GOLD SCORE ATHLETICS: TALENT DETECTION MODEL FOR TRACK AND FIELD

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ABSTRACT

Introduction: Talent detection is a dynamic and multifactorial process that must start at school. Objective: Create a mathematical model for evaluating the sporting potential of schoolchildren for athletics in speed, throwing, and endurance events and to test its psychometric properties. Methods: 2871 schoolchildren of both sexes, from 11 to 17 years old, from a military school participated. Between 2015 and 2019, students were submitted to a multidimensional battery of tests containing anthropometric, physical-motor, psychological, socio-environmental, maturational, and performance indicators. In addition, ten teachers evaluated the students regarding the intangibles aspects of their sporting potential and the expectation of future success during this period. Adopting analytical and heuristic procedures, the Gold Score Athletics was created – linear, hybrid (tests + coaches´ eye), and weighted index, according to each indicator's importance, depending on the event type. Results: In the model validation sample (n = 1384), 13.9%, 16.6%, and 11.7% of boys and 10.9%, 10.1%, and 9.1% of girls were classified as high potential (Gold Score ≥ 60) for speed, throwing and endurance events, respectively. Internal consistency (r = 0.76 to 0.82) and diagnostic stability were high (r = 0.72 to 0.81). The Gold Score Athletics for sprinters, throwers, and long-distance runners, both for boys and girls, was higher in students selected for a national competition when compared to those not selected ($p < 0.001$; *d*: 0.95 a 1.44) – construct validity – and higher in medalists in an athletics competition, held two years after diagnosis, when compared to non-medalists ($p < 0.05$; *d*: 0.62 a 1.87) – predictive validity. Conclusion: The Gold Score Athletics is a valid and reliable scientific model for evaluating the sport's potential of schoolchildren, being useful in the talents detection for Athletics. ***Level of Evidence II; Diagnostic study.***

Keywords: Track and Field; Physical Fitness; Statistics.

RESUMO

Introdução: A detecção de talentos é um processo dinâmico e multifatorial que deve começar pela escola. Objetivo: Criar um modelo matemático de avaliação do potencial esportivo de escolares para as provas de velocidade, lançamentos e resistência no atletismo, e testar as suas propriedades psicométricas. Métodos: Participaram 2871 escolares de ambos os sexos de 11 a 17 anos de um colégio militar. Os alunos foram submetidos a uma bateria de testes multidimensionais, contendo indicadores antropométricos, físico-motores, psicológicos, socioambientais, maturacionais e de desempenho. 10 professores avaliaram os alunos quanto aos aspectos intangíveis do potencial esportivo e a expectativa de sucesso futuro. Adotando procedimentos analíticos e heurísticos, criou-se o Gold Score Athletics – índice linear, híbrido (testes + olho do treinador) e ponderado, de acordo com a importância de cada indicador em função do tipo de prova. Resultados: Na amostra de validação do modelo (n = 1384), 13,9%, 16,6% e 11,7% dos meninos e 10,9%, 10,1% e 9,1% das meninas foram classificados como elevado potencial (Gold Score ≥ 60) para provas de velocidade, lançamentos e resistência respectivamente. A consistência interna (r = 0,76 a 0,82) e estabilidade do diagnóstico foram elevadas (r = 0,72 a 0,81). O Gold Score Athletics para velocistas, lançadores e corredores de longa distância, para ambos os sexos, foi maior nos estudantes selecionados para uma competição nacional quando comparados aos não selecionados (p < 0,001; d: 0,95 a 1,44) – validade de construto – e maior nos medalhistas em uma competição de Atletismo, realizada dois anos após o diagnóstico, quando comparados aos não medalhistas (p < 0,05; d: 0,62 a 1,87) – validade preditiva. Conclusão: O Gold Score Athletics é um modelo científico válido e fidedigno de avaliação do potencial esportivo de escolares, sendo útil na detecção de talentos para o Atletismo. ***Nível de Evidência II; Estudo diagnóstico.***

Descritores: *Atletismo; Aptidão Física; Estatística.*

RESUMEN

Introducción: La detección de talentos es un proceso dinámico y multifactorial que debe iniciarse en la escuela. Objetivo: Crear un modelo matemático para evaluar el potencial deportivo de escolares para pruebas de velocidad, lanzamiento y resistencia en atletismo, y probar sus propiedades psicométricas. Métodos: Participaron 2871 escolares de ambos sexos de 11 a 17 años de una escuela militar. Los estudiantes fueron sometidos a una batería de pruebas multidimensionales, que contenían indicadores antropométricos, físico-motores, psicológicos, socioambientales,

