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Originales

Normative values for agility in Brazilian adolescents

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ABSTRACT

Detecting young talents is one of the most significant challenges in the sports sciences. Early performance assessment is an essential component of talent discovery programs. This study aimed to establish normative values and verify the reliability of the Illinois Agility Test (IAT) while assessing the agility of Brazilian adolescents. A total of 649 school adolescents of both sexes between 14 and 18 years old participated in the study performing the IAT. To assess the psychometric quality regarding reliability, part of the sample performed the test in duplicate with a minimum interval of 24 hours and a maximum of 72 hours. The following percentile values were established for the male IAT: (P5 < 17.76 s) for “Excellent”; between P40 and P60 (19.37 to 20.24 s) for “Regular”; P80 > 21.21 s as “Much below average”. For the female IAT, the following values were established (P5 <20.84 s) for "Excellent"; between P40 and P60 (22.88 to 23.85 s) for "Regular"; P80> 25.08 s “Much below average”. Bland-Altman analysis pointed to an ICC of 0.936. Agility performance curves for adolescents were developed, collaborating to detect talent when the IAT obtained a performance less than or equal to 17.76 s for males and 20.84 s for females.

Keywords: Athletic performance; physical activity; physical fitness; teenagers.

Valores normativos de la agilidad en adolescentes brasileños

RESUMEN

La detección de jóvenes talentos es uno de los retos más importantes de las ciencias del deporte. La evaluación temprana del nivel de rendimiento es un componente esencial de los programas de descubrimiento de talentos. El objetivo de este estudio fue establecer valores normativos y verificar la repetibilidad del Illinois Agility Test (IAT) en la evaluación de la agilidad de adolescentes brasileños. Participaron en el estudio 649 estudiantes adolescentes de ambos sexos entre 14 y 18 años, por mediodel IAT. Para evaluar la calidad psicométrica en cuanto a la repetibilidad, parte de la muestra realizó la prueba por duplicado con un intervalo mínimo de 24 horas y máximo de 72 horas. Para el IAT masculino se establecieron los siguientes percentiles: P5 (< 17,76 s) para “Excelente”; entre P40 y P60 (19,37 a 20,24 s) para “Regular”; y P80 (> 21.21 s) como “Muy por debajo del promedio”. Para el IAT femenino se establecieron los siguientes valores P5 (<20,84 s) para “Excelente”; entre P40 y P60 (2,88 a 23,85 s) para "Regular"; y P80 (> 25,08 s) “Muy por debajo de la media”. El análisis de Bland-Altman indicó un ICC de 0,936. Se desarrollaron curvas de rendimiento de agilidad para adolescentes, que pueden ser utilizadas para detectar talento cuando el IAT obtenga un rendimiento menor o igual a 17,76 s para varones y 20,84 s para mujeres.

Palabras clave: Rendimiento atlético; Actividad física; aptitud física; Adolescentes.

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Valores normativos de agilidade em adolescentes brasileiros

RESUMO

Detectar jovens talentos é um dos desafios mais significativos nas ciências do esporte. A avaliação de desempenho precoce é um componente essencial dos programas de descoberta de talentos. O objetivo deste estudo foi estabelecer valores normativos e verificar a repetibilidade do Illinois Agility Test (IAT) na avaliação da agilidade de adolescentes brasileiros. Participaram do estudo 649 adolescentes escolares de ambos os sexos entre 14 e 18 anos realizando o IAT. Para avaliar a qualidade psicométrica quanto à repetibilidade, parte da amostra realizou o teste em duplicata com intervalo mínimo de 24 horas e máximo de 72 horas. Para o IAT masculino foram estabelecidos os seguintes percentis: (P5 < 17,76 seg) para “Excelente”; entre P40 e P60 (19,37 a 20,24 seg) para “Regular”; P80 > 21,21 seg como “Muito abaixo da média”. Para o IAT feminino foram estabelecidos os seguintes valores (P5 <20,84 seg) para "Excelente"; entre P40 e P60 (22,88 a 23,85 seg) para "Regular"; P80> 25,08 seg “Muito abaixo da média”. A análise de Bland-Altman apontou um ICC de 0,936. Foram desenvolvidas curvas de desempenho de agilidade para adolescentes, colaborando para detectar o talento quando o IAT obteve um desempenho menor ou igual a 17,76 seg para o sexo masculino e 20,84 seg para o sexo feminino.

