45

Note: Percentages refer to the lines
Source: The authors

In Tables 2, 3 and 4 describe the variables that characterize the multidimensional profile of the sporting potential of trampoline gymnasts, divided by age group. Statistically significant differences were observed among the gymnasts in body size and composition and in the somatotype (except, in mesomorphy for the female gender), handgrip strength, countermovement jump (except, in the female gender), flexibility and sport experience (except, in age of onset for the female gender) as a function of age categories ($p<0.05$).

According to the data collected together with the coaches, in females, the highest proportion of gymnasts with very good or excellent potential was observed in the 9-10 years and 15-16 years categories. In males, the highest proportion of these classifications was observed in the 9-10 years, 13-14 years and 17+ years categories.

Table 2. Multidimensional profile of Sporting potential in female trampoline gymnasts (n=89)

	9-10 years	11-12 years	13-14 years	15-16 years	≥17 years	F	p-value
Socio-environmental Indicators							
Starting age (years)	6.8±1.5[a]	8.2±2.0[b]	7.5±2.0[b]	7.6±2.2[b]	7.7±1.3[b]	2.013	0.10
Time federated (years)	1.4±0.70[a]	1.8±1.4[a]	4.3±1.8[b]	6.2±2.0[c]	8.3±1.2[d]	77.760	<0.001*
Practice time (years)	2.8±1.2[a]	3.3±2.0[a]	6.1±2.2[b]	8.0±2.1[c]	9.5±1.2[d]	43.815	<0.001*
Anthropometric Indicators							
Body Mass (Kg)	31.1±5.7[a]	36.1±6.0[b]	46.3±4.1[c]	53.1±6.4[d]	55.2±5.3[d]	60.091	<0.001*
Height (cm)	136.7±6.9[a]	146.8±6.0[b]	155.9±3.6[c]	160.1±5.9[c]	158.8±4.9[c]	51.815	<0.001*
Sitting height (cm)	70.7±4.3[a]	75.4±4.6[b]	81.4±2.7[c]	84.3±2.8[c]	84.7±2.3[c]	44.592	<0.001*
mmii length (cm)	66.1±4.4[a]	71.3±3.3[b]	74.4±2.2[c]	75.8±3.3[c]	74.1±2.9[c]	23.670	<0.001*
Wingspan (cm)	137.0±8.1[a]	146.7±7.2[b]	159.6±4.6[c]	163.6±4.0[c]	161.3±4.3[c]	53.797	<0.001*
Sum 3DC (cm)	28.4±10.0[a]	26.6±7.2[a]	29.5±8.9[a]	32.8±3.4[a]	39.6±7.2[a]	5.788	<0.001*
Endomorphy	3.4±1.3[a]	2.8±0.93[a]	3.2±1.1[a]	3.4±0.56[a]	4.1±0.75[a]	3.068	0.02
Mesomorphy	3.4±0.97[a]	3.1±0.91[a]	3.3±0.94[a]	3.4±0.92[a]	3.9±0.69[a]	1.761	0.14
Ectomorphy	3.3±1.2[a]	4.0±1.1[b]	3.2±1.0[c]	2.6±0.87[c]	2.0±0.57[c]	7.637	<0.001*
Physical-motor Indicators							
Handgrip Strength (N)	14.6±3.5[a]	19.32±6.4[b]	22.5±5.9[b]	29.1±6.5[c]	26.3±5.7[c]	16.861	<0.001*
CMJ (cm)	22.3±4.0[a]	23.2±3.5[a]	23.4±3.7[a]	24.4±5.7[a]	26.1±4.3[a]	1.655	0.17
Flexibility (cm)	37.7±3.8[a]	38.0±5.5[a]	42.3±4.4[b]	45.7±2.9[b]	43.6±4.6[b]	9.264	<0.001*
Sporting Potential - Coaches						**X^2**	**p-value**
Excellent	11.5%	3.8%	6.7%	22.2%	0%	36.113	<0.001*
Very Good	26.9%	23.1%	6.7%	22.2%	0%		
Good	42.3%	73.1%	80%	44.4%	100%		
Fair	19.2%	0%	6.7%	0%	0%		
Poor	0%	0%	0%	11.1%	0%		