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madurativos y de desempeño. 10 docentes evaluaron a los alumnos sobre los aspectos intangibles del potencial deportivo y la expectativa de éxito futuro. Adoptando procedimientos analíticos y heurísticos, se creó el Gold Score Athletics, índice lineal, híbrido (pruebas + mirada del profesor) y ponderado, según la importancia de cada indicador según el tipo de prueba. Resultados: En la muestra de validación del modelo (n = 1384), el 13,9%, 16,6% y 11,7% de los niños y el 10,9%, 10,1% y 9,1% de las niñas fueron clasificados como de alto potencial (Gold Score ≥ 60) en velocidad, lanzamiento y eventos de resistencia. La consistencia interna (r = 0,76 a 0,82) y la estabilidad diagnóstica fueron altas (r = 0,72 a 0,81). El Gold Score Athletics para velocistas, lanzadores y corredores de fondo, para ambos sexos, fue mayor en los estudiantes seleccionados para una competición nacional en comparación con los no seleccionados (p < 0.001; d: 0,95 a 1,44) – validez del constructo – y mayor en medallistas en una competición de atletismo, realizada dos años después del diagnóstico, en comparación con los no medallistas (p < 0,05; d: 0,62 a 1,87) – validez predictiva. Conclusión: El Gold Score Athletics es un modelo científico válido y fiable para evaluar el potencial deportivo de los escolares, siendo útil en la detección de talentos para el Atletismo. ***Nivel de Evidencia II; Estudio diagnóstico.***

Descriptores: *Atletismo; Aptitud Física; Estadística.*

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INTRODUCTION

The search for sports talent is part of the daily life of coaches, managers, sports clubs, and Sports Science.[1-4] The identification of sports talent is a step in the long-term training process that aims to detect young athletes with high potential to become elite athletes.[5,6] When this process is carried out at school with young people not yet involved in systematic and specialized sports practice, it is called talent detection. Several countries have systematic models for identifying and developing talented young athletes.[7] In athletics, this topic has been widely investigated by researchers,[8-10] specially to develop models and tools that enable greater accuracy and success in identifying talent.[11-15] At school, however, no models are found to estimate the potential of children for athletics.

Identifying and developing sporting talent is one of the pillars of international sporting success.[16,17] The existing consensus is that this process should begin at school.[18-20] The school should promote sports practice both from the perspective of a physically active lifestyle and social inclusion and for talent development. Besides offering all students supervised, diversified, and quality sports practice, the Physical Education teacher must provide the appropriate development conditions for those with high sporting potential.[18,21,22] In this sense, the school must evaluate the sporting potential of students as a first step in discovering new talents, using a multidimensional, longitudinal, and inclusive approach.[23,24]

Every child and adolescent have a sporting potential that must be evaluated to be adequately developed. This sporting potential results from a dynamic interaction of multiple indicators related to the individual, the task, and the environment, such as anthropometric, physical-motor, psychological characteristics, skills, family support, quantity, and quality of training, which change over time and determine long-term sporting performance.[25-28] The scientific method has contributed to the understanding of the intervening factors that lead the young talented athlete to become an elite athlete throughout the training process.[27]

The scientific talent identification models aim to identify young people with high sporting potential, guide them to the sports that best suit their profile, select the most talented, and predict future success.[29] Talent is known to be identifiable, and that future performance can be predicted. However, it is a difficult and often inaccurate process,[30] since the trajectory of athlete development to high performance is often not linear.[31] However, advances in data science have allowed the development of expert systems for detecting sports talent, combining objective data from athletes obtained through tests of tests and performance in competition, the subjective assessment made by coaches, and statistical modeling.[32,24]

Sport Interactive in the UK,[34] *Sport Talent* in Croatia,[32] and the *Flemish Sports Compass* in Belgium[33] are examples of talent identification models used in schools. In Brazil, the Z-Celafiscs Strategy[35] and, later, PROESP - Projeto Esporte Brasil[36] are precursor scientific models for talent detection. Aiming to improve the previous models, researchers at the Universidade Federal de Ouro Preto developed the Golden Athletes® Project to validate an intelligent system for multidimensional and longitudinal assessment of the sporting potential of children and adolescents.[24,37]

The *Projeto Atletas de Ouro*® began at the Military School of Juiz de Fora (CMJF) in 2015, intending to identify students with high sports skills, map their strengths and weaknesses, guide them to the modalities more appropriate to their profile, assisting teachers in the process of long-term sports training. Using a battery of general and multidimensional tests in schoolchildren aged 11 to 17, a model for assessing sporting potential was created, including biological maturation and subjective assessment by teachers. Since then, specific talent detection models have been developed for soccer, basketball, swimming, and trampoline gymnastics.[24] Continuing the development of the tool, further studies are needed to model other sports, including athletics.

Track and field athletics comprises running, jumping, throwing, combined events, field races, mountain races, and athletic walking.[38] Each type of event requires a specific profile for high performance, which implies young athletes' guidance, selection, and development processes.[39,40] Sprinters and jumpers, for example, have apparently developed muscle mass and high power of lower limbs; throwers are taller and have high body mass associated with upper limb strength, while fundists have though aerobic capacity, movement efficiency, and a low percentage of body fat.[41,1] The morphological and physical capacity differences between the types of tests make athletics a sport of high analytical complexity.[42,43] In this sense, systematic methods for evaluating multiple indicators of sporting potential, linked to the long-term training process, can help the young person choose the sport most appropriate for his profile.[33]

Athletes' success in such distinct events is determined by a diverse set of morphological and motor characteristics such as height, limb length, strength, aerobic capacity, power, and speed, articulated with technical aspects specific to each event.[44] Young athletes who possess an optimal combination of the performance indicators of the sport and who respond favorably to training and competition have a greater chance of future success.[3,33] For this, it is necessary to continuously monitor biological maturation, physical growth, and physiological and motor adaptations in response to the training provided.[14] Moreover, coaches' knowledge adds value to talent identification models, especially in defining which indicators should be evaluated and the relative importance of each one in talent development.[10,40]