Palavras-chave: Performance atlética; Atividade Física; Aptidão física; Adolescentes.

Introduction

Detecting young talents is one of the most significant challenges in the sports sciences. due to several interconnected factors such as physiological, technical, tactical, psychological, and sociological influences[1–5]. A precise selection process considers geographical conditions, allowing better performance and results, as well as contributing to the optimization of human, technical and economic resources[6]. Consequently, it makes the process more effective regarding parameters quality, reducing failure rates and wasted time. Thus, early performance assessment is an essential component of talent discovery programs.

The physical tests, conducted individually or as one of many steps on a test, allow for gathering normative data and distribution, which can be used in different ways regarding talent detection or those with extreme values. Their use also implies on establishing development levels expected when analyzing the same sport in different age groups[7], or establishing the ideal profile according to the tactical function exercised in collective teams[6] or, still, the difference between professional and amateur athletes[6]. Finally, considering some essential physical qualities, it is possible to verify whether a young person has any performance deficit expected for her/his age group, requiring a careful evaluation of the factors that might be negatively influencing the development of a particular skill level[8].

Physical qualities can be divided into two large groups: “physical”, which includes flexibility, and “motor skills”, such as agility[9]. These qualities have very specific characteristics, some of which are easy to control and others more complex, due to their interaction with other physical parameters, like agility. Edwards et al.[10] stated that a good agility performance is essential for success in many competitive sports.

It is noteworthy that the Illinois Agility Test (IAT) has interesting execution characteristics since it largely meets the recommendations of Sheppard and Young[9] for an agility test combined to physical and cognitive qualities. Hachana et al.[11] established that the IAT fulfills the criteria of reliability and validity, hence being an applicable test to assess agility. Therefore, the present study aimed to establish normative curves of agility performance among Brazilian adolescents, applying the IAT and verifying its reliability in such population.

Methods

Participants and recruitment

A descriptive cross-sectional study was conducted with 649 school adolescents (360 females and 289 males) aged from 14 to 18 years old. The participants were recruited from a state school in Minas Gerais, Belo Horizonte, Brazil.

The study proposal was sent to the guardians, with a term of consent to be signed by the underage students, as well as the term of the free and informed consent form (ICF) to collect the parents' signature or to be signed by participants older than 18 years prior to the study. This study was conducted according to the Declaration of Helsinki and approved by the local Institutional Review Board for Human Subject Protection (62163316.7.0000.5153). This study complied with CONSORT guidelines.

The inclusion criteria were volunteers who wished to participate, individuals without orthopaedic or metabolic restrictions, or other problems causing physical discomfort or difficulty. As the data collection was conducted in a full school period, only the students who attended Physical Education classes regularly in the past month of classes were included in the study. Meanwhile, exclusion criteria included pregnant women with sick leave, individuals with poor health status, as well as febrile conditions and motor problems.

Procedures

IAT was applied at a flat surface with a total area of 400 m^2 (20 mx 20 m), 8 cones, stopwatch in the installed application Smartphone iPhone 5 (Apple). Initially, a figure of a rectangle of 10 meters x 5 meters was marked with 4 main cones. On the central axis at the smallest part of the rectangle, at 2.5 meters, 4 secondary cones were positioned parallel to the 10-meter axis at 3.33 meters each, as shown in Figure 1.