Note: Mean ± standard deviation. (Length mmii: lower limb length; CD: skinfolds; CMJ: countermovement jump; F: value of the Analysis of Variance (ANOVA) test statistic; a,b,c,e,d: different letters in the same row indicate significant differences between the respective age category and the subsequent one; X2: value of the Chi-square test statistic)

Source: The authors

Table 3. Multidimensional profile of Sporting potential in male trampoline gymnasts (n = 58)

	9-10 years	11-12 years	13-14 years	15-16 years	≥17 years	F	p-value
Socio-environmental Indicators							
Starting age (years)	6.8±1.4[a]	8.1±1.3[a]	8.1±2.0[a]	8.1±2.3[a]	10.4±3.0[b]	4.735	0.002*
Time federated (years)	1.5±1.1[a]	3.0±1.7[a]	4.1±2.0[a]	6.6±1.7[b]	6.9±3.8[b]	9.168	<0.001*
Practice time (years)	2.3±1.1[a]	3.7±1.4[a]	5.3±2.1[b]	7.6±1.9[c]	8.7±3.3[c]	14.073	<0.001*
Anthropometric Indicators							
Body Mass (Kg)	32.9±7.4[a]	39.2±6.8[a]	43.3±10.7[a]	55.7±4.4[b]	61.9±5.5[b]	31.630	<0.001*
Height (cm)	134.5±7.7[a]	146.1±6.1[b]	155.4±14.9[c]	174.0±6.8[d]	175.1±5.2[d]	39.371	<0.001*
Sitting height (cm)	71.4±3.5[a]	74.9±2.9[a]	78.9±6.7[a]	86.0±4.8[b]	90.8±3.3[c]	36.905	<0.001*
mmii length (cm)	63.0±4.6[a]	71.1±3.2[b]	76.5±8.6[c]	88.0±5.7[d]	84.2±3.8[d]	30.176	<0.001*
Wingspan (cm)	135.3±8.9[a]	149.1±5.0[b]	156.1±15.3[b]	177.1±5.8[c]	178.6±7.3[c]	39.648	<0.001*
Sum 3DC (cm)	31.6±14.2[a]	27.5±6.6[a]	22.3±5.0 [a]	18.7±2.9[a]	20.2±3.2[a]	5.707	0.001*
Endomorphy	3.4±1.4[a]	2.9±0.52[a]	2.1±0.54[b]	1.5±0.35[b]	1.8±0.35[b]	11.680	<0.001*
Mesomorphy	4.0±1.1[a]	4.6±1.0[a]	3.6±1.1[b]	2.9±0.94[b]	3.6±0.78[b]	2.919	0.03*
Ectomorphy	2.4±1.1[a]	3.0±0.98[a]	4.0±1.2[b]	4.8±0.65[b]	3.9±0.92[c]	6.605	<0.001*
Physical-motor Indicators							
Handgrip Strength (N)	16.8±5.5[a]	19.1±6.1[a]	25.0±7.9[a]	31.4±5.1[b]	39.5±7.2[c]	24.283	<0.001*
CMJ (cm)	22.0±3.8[a]	26.1±4.0[a]	26.6±4.1[a]	31.9±1.6[b]	35.6±8.5[b]	10.496	<0.001*
Flexibility (cm)	38.1±4.7[a]	32.7±5.2[b]	35.9±3.5[b]	39.4±3.1[b]	40.6±7.2[b]	3.76	0.02*
Sports Potential - Coaches						X^2	p-value
Excellent	20%	14.3%	0%	0%	31.6%		
Very Good	20%	0%	40%	28.6%	10.5%		
Good	60%	85.7%	46.7%	71.4%	52.6%	17.232	0.03*
Fair	0%	0%	13.3%	0%	5.3%		
Poor	0%	0%	0%	0%	0%		