Scientific evidence has contributed to a better understanding of the process of identifying and developing talent in track and field, based on

studies of athletes from different tests,[47,46] comparison of athletes from different competitive levels,[47,48] performance prediction,[40,14,15] proposals for identifying and selecting young athletes,[8,13,9,6,49] talent development models11,[24] and longitudinal studies of athletes' career development.[50,12] However, there is a need to develop new tools for talent detection in athletics, especially in the Brazilian school setting, considering the interaction of multiple indicators of sporting potential.[44,51]

Given the above, the objective of this study was to create a mathematical model for assessing the sporting potential of schoolchildren in athletics, specifically for the speed, throwing, and endurance tests, and to test its psychometric properties. The hypothesis is that the model will be valid and reliable for estimating the athletic potential of schoolchildren for athletics.

MATERIALS AND METHODS

This study is part of the longitudinal research called "*Projeto Atletas de Ouro*®: *Avaliação Multidimensional e Longitudinal do Potencial Esportivo de Jovens Atletas*" (Multidimensional and Longitudinal Assessment of Sporting Potential in Young Athletes), approved by the Research Ethics Committee of the Universidade Federal de Ouro Preto (CAAE: 32959814.4.1001.5150). In this study stage, the mathematical model for assessing the sporting potential of young athletes in track and field was developed.

Research Model

A total of 2871 CMJF schoolchildren participated in the study, 1312 female and 1559 male, aged 11 to 17 years, assessed from 2015 to 2019. The sample for the construction of the mathematical model was composed of 1487 records of tests performed in female (n = 659) and male (n = 828) CMJF students, aged between 11 and 17 years, evaluated in the period from August 2015 to June 2017. One thousand one hundred eighteen records were of students who participated only in physical education classes, 113 were athletics practitioners, and 256 practiced other sports. In the teachers' evaluation of the sporting potential, 33.2% were classified as high potential, and athletics was suggested as the sport with the highest probability of future success for 16.2% of the students. In addition, 37.9% of the students had competitive experience, 20.6% had already won a medal at least at the municipal level, and 9.7% had participated in the Friendship Games - a national school competition. The mathematical model validation sample consisted of 1384 test records (653 girls and 731 boys) conducted from March 2018 to March 2019. A total of 10 teacher-coaches from the Physical Education Section of CMJF (mean age 41.0±8.0 years and mean time of experience 12.5±9.8 years) specialized in different sports (soccer, volleyball, orienteering, swimming, fencing, military triathlon, basketball, volleyball, handball, and track and field) and with academic backgrounds - undergraduate (n=2), specialist (n=3), and master's (n=5) - participated, most of them former athletes. The inclusion criteria for participation in the study were: age range of 11 to 17, being enrolled and regularly attending classes at CMJF, and being present on the day of data collection. The students who did not hand in the TCLE signed by their guardian or who refused to participate were excluded, as well as those who presented any physical or clinical condition that interfered with the performance of the tests. The consent of the legal guardians and the agreement students obtained before participation in the study.

Instruments and Procedures

Between 2015 and 2019, the schoolchildren performed an annual battery of multidimensional tests to measure anthropometric, physical-motor, psychological, environmental, and maturational indicators related to sporting potential. In addition, the PE teachers evaluated their students on the intangible aspects of sporting potential and the expectation of future success (Chart 1). The indicators of sporting potential evaluated, as well as the procedures for the tests, and measurements are described in Miranda *et al.* (2019),[52] Ribeiro Júnior *et al*. (2019)[53] and Werneck *et al*. (2020).[24]

The battery of tests was applied during the students' physical education class time, lasting approximately 90 minutes, on three different days. The data were collected from Monday to Friday between 09:00 and 12:30. The evaluation was done by properly trained professionals, with fixed evaluators selected for each test. On the first day, a lecture was held in the CMJF auditorium, where the testing protocol and the collection of socio-demographic information and sporting experience of the students were explained, under the supervision of the Physical Education teachers. On the second day, anthropometric measurements were collected and physical-motor tests were performed, in the form of a circuit, in the gym. On the third day, a 20-meter back-and-forth race test was performed to evaluate cardiorespiratory endurance. Then, the collected data were stored in an electronic spreadsheet, using Excel® software, version Windows 10.0. Finally, procedures were performed for organizing, validating, and debugging the data, creating new variables, standardizing, and creating graphs to present the individual student results.

Chart 1. Factors and indicators of sporting potential evaluated by the battery of tests of the Golden Athletes Project® in schoolchildren.