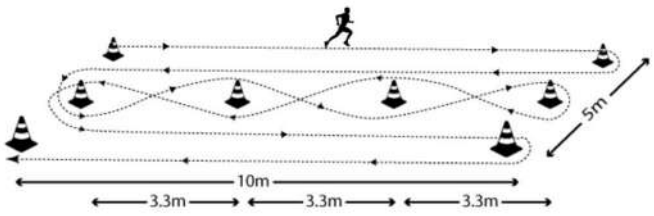

Figure 1. Illinois Agility Test (IAT) protocol illustration.

Considering the characteristics of the test, each participant covered the course in a preparatory manner on two occasions. The first trotting, the second with a light run, without time recording.

Table 1. Characteristics of young scholars assessed

Variables	Males (n= 289)	Females (n= 360)
Body Mass (kg)	67.78 ± 13.25; (44 – 149.5)	60.14 ± 13.17; (37.4 – 119.9)
Height (m)	173.9 ± 6.3; (155.5 – 200)	162.16 ± 6.18; (144.5 - 183)
IAT	19.98 ± 1.63; (16.54 – 25.80)	23.59 ± 2.06; (19.51 – 33.94)

Data are presented as mean ± standard deviation (minimum-maximum). IAT, Illinois Agility Test.

Table 2. Percentile values for high school students of both sexes proposed at different classification levels in the IAT in seconds.

Percentile	Males	Classification	Females
5%	17.76	**EXCELLENT**	20.84
10%	18.10	**MUCH ABOVE AVERAGE**	21.20
15%	18.44		21.61
20%	18.59	**ABOVE AVERAGE**	21.87
25%	18.80		22.10
30%	18.97		22.40
35%	19.14		22.70
40%	19.37	**REGULAR**	22.88
45%	19.58		23.10
50%	19.80		23.33
55%	20.05		23.52
60%	20.24		23.85
65%	20.37	**BELOW AVERAGE**	24.20
70%	20.64		24.48
75%	20.89		24.81
80%	21.21	**MUCH BELOW AVERAGE**	25.08
85%	21.68		25.43
90%	22.23		26.16
95%	22.91		27.14

The third attempt was at maximum speed with time recording. The participant started in a prone position, with their hands resting on the floor and their arms lined with their shoulder's height. When commanded, the participant quickly moved in a linear run to the second main cone, making a 180° turn and running diagonally to the first central cone. Then, they performed zigzag movements to the fourth central cone until returning to the first cone. At this point, the participant ran diagonally to the third main cone, rotating almost 180°, and finishing with a linear run to the last central cone, where the final time was recorded. Moreover, in case of execution difficulty, a minimum of 2 minutes of recovery were given before a second attempt. The timing was considered in seconds and hundredths of seconds. The stopwatch was settled along with the test start and stopped once the final line was crossed.

All the tests were conducted during class hours at the school's sports court on a covered, painted cement floor. Data collection was gathered by a trained researcher at the presence of the class teacher assisting the dynamics of the tests. The data collected included name, age, sex, grade, class, test registration time, and anthropometric data.

As a standard procedure, no organic or local muscle warm-up was performed, besides only two rehearsals to facilitate the memorization of the route in each one of the tests, which were applied on different days, with a minimum interval of 48 hours. No verbal stimulation or feedback of any type were provided to the participant. To meet the reliability goal of the study, at least 20% of the sample was reassessed with an interval between 48 and 72 hours.

Anthropometric measurements were taken in different days of the tests in a private area. Body mass was measured using a scale with a 50 grams precision, and height was measured with a stadiometer (Sanny®) with a 1 mm precision, following the International Society for the Advancement of Kinanthropometry recommendations.[12]

Statistical Analysis

Statistical analysis was performed using descriptive analysis with mean, standard deviation, maximum and minimum values. Subsequently, based on the timing results, we established normative tables of performance sing the percentiles 5,10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 70, 75, 80, 85, 90, and 95% for performance classification. To ensure the quality of the proposed table of normative data, each group had a number of assessed ones greater than 100. Then, the following cut-off points were recommended for the six performance categories for both tests and sexes: <P5% for the excellent category; between P10 and P15% for "Much above average"; between P20 and P35% "Above average"; between P40 and P60% "Regular"; between 65 and 75% "Below average"; > P80% "Much below average". The classification proposed by Davies et al.[13] was used for the participants aged between 16 and 18.