Note: Mean ± standard deviation. (Length mmii: lower limb length; CD: skinfolds; CMJ: countermovement jump; F: value of the Analysis of Variance (ANOVA) test statistic; a,b,c,e,d: different letters in the same row indicate significant differences between the respective age category and the subsequent one; X2: value of the Chi-square test statistic)

Source: The authors

A statistically significant relationship was observed between age category and maturational stage classification of athletes, both in males (X2=17.236; p=0.03) and females (X2=36.113; p<0.001). A higher proportion of normomature and maturationally advanced

gymnasts was observed in the 9-10 years category in both male and female. However, in the female gymnasts, from and including the 11-12 years category, a greater proportion of normomature and maturationally delayed gymnasts was observed. The increase in the APHV in girls along the age categories corroborates this finding. In males, we observed a higher proportion of normomatures and advanced, starting from and including 11-12 years category. The mean APHV observed in girls was 12.2 ± 0.6 years and the age at menarche was 11.8 ± 0.9 years. The APHV for boys was 14.0±0.9 years.

Table 4. Maturational indicators of Brazilian trampoline gymnasts, by gender and age group

	9-10 years		**11-12 years**		**13-14 years**		**15-16 years**	
	Male	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**
Maturational Indicators								
PAH (cm)	172.7±5.4	163.5±5.2	175.4±3.2	165.4±4.4	174.2±9.1	162.8±3.4	180.3±7.8	161.5±5.5
%PAH	77.8±3.0	83.5±2.3	83,2±2,7	88.7±2.3	89.0±4.1	95,7±1.5	96.5±2.6	99.1±0.51
Z-score PAH	1.7±1.4	0.73±0.90	0.18±0.66	-0.36±0.65	0.20±0.90	-0.69±0.61	0.72±0.76	-0.71±1.1
APHV (years)	12.,8±0.37	11.7±0.37	14.1±0.25	12.1±0.47	14.4±0.71	12.5±0.33	14.7±0.71	13.1±0.47
MO (years)	-3.6±0.67	-2.1±0.61	-2.1±0.59	-070±0.58	-0.95±1.0	-1.0±0.45	-1.1±0.80	-2.4±0.36
Menarche (years)	-	-	-	10.6±0.57	-	11.7±0.75	-	12.2±0.79
Maturational Stage								
Delayed	0%	0%	0%	15.4%	0%	26.7%	14.3%	22.2%
Normal	40%	69.2%	100%	84.6%	86.7%	73.3%	71.4%	77.8%
Advanced	60%	30.8%	0%	0%	13.3%	0%	14.3%	0%

Note: M= Male; F=Female; PAH: Predicted Adult Height, APHV: Age at Peak Height Velocity, MO: Maturity Offset
Source: The authors

Discussion

The objective of the present study was to evaluate anthropometric, physical-motor, socio-environmental and maturational indicators, as well as the sporting potential of Brazilian gymnasts of TG, specifically in the individual trampoline event, investigating differences between age groups, since there are few descriptive scientific studies on the typical profile of athletes in this modality. In a review, in the Scielo and Pubmed databases, conducted in February 2019, no article with similar characteristics to this one was found, making this study a pioneer in this theme in Brazil. The literature is rich in works that evaluate anthropometric, physical-motor and maturational measures in AG and RG gymnasts, but the scientific collection related to TG is still scarce.

Beginning Age in the TG

The present study revealed that the starting age in TG occurs, on average, between seven and eight years of age in young athletes, both female and male. Adult male athletes, on the other hand, reported an average starting age in TG at 10 years old. Compared to other sports, the starting age in the TG is on average two years later than in AG, which occurs between five and seven years[5] in both genders; and also in RG, taking place between five and eight years in

females[19]. Even still, TG also tends to have an early initiation when compared to other sports, due to the very nature of the modality, where coaches already start to observe the profile of gymnasts, in addition to specific motor skills and abilities. The earlier a child starts, the faster he/she will acquire the qualities required for competitive gymnastics[6].