Factors	Indicators	Unit/Classification
Test Battery		
Anthropometric	Body Mass	kg
	Height	cm
	Expected adult height (EAP)	cm
	Sitting Height	cm
	Length Lower Limbs	cm
	Spread	cm
	Body Fat	%
Physical-Motor	Handgrip strength test	kgf
	Medicine ball throwing test (2kg)	m
	Countermovement vertical jump	cm
	10m and 20m speed race	s
	Sitting and Reaching Flexibility Test	cm
	20m back and forth race	m / VO_2max
Psychological	SOQ - Motivational Orientation (competitive, winner, determined)	pts
	ACSI-28 - Coping Skills (coping with adversity, performance under pressure, goals/mental readiness, concentration, worry-free, confidence/motivation, coachability)	pts
	Perceived Athletic Competence	pts
Environmental	Sports experience (train, practice time, sports preference)	yes / no years and months / type of sport
	Competitive level	local/regional, state, national, international
	Victory in competition	
	Socioeconomic level (ABEP)	pts / A, B, C, D, E
	Level of physical activity	pts
	Family Participation	pts
	Parents' sports practice	yes / no
	Athlete in the family	yes / no
Maturational	Percentage EAP achieved	%
	APS Z-score achieved	delayed, normomature, advanced
	Maturity offset	years
	PVC Age	years
Subjective Teacher Evaluation		
Teacher's Perspective	Sporting Potential	Likert Scale from 1 to 5
	Intangible Aspects	pts

A description of the test procedures and measurements can be found in Miranda *et al.* (2019), Ribeiro Júnior *et al.* (2019) and Werneck, Coelho, and Ferreira (2020).

Modeling the sporting potential of schoolchildren

Statistical modeling aims to model phenomena that have uncertainties and extract knowledge for decision-making.[54] It represents the operational way scientific models for identifying sports talent quantify the potential of young people. The assumption is that it is possible to identify sports talents and predict future performance with some probability of success, aiming to help physical education teachers in the decision-making process related to developing their student's potential.

A phenomenon that cannot be observed directly is evaluated using indicators. In practice, we estimate the sporting potential by diagnosing personal and environmental characteristics inherited, acquired, measured, and observed. Once analyzed, we can estimate the student's potential for a certain sport. The modeling of the sporting potential of schoolchildren, therefore, comprises a procedure that aims to obtain a valid and reliable estimate of the sporting potential of students for a particular sport from the analytical and heuristic processing of multiple indicators of sporting talent and is represented by a mathematical equation.[24]

Building the model

In this study, the construction of the operational model for assessing the athletic potential for athletics was divided into steps, according to the method described by Werneck *et al.* (2020)[24] and Werneck, Coelho, and Miranda.[51] In the first step, a univariate descriptive analysis was performed to calculate and measure the data's central tendency, dispersion, position, and distribution. Next, quantitative variables were normalized, according to the procedures adopted by the Z-Celafiscs Strategy.[35] The Z score of tests in which performance was against time was reversed (10-meter speed run, for example), so that r values always represented higher performance. To calculate the Z score, the mean and standard deviation were used as reference values, by age group and sex, according to the study by Miranda *et al*. (2019).[52] Based on the standardized normal distribution, the Z score for each indicator was converted to the corresponding percentile value so that the indicator score ranged from 0 to 100%. Students with exceptional performances above the 90th percentile (P90) in the indicators relevant to performance in speed, throwing and endurance modalities had a bonus score in their final score.

In the second step, a top-down performance prediction approach[55] was adopted to investigate differences and similarities among the schoolchildren, relationships among the variables, and possible performance and potential sporting determinants. For this purpose, bivariate statistical analyses were performed (t-tests and Chi-square test) to find differences in the various indicators between students practicing athletics vs. non-practicing, students with high potential according to teachers' subjective perception vs. low potential, students with potential for future performance in athletics vs. another modality, and students selected for the Friendship Games vs. not selected, as well as medal winners vs. non-medal winners. In this exploratory analysis, the statistical significance and the size of the effect (practical relevance) of the differences found for each indicator analyzed was observed, as one of the criteria for choosing the variables to be included in the mathematical model.

In the third stage, we adopted a bottom-up approach to acquiring knowledge of the factors necessary for developing young elite athletes.[55] To this end, we used two sources of information: the knowledge of coaches(experts)[10] and the available scientific literature. Based on the athletics performance model and previous studies, a questionnaire was administered to 10 Brazilian track and field coaches to investigate the degree of importance attributed to different factors and indicators that determine performance in different track and field events.[10] Also, retrospective longitudinal studies with elite athletes and Olympians were reviewed to obtain evidence and search for patterns regarding the characteristics that explain athletic success in track and field.

In the fourth stage, based on the analytical and heuristic procedures used in the previous stages, we operationalized the estimation of sporting potential through an index called *Gold Score Athletics*. *The Gold Score Athletics* is a standardized index ranging from 0 to 100%, obtained by a linear equation, composed of 6 factors with 24 indicators, presented in Chart 2. The relative importance of factors and indicators of sporting potential was defined from exploratory data analysis, literature review, and expert knowledge, varying between the speed, throwing, and endurance events. Therefore, *Gold Score Athletics* is a hybrid multidimensional and multidisciplinary model that combines observed test performance and developmental potential assessed by coaches, generating a quantitative estimate of schoolchildren's athletic potential for athletics. The criteria for determining sporting talent was Gold Score >80% in the mathematical model.

Calculation Gold Score Athletics

For each factor, the percentile values of each indicator are added together and multiplied by their respective weights. Then, the result is divided by the sum of the weights of the indicators ($_{\sum \beta Fi}$). Then the results obtained in each factor are multiplied by their respective weights, and divided by the sum of the factor weights ($_{\sum FaF}$). The student with scores above the 90th percentile (P90) in the indicators relevant to performance in the question test (speed, throwing or endurance) and the variables sport preference, sport indicated by the teacher, and somatic maturation enter the equation as an adjustment factor. Equation 1 defines Gold Score Athletics.