Moreover, to assess psychometric quality regarding reliability, part of the sample performed the test in duplicate with a minimum interval of 48 hours and a maximum of 72 hours.

The paired Student's t-test was performed to assess the test's reliability. Pearson's correlation level between test and re-test was established. The Bland-Altman test was also used to determine the interclass correlation coefficient between test and retest, following the criteria established by Koo and Li[14].

The statistical software Primer® was used to calculate Student's t-test and correlation tests. For all tests was used a significance level of $p < 0.05$. The results of the Bland-Altman test were conducted by Statistical Package for Social Science (SPSS - version 13.0).

Results

A total of 649 high school students were evaluated, 289 males (16.9 ± 0.9 years) and 360 females (16.8 ± 0.9 years). Table 1 presents body mass, height, and IAT performance.

The obtained IAT values allowed the establishment of the percentile curve (excellent, much above average, above average, regular, below average, and much below average), as indicated in Table 2, for each sex.

Table 3. Number of participants in each percentile classification range by sex

Level of Classification	Males (n=289)	Females (n=360)
Excellent	12 (4.15 %)	19 (5.27%)
Much above average	32 (11.07%)	36 (10.00%)
Above average	57 (19.72%)	80 (22.22%)
Average	72 (24.91%)	84 (23.33%)
Below average	43 (14.87%)	53 (14.73%)
Much below average	73 (25.28%)	88 (24.45%)

Table 4. Performance in seconds of the test and retest of IAT obtained in young high school students

Sex	IAT (T1)	IAT (T2)	Δ (T1 -T2)	p	Correlation(r)
Male (n = 100)	19.45 ± 1.36 (16.65 – 23.10)	18.85 ± 0.95 (15.46 – 19.33)	0.60	< 0.001	0.71
Female (n = 87)	22.75 ±1.98 (19.51 – 30.52)	22.11 ± 1.78 (18.88 – 29.74)	0.64	< 0.001	0.78

Data are presented as mean ± standard deviation (minimum-maximum). IAT, Illinois Agility Test.

Table 3 shows the number of participants within each percentile classification range, as indicated in Table 2.

To verify the reliability level of the IAT, 100 male students (age: 16.9 ± 0.9 years; body mass: 66.04 ± 10.3 kg; height: 172.08 ± 18.8 cm) representing 34.6% of the sample, and a group of 87 female students (age: 16.89 ± 0.90 years; body mass: 59.45 ± 12.30 kg; height: 161.71 ± 6.09 cm) representing 24.16% of the total sample were reevaluated under the same conditions, on different days. Table 4 shows the descriptive values obtained for both sexes, in addition to p value for the Student's T-test for paired samples, as well as the correlation values obtained by the test and retest.

For males, despite having a strong correlation level between the first and the second test (r = 0.71), the paired Student's T-test indicated that the observed difference of 0.60 seconds between the first and the second test was significant (p <0.001). For females, the observed behavior was similar to males, once a correlation value of r = 0.78 was considered to be strong. However, the difference of 0.64 seconds between the first and second tests was also considered significant (p <0.001), similar to what was observed for males.

Figure 2 shows the results obtained from the Bland-Altman protocol to assess the interclass correlation coefficient (ICC) for the IAT test (test vs. retest), gathering all young people assessed and obtaining a high ICC of 0.936, considered to be excellent by the criteria established[14].