Anthropometric and Physical-Motor Profile: Female Group

The results revealed a linear and statistically significant increase in body mass from 9-10 years to the 15-16 years category. The increase in body mass is related to the growth and maturation process, especially after the menarche in girls[8]. The mean values observed corroborate with the literature[11], and the mean body mass of 45.9±5.6 kg in 13–14-year-old athletes is similar to young gymnastics athletes[21]. In relation to height, wingspan and lower limb length we observed a linear increase until the 13-14 years category, followed by a maintenance of the average value until adulthood. When compared to the gymnasts in RG and AG we have higher stature values for the TG. In contrast, in the TG the average stature is lower than the non-athlete population for the same age group. The reasons for the shorter stature of gymnasts [6] are related to genetic factors and natural selection for the sport[5,6,19].

In gymnasts, there was no significant difference in the sum of skinfolds between the age categories, and the values observed are similar to those of RG gymnasts, who showed a skin fold sum of 28.1 ± 4.8 mm in the 9-10 years category, 29.1±5.8 mm in the 15-16 years category and 39.2 ±8.6 mm in the adult category[23]. From the 11-12 years category forward, the gymnasts have lower ectomorphy values, which corroborates to some extent with the gain in body fat due to the maturation aspects and the arrival of menarche[8]. Analyzing the somatotype, we observed a predominance of ectomorph in TG gymnasts in the 11-12 years category and an endo-mesomorph profile for the adult category. In RG there is a tendency for ectomorphy in the 11-12 years and 15-16 years[23]. In the Brazilian AG, mesomorphy predominates in non-elite and sub-elite gymnasts[19].

The handgrip strength analysis revealed an increase from the 9-10 years to the 13-14 years category, followed by a new increase until the adult category. This result is related to the biological maturation process and the type of training, among other factors[15]. There are higher values than our results regarding acrobatic gymnasts[24], where there is the asymmetric parallel competition, which is characterized by the predominant use of the upper limbs.

Regarding the countermovement jump test, there was no significant difference between the female age groups. However, when compared to the data in the literature, it was possible to identify values higher than our results in the RG and AG, from 9-10 years to the 13-14 years categories[14]. This may be related to the fact that in TG the training takes place on elastic trampolines, where the coordination (execution speed) of the jumps is different due to the action of the springs in the propulsion phase, while in AG the gymnasts perform their training on boards, which have fewer elastic properties. Thus, there are differences between the modalities in the motor request of the lower limbs to perform the jumps and acrobatics. Since the test is performed on a contact mat laid out on the floor, with the restriction of upper limb movements, it is closer to the jump specificity present in RG and AG than in TG. Thus, we can understand that the results of the CMJ test are influenced by the coordination in the stretching-shortening cycle, by muscle pre-activation, and also by the rigidity of the jumping surface[25].

Despite finding lower values than in other gymnastic modalities, lower limb strength is a variable of utmost importance in TG, which demands a lot of explosive strength from the gymnasts, especially the vertical jump, because in the scoring code the gymnasts who reach more height (flight time) have a higher score attributed to their presentation[1]. This is another indicator that can help coaches in the analysis of training, aiming at the best performance of the gymnasts.

Considering the analysis of flexibility, there was an increase in this ability from the 11-12 years to the 13-14 years category, followed by a maintenance of the average value until adulthood. The RG gymnasts show higher values than our results for the categories and the flexibility maintained throughout the age categories[26]. Considering flexibility as one of the most important physical valences for the gymnastic modalities[27], we observed that due to the very nature of RG, gymnasts require more flexibility than TG gymnasts.