Equation 1

$$GS = \frac{\sum_F \alpha_F \frac{\sum_i \beta_{F_i} I_{F_i}}{\sum_i \beta_{F_i}}}{\sum_F \alpha_F}$$

Where, GS is an individual's Gold Score Athletics. F are the factors of the sport potential, $_{IFi}$ is the i-th indicator evaluated by the battery of tests corresponding to the factor F, $_{\beta Fi}$ is the weight of the i-th indicator of the factor F, and $_{\alpha F}$ is the weight of the factor. $_{\beta i} \in \{1,2,3...10\}$ and $_{\alpha F} \in \{1,2,3,4\}$. FA is the adjustment factor.

The classification of the schoolchildren in Gold Score Athletics was defined using the following criteria: <40% Developing Sport Potential; 40-59% Average Sport Potential; 60-80% High Sport Potential; >80% Sport Potential of Excellence.

Model Validation

For construct validity, the outcome was considered whether the student was selected for the Friendship Games from 2018 to 2019. For predictive validity, it was considered as an outcome of whether the student was a medalist or not in the athletics competition held in the Internal Games of the Military School of Juiz de Fora in 2021.

Chart 2. Factors and indicators used in the mathematical model for calculating Gold Score Athletics.

Factors	Indicators
F1- Anthropometric	Predicted Adult Height, Body Mass and Size.
F2- Physical-Motor	Medicine ball Throw, Countermovement jump, Speed 20m, Endurance, Motor Talent.
F3-Psychological	Perceived Competence, Competitive, Winning, Determined, Confidence/Motivation, Trainability, and Coping.
F4-Environmental	Participation in Training, Competitive Level, Family Support
F5-Intangible	Intangible Aspects, Sports Potential.
F6-Performance	Victory in Competition
Setting	Sports Preference. Sport indicated by the Teacher/Trainer, Maturational Stage.

Statistical Analysis

The data were described using mean ± standard deviation (quantitative variables) and percentages (qualitative variables). Cronbach's Alpha correlation coefficient measured the model internal consistency. The intraclass correlation coefficient (ICC) was used to analyze the stability of the diagnosis with a 12-month interval between the first and second evaluations. Construct Student's t-test assessed validity and criterion validity. Finally, the effect size was calculated by Cohen's d. All analyses were done in IBM SPSS software version 24.0 (IBM Corp., Armonk, NY). A value of p≤0.05 was adopted for statistical significance.

RESULTS

Table 1 presents the general characteristics of the students who practice athletics and the Gold Score Athletics comparison to non-athletes.

It was possible to observe that in the analysis of sprinters, 46.9% of the male students were identified as developing potential, 39.3% as medium potential, 11.4% as having high potential, and 2.5% as having potential for excellence. In females, 56.4% were identified as developing potential, 32.8% as medium potential, 9.8% as having high potential, and 1.1% as having excellent potential. For the thrower category, the percentage values found for the male schoolchildren were: 46.4% identified as developing potential, 37.1% as medium potential, 14.0% as high potential, and 2.6% as excellent potential. For the schoolgirls, they were: 47.8% were identified as developing potential, 42.1% as medium potential, 9.2% as high potential, and 0.9% as excellent potential. In the analysis regarding the sporting potential of male fundists, 52.4% were classified as developing potential, 35.8% as medium potential, 8.6% as high potential, and 3.1% as the potential for excellence. In the analysis of the sporting potential of female fundists, the values found were: 60.2% as developing potential, 30.8% as medium potential, 7.7% as high potential, and 1.4% as excellent potential. The data are presented in Figure 1.

Statistically significant differences were observed in all comparisons, both for boys [sprinters *vs*. throwers (p= 0.004); sprinters *vs*. (p= <0,001);

Table 1. Comparison of multidimensional indicators of sporting potential and Gold Score Athletics of 13 to 17-year-old school athletes and non-athletes.