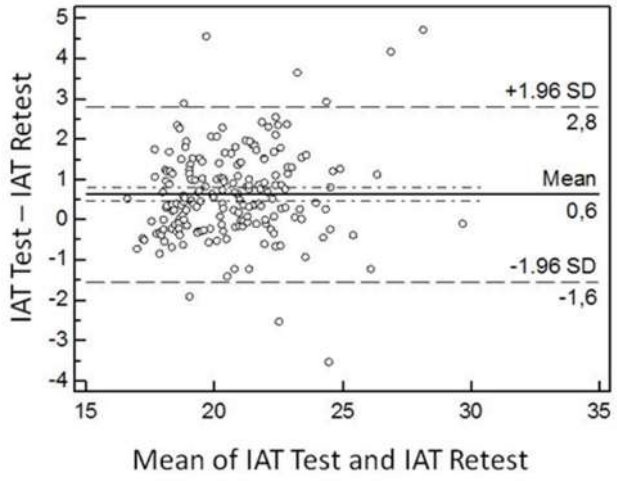

Figure 2. Bland-Altman graph for the IAT test (test vs. retest) gathering all the assessed participants.

Discussion

The present study aimed to establish normative curves of agility performance among Brazilian adolescents, applying the IAT and verifying its reliability in such population. The average performance in the IAT obtained for both male (19.98 ± 1.63 s) and female adolescents (23.59 ± 2.06 s) are classified as "very poor" according with the classification developed for North American adolescents[13]. This indicates that, on average, the assessed group, regardless of sex, requires the inclusion of supervised physical activities to improve the agility level.

The "poor performance" reported, when comparing to North American young population, supports a warning signal of an increased sedentary behavior trending among Brazilian adolescents[15], with a higher prevalence among females. Therefore, the recommendation should be to increase levels of physical activity and physical performance avoiding a worse situation in the coming decades.

Considering a normative standard for our cultural reality, it is interesting to observe that the distribution of participants in the "excellent" category of the percentile curve proposed in this study was close to 5% of the total sample regardless of sex (Table 3). In theory, these young people have, at least among their "peers", a greater physical performance parameter, which can still be improved with training. Therefore, this can be endorsed among team sports in which agility plays an essential role in performance[16].

The performance of these young male students is close to young soccer players[17,18] and military personnel[19]. However, it is noteworthy to mention the age of the appraised participants of the respective studies. Only the participants of the study by Raya et al.[19] were much older than our assessed group, while in the remaining studies ranged between 13 and 14 years. On the other hand, the female participants in the present study also had a worse performance (23.59 ± 2.06 s) when compared with Turkish university students (20.8 ± 1.9 s).[20]

Therefore, age is an essential factor to notice regarding the development of some issues that influence the final results of the agility test[21]. According to Zemková and Hamar[16], agility performance increases with advancing age until adolescence. Their values markedly decreased from 7 to 10 years old (27.1%) and from 10 to 14 years old (26.5%), followed by a slow period of 14 to 18 years old (16.5%). This fact generates the need to prepare normative tables considering the age group. Also, the use of cleats facilitates the grip on the floor in the five 180° turns in studies with soccer players can directly affect the final result of the test.

According to Vescovi et al. [7], the peak of development of agility obtained in 414 young soccer players between 12 and 21 years old occurs between 15 and 16 years old, which is precisely the age group assessed in the present study. According to the same authors, different normative tables must be established for adult participants. A study conducted with soccer players of different ages in the U12, U14, U16, and U18 categories, observed that age is a determining factor in performance, having the two initial categories as the worst level of performance in comparison to older athletes[21]. This makes it necessary to elaborate age-specific normative tables, similar to what was done in the present study.

The results found in the present study reinforce the need to create a specific normative data table for adolescent population and enable the monitoring of the secular trend. Several studies with similar models were conducted in Brazil considering other physical parameters, such as one conducted by Silva et al.[22] in the city of Cariri (Ceará) with 6,238 children and youngsters between 8 and 17 years old; and by Guedes and Guedes [23] who proposed normative tables in various physical tests for the Brazilian population. Therefore, this study aims to provide a pioneering table for assessing agility using the IAT, considering that there are no references for this protocol in Brazil. The results obtained in the present study might also collaborate with international comparison studies, considering that the IAT comprises a simple, quick test, easy to apply in its logistics, facilitating its replication in any country.