Anthropometric and Physical-Motor Profile: Male Group

In relation to the anthropometric variables, the body mass of the youth relative to the 13-14 years to 15-16 years categories increased significantly. This increase in body mass is related to the maturational and hormonal factors that occur during puberty, where boys gain more lean mass and for a longer time when compared to girls who, on the contrary, increase body adiposity in this age group[8]. In general, TG gymnasts have lower body mass when compared to male AG. In Brazilian male high performance AG, in the 11-12 years, 13-14 years, and 15-16 years categories, we observed mean values of 47.5 ± 9.8 kg, 60.6 ± 8.0, and 64.6 ± 7.1 kg 28, respectively, which were higher compared to the gymnasts in the present study for the same ages.

In regards to height, we can observe that, on average, male TG athletes have greater height in relation to other gymnastic modalities. Perhaps due to the biomechanical advantage of the greater lever arm of the lower limbs, in the body interaction with the elasticity of the acrobatic trampoline. In Table 3, we observe that there was a significant increase in the mean values for height, sitting height, wingspan, and body size of the gymnasts from the 13-14 years to the 15-16 years category. These data correlate with the APHV of the gymnasts which was estimated at 14.0±0.9 years. A possible explanation for this growth is maturation, which is directly related to these variables, since in this phase there is a rapid increase in both weight and height of the youngsters[8].

The height of male AG gymnasts was smaller[28], especially among the 15-16 years and 17-18 years categories, compared to TG 15-16 years and adult categories. The predominant somatotype was mesomorphy between the 9-10 years and 11-12 years category and the ectomorphy from the 13-14 years to the adult category. The predominant somatotype of the AG mesomorphic/ectomorphic gymnasts[28] and acrobatic gymnasts mesomorphic[29] remained the same regardless of the age category.

Men have greater handgrip strength than women[15], which corroborates with our study when we compared Tables 2 and 3, in all age categories. We also observed that there was a significant increase in strength from the 13-14 years to the 15-16 years male category, related to the maturation development of these gymnasts, where a significant gain in strength is observed at this age[8]. Corroborating with our results, higher handgrip strength values were found in the juvenile in relation to the infantile-juvenile category in high-performance Brazilian gymnasts[28]. The handgrip strength is required in specific sports modalities, in which the level of strength generated may be the difference between victory and defeat. Therefore, manual dynamometry may be a valuable tool to be used to detect sporting talent in sports that require this physical capacity[15].

Regarding the CMJ, we observed similar jumping values between the 11-12 years and the 13-14 years categories. We also observed a significant increase from the 13-14 years to the 15-16 years category. This increase can be explained by the onset of puberty, when there is a significant increase in muscle mass due to the release of sex hormones and the growth hormone during this phase[8].

Considering the flexibility analysis, we observed that the 9-10 years category presented a higher level of flexibility when compared to the gymnasts in the 11-12 years and 13-14 years categories, and lower than the 15-16 years and adult categories. This flexibility characteristic

is not the one expected for different age groups. The TG athletes show higher flexibility values when compared to athletes of the same age category from other modalities[8].

Contrasting our findings, the flexibility level of AG[28] gymnasts is higher than our results in all age categories. We can say that in the TG modality gymnasts have a lower level of flexibility compared to AG[8]. The flexibility results in TRG should be the best among the gymnastics modalities, in all categories, because the body position adopted in the sit and reach test is identical to one of the three possible body positions used in pike, and it is more evaluated by the TG[1] referee than in the other gymnastics.