Indicators	Male				Female			
	Athletes (n = 103)	Schoolchildren (n = 410)	p-value	d	Athletes (n = 72)	Schoolchildren (n = 439)	p-value	d
Chronological age (years)	15.6±1.3	15.0±1.3	<0.001	0.46	15.0±1.3	15.0±1.3	0.92	0.01
Birth Quartile (1ºQ)	22.3%	22.7%	0.42	0.07	19.4%	28.0%	0.16	0.10
Anthropometric								
Body Mass (kg)	60.0±9.1	61.5±13.5	0.19	0.11	52.5±9.2	54.7±10.9	0.11	0.20
Height (cm)	170.5±7.0	169.2±7.9	0.13	0.16	159.6±5.9	160.1±6.0	0.45	0.08
Width (cm)	174.0±8.2	172.7±9.1	0.19	0.14	161.4±6.4	161.9±7.4	0.54	0.06
Fat Percentage (%)	14.1±6.8	17.2±7.1	<0.001	0.43	21.6±4.4	24.0±5.7	0.001	0.42
Physical-Motor								
Flexibility (cm)	25.2±8.1	22.8±9.1	0.02	0.26	32.2±8.4	29.1±8.1	0.005	0.38
Hand Grip (kgf)	36.6±8.5	33.4±8.9	0.001	0.36	25.5±5.3	24.9 ±5.7	0.46	0.10
Medicine Ball Throw (m)	5.2±0.9	4.8±0.9	<0.001	0.44	3.6±0.48	3.4±0.48	0.01	0.41
Vertical jump (cm)	33.8±7.4	28.8±6.6	<0.001	0.75	24.4±4.2	21.0±4.2	<0.001	0.80
Speed 20 m (s)	3.28±0.27	3.49±0.28	<0.001	0.75	3.71±0.26	3.98±0.31	<0.001	0.87
20m back and forth race (m)	1470.5±410.1	1047.7±330.6	<0.001	1.27	887.4±250.0	645.0±223.3	<0.001	1.08
VO_2max (ml/kg/min)	50.4±5.3	45.4±4.8	<0.001	1.04	43.0±4.1	39.6±4.1	<0.001	0.82
Maturational								
Predicted adult height (cm)	176.7±6.7	178.3±6.7	0.04	0.23	162.9±5.1	163.3±5.5	0.60	0.07
PAH (%)	96.5±3.5	94.9±4.1	0.001	0.39	97.9±1.9	98.0±1.9	0.76	0.05
Z-score	0.60±0.77	0.59±0.74	0.85	0.01	-0.72±1.08	-0.68±1.17	0.75	0.03
Status Maturacional								
Delayed	0.0%	1.9%	0.37	0.06	45.7%	38.8%	0.55	0.05
Normomature	72.7%	72.9%			47.1%	53.4%		
Advanced	27.3%	25.2%			7.2%	7.8%		
MO (years)	1.42±1.1	1.0±1.2	0.001	0.35	2.1±0.9	2.2±0.9	0.74	0.11
APHV (years)	14.1±0.7	14.0±0.6	0.005	0.16	12.9±0.6	12.8±0.6	0.51	0.16
Psychosocial								
Coping Skills	12.4±2.8	10.4±3.0	<0.001	0.66	11.6±3.1	9.5±2.7	<0.001	0.77
Perceived Competence	7.2±1.6	6.2±1.7	<0.001	0.59	6.9±1.5	5.9±1.6	<0.001	0.21
Winner	2.6±0.8	2.5±0.8	0.003	0.12	3.5±0.7	3.4±0.8	0.37	0.12
Determined	4.3±0.7	4.0±0.9	<0.001	0.33	4.3±0.5	3.8±0.8	0.002	0.62
Competitive	4.1±0.8	3.5±0.8	<0.001	0.75	3.9±0.7	3.3±0.8	<0.001	0.75
Family Support	26.2±7.3	24.6±8.2	0.01	0.19	26.5±8.0	22.0±8.4	<0.001	0.53
Coach Evaluation								
High Sports Potential (%)	20.1%	79.9%	<0.001	0.32	14.1%	85.9%	<0.001	0.25
Intangibles	31.0±10.0	25.6±8.3	<0.001	0.65	27.3±8.2	22.3±7.9	<0.001	0.63
Gold Score Athletics								
Sprinters (%)	55.8±17.7	37.5±13.3	<0.001	1.37	59.5±16.6	37.7±13.5	<0.001	1.61
Throwers (%)	52.7±15.2	38.4±13.3	<0.001	1.07	54.4±13.8	38.4±11.6	<0.001	1.37
Fundists(%)	55.6±17.2	35.8±11.8	<0.001	1.67	57.7±16.2	36.8±12.5	<0.001	1.67

(%PAH: Attained percentage of predicted adult height; MO: Maturity Offset; APHV: Age at peak height velocity.

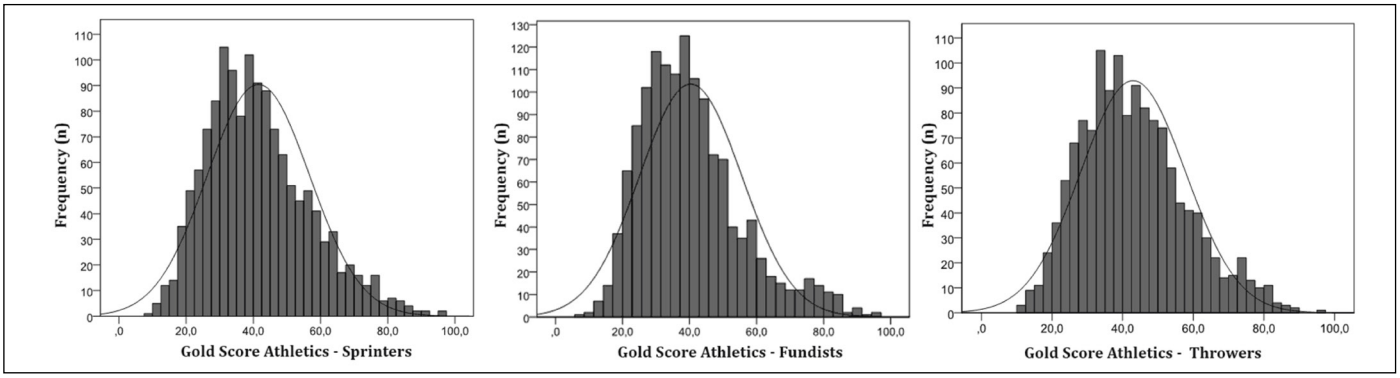

Figure 1. Histogram of the Gold Score Athletics of male (n = 731) and female (n = 653) schoolchildren for the speed, throwing, and long-distance running events.

sprinters vs. fundists (p= <0,001)] and for girls [sprinters *vs*. fundists (p= <0,001); sprinters *vs*. throwers (p= <0,001); fundists vs. (Figura 2)

The internal consistency of the sport potential factors ranged from 0.76 (female fundists) to 0.82 (male fundists and throwers) and the stability of the sport potential factors ranged from 0.72 (Female throwers) to 0.81 (throwers), as presented in Table 2.