The percentile curve presented in Table 2 can be used as a reference for high school students, contributing to a diagnosis of the student's fitness level for this assessed physical quality. Performances with scores above the 50% percentile would still indicate the need for greater attention among youngsters, aiming to identify which factors would be causing a negative result.

As part of the main goals of this study the reliability of the IAT was assessed, which corresponds to the most important characteristic of a measure[23]. A test has a good level of reliability when there is consistency or an observed repetition, to a certain degree in which repeated measures of the same variable are replicated under the same conditions and by the same participant on different occasions[24]. In the present study, these conditions were followed, being assessed by the same physical educator (intra-evaluator reliability), in the same participant sample, same school environment (sports court), and same time of the day. Regarding the reliability of the IAT results, the finding was interesting. Pearson's correlation value indicates a “strong correlation” regardless of sex, which certifies a test with a good reliability index[24].

It should be highlighted that in the second testing moment, there was a gain of almost 0.6 s for both males and females. This difference was considered significant when using the paired Student's t-test. This difference between the results of the test vs. retest, can be credited to a greater understanding of the situation and improvement of the cognitive aspect of the task,[25] considering that in the time interval between the test and retest, around a week, there was no improvement in basic physical qualities that could influence the result. Thus, a more appropriate familiarization witht the test should be required before the evaluations.

By analyzing test and retest performance in all youngsters using the Bland-Altman test, it was possible to obtain an ICC = 0.94, which is considered to be high, better than the obtained by Katis and Kellis[18] (ICC = 0.85), and similar to Hachana et al.[11] (ICC = 0.96), who established that the IAT has quite good reliability criteria to assess agility. Daneshjoo et al.[26] also found high reliability when assessed by the IAT's ICC, ranging the ICC results from 0.89 to 0.96. Therefore, the IAT's reliability can be considered positive; however, due to the cognitive requirement, we recommend conducting a period of familiarization with the dynamics of the test to obtain a better result. It should be highlighted that the test was conducted without warm-up, aiming to standardize the basic condition.

Amiri-Khorasaniet al.[27] observed in their study that the type of warm-up interferes with the result of the IAT. The study was conducted with professional soccer players divided into two groups with less (5.12 ± 0.83 years) and greater training experience (8.18 ± 1.16 years), respectively, comparing four forms of warm-up before IAT and it concluded that dynamic stretching improves performance significantly and the more experienced the players are, the more agile. Taher and Parnow[28] also observed similar results with elite high school soccer players. Therefore, better performances can be expected when choosing to perform an organic warm-up, which will also cause the tables proposed in the present work to be reassessed, changing the classification patterns.

The IAT is interesting because its execution characteristics largely meet the recommendations of Sheppard and Young[9] for an agility test to combine physical and cognitive qualities. Therefore, it should be included as a routine test for the second phase of elementary school and high school. Thus, the proposition of the normative data presented in this study allows it to be used as a reference in the diagnostic, formative, and summative assessment throughout the school year, especially in high schools, in Brazil.

The present study had some limitations, such as the fact that the test timing was marked using a manual stopwatch. A photocell system would gather greater data precision. The relationships between maturation and anthropometric and physical performance characteristics are dynamic and can often produce interpretation errors, confusing the ability to accurately assess adolescent performance during adolescence. As the age group of the adolescents assessed had different maturation levels, the identification of maturation age could provide interesting information for a better interpretation of the results and an anthropometric survey.

Conclusions

The agility performance curves for high school students have been established based on sex and the type of test used. These curves can aid in talent identification, with optimal IAT performance defined as less than or equal to 17.76 seconds for males and less than or equal to 20.84 seconds for females. Additionally, the IAT demonstrated a high reliability index, making it a highly recommended test for assessing agility in high school adolescents.

Youth training process plays an important role in affecting positively the development of individual components of athletic performance. These findings might help sports practices for clinicians and conditioning coaches, particularly by helping to identify and improve talent identification programs' accuracy through a physical fitness assessment.

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