Biological Maturation

Biological maturation can be defined as all the morphological and physiological changes that occur during the growth process due to physical, psychological, and social transformations, establishing a link between childhood and late adulthood[8]. By verifying maturational indicators of Brazilian trampoline gymnasts, it was possible to analyze that the gymnasts in both sex categories present the expected adult height higher than AG and RG gymnasts[6,8,11] and within the Brazilian population average In regards to somatic maturation, our study found that the APHV for males was 14.0 ± 0.9 years and for females was 12.2 ± 0.6 years, corroborating the mean values observed in the non-athlete population[8]. The APHV is the most commonly used indicator in longitudinal studies, considering the somatic maturation of adolescents[8]. This information about the APHV is of paramount importance to determine training strategies adopted when prescribing training loads for young athletes, mainly aiming to prevent the risk of injury. Athletes of the same age category who will reach PHV late cannot be submitted to similar training loads as those who have already reached PHV. Therefore, assessing maturity offset is an important parameter for coaches from a practical point of view[8].

Assessment of sporting potential by coaches

Considering that coaches are able to assess the sporting potential of young athletes in a valid and reliable way, the simplest way to quantify it is by asking them about their expectations for future performance[18]. In the present study, 30% of the gymnasts were evaluated as having very good or excellent potential, with variations between genders and age groups. The highest proportion of gymnasts with high potential in females was observed in the 9-10 years and 15-16 years categories, while in males the non-observance of gymnasts with excellent potential in the 15-16 years category suggests an important transition phase in the life of the young gymnast. It is worth mentioning that issues related to the lack of adequate equipment, support to clubs, and the conditions of the training centers[4] may influence the opinion of the coaches concerning the sporting potential of athletes in the Brazilian TG. But the fact is that the greatest Olympic powers have developed systematic means to identify talented athletes as early as possible and promote their development in a specific sport. Scientific evidence shows that sporting talent is identifiable and that, once provided favorable conditions and adequate training, high abilities can manifest themselves in the future. For this, it is essential to combine practical experience and scientific knowledge in a longitudinal perspective[18]. This is particularly evident in early specialization sports, such as gymnastics[5,6].

New studies should be conducted in an attempt to better understand the subjective assessment made by coaches regarding the sporting potential of the athletes. Anyway, the knowledge of the coaches is essential in the identification and development of talents, because there are certain characteristics that are difficult to observe and measure, except for the eyes of the coaches, who are able to estimate the development potential of the athlete and the chance of obtaining success in the future[18].

One of the strengths of the study is the representativeness of the gymnasts sample and the multidimensional approach used in the investigation of performance factors in TG.

Regarding practical implications, this study presented reference data that did not exist in the country and can help coaches in the detection and selection of talents for the TG, in the analysis of an ideal profile for it, contributing to a more effective training program and thus minimizing the possibility of errors in the process of long-term sports training, thus allowing young gymnasts a long and lasting career within this sport modality. The analysis of these variables in the detection, selection, and development of sporting talent for TG is extremely relevant. When the multiple aspects relevant to performance in TG are properly identified and developed, this contributes significantly to the success of a trampoline gymnast.

The limitations of the study include the fact that information about sports experience (competitive level, beginning age in the modality, year in which he/she was federated) was not measured by means of a validated instrument, but only by the self-report of the athletes. Similarly, there is no indication of reproducibility of the sporting potential evaluation made by the coaches in this study. However, data presented by the Projeto Atletas de Ouro® attest that self-report is the main way to assess the practice time and that the subjective perception of the coaches is valid for the diagnosis and prognosis of the performance potential in the future of young athletes[18].

It is also worth noting that the coaches who participated in this study represent only four of the 26 states in Brazil. This means that the potential successful athletes identified in this study represent only a part of the existing potential in the population, while portraying the reality of the restricted development of TG in the country[4]. This is the first study on the multidimensional performance profile of Brazilian trampoline gymnasts. Therefore, new studies are necessary in order to suppress the identified limitations, as well as to contribute to the process of scientific knowledge production about the TG.

Conclusions

It is concluded that the profile of the typical trampoline gymnast, both female and male, varies according to age category in relation to body size and composition, somatotype, sports experience, biological maturation, handgrip strength, lower limb explosive strength, and flexibility. Furthermore, according to the subjective perception of the coaches, 30% of Brazilian trampoline gymnasts showed high sporting potential.

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