The construct validity and criterion validity were satisfactory, and it was observed that the selected students (Table 3) and the medal-winning students had higher Gold Score Athletics. The difference between non--selected and non-medal-winning students was statistically significant (Table 4). From a practical point of view, the observed differences were of moderate to high magnitude.

DISCUSSION

In the present study, a linear, multidimensional, hybrid, computerized mathematical model was developed that provides a valid and reliable estimate of the sporting potential of school athletes in track and field, called the Gold Score Athletics. In addition, the model presented satisfactory psychometric properties, regarding internal consistency and diagnostic stability after 12 months, validly discriminating schoolchildren of different competitive levels and the highest level of victory in the competition. Gold Score Athletics is a technological innovation that combines a battery of tests, biological maturation, the coach's eye, and statistical modeling, forming an expert system to support teachers and coaches in their decision-making the process of identification, selection, and development of sports talent in school, with strong social impact and relevance to physical education and school sports.

The development of Gold Score Athletics corroborates previous studies that have also developed school-age talent identification models, for example *Sport Interactive* in the UK,[2] *Sport Talent* in Croatia[32] and the *Flemish Sports Compass* in Belgium.[33]

To predict future success in athletics, Henriksen, Stambulova, and Roessler (2010)[40] developed a performance prediction model based on an ecological and holistic approach that encourages practitioners to broaden their focus beyond themselves to help them in a successful transition to the professional level. In Poland, Maszczyk, Zając, and Ryguła (2011)[15] used neural models to establish a predictive relationship for throwing sports outcomes, and found a good relationship between the *Perceptron* network model and outcome prediction. Another study that proposed predicting future success was conducted by Liu and Schutz (1998).[14] These authors proposed identifying the best mathematical model and data set to predict future athletic performance. But to date, it appears that Gold Score Athletics is the first mathematical model that uses a multidimensional test battery, an assessment of biological maturation, an analysis of environmental and psychological factors, and a subjective assessment by teachers.

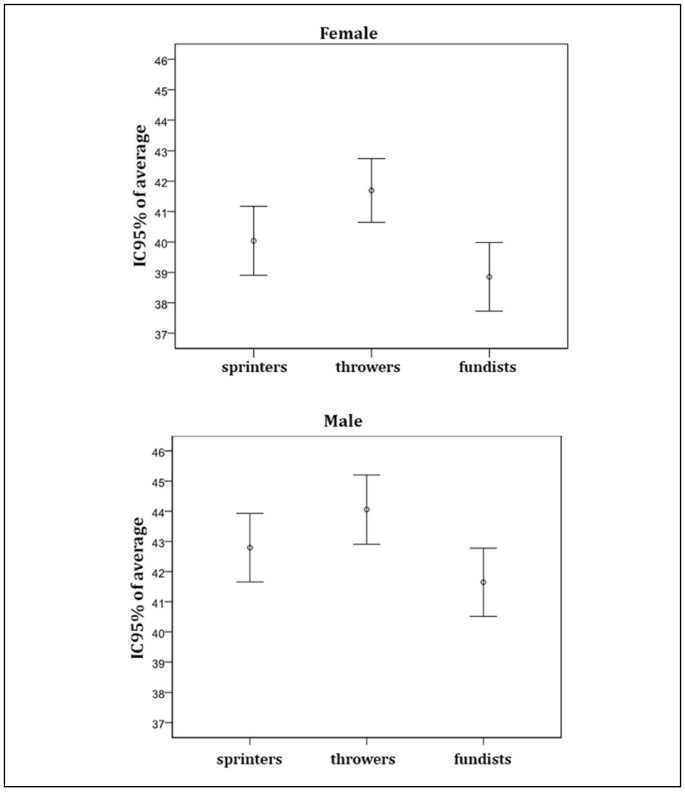

Figure 2. Gold Score Athletics bar-and-error graph of male (n = 731) and female (n = 653) schoolchildren for the speed, throwing, and cross-country running events.

Table 2. Internal consistency and stability after 12 months of the sport potential factors and the Gold Score Athletics in school athletics athletes.

Gold Score Athletics	Internal Consistency		Stability		
	Mean ± SD	Alpha	Baseline	After 12 months	CCI (IC95%)
Male					
Sprinters	42.8±15.6	0.81	41.4±14.5	44.1±16.4	0.78 (0.71-0.83)
Throwers	44.0±15.8	0.82	42.8±15.2	45.2±16.2	0.81 (0.75-0.85)
Fundists	41.6±15.6	0.82	41.0±15.0	42.2±16.1	0.78 (0.72-0.83)
Female					
Sprinters	40.0±14.7	0.76	40.3±14.1	39.7±15.3	0.77 (0.70-0.83)
Throwers	41.7±13.6	0.76	41.5±12.9	41.9±14.3	0.72 (0.63-0.78)
Fundists	38.8±14.6	0.77	39.7±14.2	38.1±15.1	0.75 (0.67-0.81)

To be more accurate in predicting talent, the performance and current condition of the schoolchild must be evaluated through physical-motor tests. Still, one must also consider what is expected concerning his or her development and prospects. The preliminary modeling performed by the Gold Athletes Project®, it was shown that the proposed test battery measures current performance. At the same time, the coaches' opinion

Table 3. Comparison of Gold Score Athletics for the speed, throwing, and distance running events in schoolchildren selected and not selected for the Friendship Games - a national level school competition.

Factors / Models	Group		p-value	D
	Selected	Not Selected		
Male	**n = 91**	**n = 640**		
Sprinters	55.2±14.7	41.0±14.9	0.000*	0.95
Throwers	56.8±14.8	42.2±15.1	0.000*	0.96
Fundists	54.5±15.1	39.8±14.8	0.000*	0.99
Female	**n = 77**	**n = 576**		
Sprinters	55.5±14.1	37.9±13.5	0.000*	1.30
Throwers	57.1±12.8	39.6±12.3	0.000*	1.42
Fundists	55.2±16.8	36.6±12.9	0.000*	1.44

(*statistically significant difference, $p<0.05$; *d*: effect size)

Table 4. Comparison of the Gold Score Athletics for the speed, throwing, and distance running events in medal-winning and non-medal-winning schoolchildren in a school athletics competition 2 to 3 years after diagnosing athletic potential.

Factors / Models	Competition Performance		p-value	d
	Medalists	Non-Medalists		
Male	**n = 24**	**n = 201**		
Sprinters	54.3±22.2	44.8±15.1	0.006*	0.62
Throwers	56.7±20.5	45.9±15.5	0.002*	0.69
Fundists	54.8±24.1	43.0±14.5	0.001*	0.81
Female	**n = 20**	**n = 160**		
Sprinters	63.5±13.1	40.4±14.0	0.000*	1.65
Throwers	55.0±11.9	43.8±12.5	0.000*	0.89
Fundists	64.0±13.7	41.1±12.2	0.000*	1.87

(*statistically significant difference, $p<0.05$; *d*: effect size)

estimates the development potential, so they should be analyzed together for better understand athletes' sporting potential.[37] Thus, Gold Score Athletics, *the* mathematical model proposed in this study, confirms the hypothesis that sporting talent is identifiable and measurable. It can be estimated through a linear equation and the main factors and indicators of sporting potential.

As athletics is composed of a great variety of disciplines, consequently, it demands different athletic profiles from its participants. Considering this characteristic, the Gold Score Athletics presents itself as a valid model to discriminate the schoolchildren regarding their potential for each group of tests, since different scores were identified according to the group of tests analyzed.

The construct validity of the Gold Score Athletics was evidenced when it was observed that the scores developed to compare schoolchildren selected for the games were higher than the scores of schoolchildren who had not been selected. It was also observed that the Gold Score Athletics showed predictive validity since the scores of medal-winning schoolchildren were higher than those of non-medal-winning schoolchildren, demonstrating that the predictive data initially collected by the model for athletic talent was confirmed through the positive performance results (being a medal winner). These results confirm that the model, for being multidimensional, presents greater effectiveness than an individual analysis of teachers and coaches, or even of models that consider, for example, only the physical-motor aspects, corroborating the statements of the study by Baker, Cobley, Schorer, and Wattie (2017).[29]

The results also corroborate several studies in athletics that found statistically significant differences between athletes in different events[45,46] and competitive levels[47,48] and that have investigated performance predictor variables.[40,14,15]

CONCLUSION

The Gold Score Athletics presents itself as a dynamic tool, with a holistic characteristic, applied to the process of identification and development of sports talent in school, since it qualitatively and quantitatively analyzes a large number of multidimensional characteristics associated with the sports potential of students practicing or not athletics, becoming an essential tool for talent detection and for predicting future performance.

Gold Score Athletics presents itself as an important tool, as it is applicable in schools and institutions that select, identify, promote, and develop school athletes. With the use of the computerized system, based on the Gold Score Athletics, it is possible to recognize those students who have the greatest potential for excellence in athletics, to increase investments in financial and human resources in the training process of these students, to optimize training to improve the potential and minimize weaknesses, supporting possible decisions of teachers and coaches in the inclusion or exclusion during the development process of the sport.

However, it is necessary to apply systematic evaluations, avoiding hasty judgments based only on cross-cutting diagnoses, guaranteeing development opportunities to all students. The model allows highlighting the best-performing schoolchildren at the time of evaluation, but also to conduct the results so that the schoolchildren are offered the best conditions to develop at the limit of their potential, considering that they may present a superior performance in the future, also considering the maturation process.[34]

As limitations, it should be noted that the normative values refer to the sample itself, making it possible to generalize the results only to the competitive level in which the study participants are inserted. Nevertheless, the difficulty of detecting sports talent is inherent to the theme. Furthermore, new studies may contribute to a better understanding of the phenomenon, allowing constant adaptation of the model proposed in this study.

We conclude that the Gold Score Athletics is a valid and reliable model for estimating and assessing the sporting potential of school athletes. And, given the evidence of validity and stability of the diagnosis performed, it can be said that the modeling of the sporting potential proposed in this study has shown promise as an instrument to systematize the identification of sporting talent for athletics in school.

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