

APPLICABILITY OF AN AGILITY TEST IN YOUNG PLAYERS IN THE SOCCER FIELD

APLICABILIDADE DE UM TESTE DE AGILIDADE EM JOVENS FUTEBOLISTAS EM CAMPO

APLICABILIDAD DE UN TEST DE AGILIDAD EN FUTBOLISTAS JÓVENES EN EL CAMPO



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ABSTRACT

Introduction: in soccer, agility is a relevant parameter that is defined as the ability to change the direction of the body rapidly and is a result of a combination of strength, speed, balance and coordination. **Objective:** to demonstrate the reliability and validity of the modified Barrow test in soccer players aged 10 to 14 years, analyze its relationship with age, maturation, experience and body size and test the effectiveness of the protocol for distinguishing performance changes during a 10-month competitive season. **Methods:** fifty-one adolescent Basque soccer players were enrolled. Age, maturation, experience, body size, vertical jump and 15-m sprint were measured. The reliability of the test was analyzed using replicate tests in a subgroup ($n = 34$). Another subgroup of 33 players ($n = 18$, under-11, 10.4 ± 0.3 years; $n = 15$ under-13, 12.0 ± 0.8 years) was evaluated at the beginning and the end of the season. **Results:** the reliability of the test was good (change in mean = -0.5% , 95% CI -1.2 to 0.2 , $SD=0.14$; coefficient of variation = 0.9% , 95% CI -0.7 to 1.5 , $SD=0.25$). Chronological age and adiposity were significant predictors of agility performance ($P < 0.01$). An improvement in performance was observed over a 10-month soccer season, with a significant group effect ($P < 0.01$). **Conclusion:** the agility test demonstrated logic and validity, and proved to be a reliable and objective instrument for assessing adolescent soccer players.

Keywords: sexual maturation, adolescent, athletes, physical fitness.

RESUMO

Introdução: a agilidade é um parâmetro relevante de desempenho no futebol, que pode ser definido como a capacidade de alterar a direção do corpo com rapidez, sendo resultado da combinação de força, velocidade, equilíbrio e coordenação. **Objetivo:** demonstrar a confiabilidade e a validade do teste de Barrow modificado em jogadores de futebol com idade entre 10 e 14 anos, analisar sua relação com idade, amadurecimento, experiência e tamanho do corpo e comprovar a efetividade do protocolo para distinguir as mudanças no desempenho ao longo de uma temporada de 10 meses de competição. **Métodos:** participaram 51 jovens jogadores de futebol bascos). Foram realizadas as seguintes mensurações: idade, maturação, experiência, composição corporal, salto vertical e corrida de velocidade de 15 metros. A confiabilidade do teste foi analisada pela repetição das medidas em um subgrupo de 34 jogadores ($n = 18$ sub-11, $10,4 \pm 0,3$ anos; $n = 15$ sub-13, $12,0 \pm 0,8$ anos). **Resultados:** a confiabilidade do teste foi boa (mudanças da média = $-0,5\%$, IC 95% $-1,2$ a $0,2$, $DP = 0,14$; coeficiente de variação = $0,9\%$; IC 95% $-0,7$ a $1,5$, $DP = 0,25$). A idade cronológica e a adiposidade foram preditores do desempenho de agilidade ($P < 0,01$). Foi observada melhora significativa no desempenho durante os 10 meses de temporada, com efeito de grupo significativo ($P < 0,01$). **Conclusão:** o teste de agilidade demonstrou lógica e validade, além de ser um instrumento confiável e objetivo para avaliar a agilidade em jogadores de futebol adolescentes.

Palavras-chave: maturação sexual, adolescente, atletas, aptidão física.

RESUMEN

Introducción: en fútbol, la agilidad es un parámetro relevante. Así, este parámetro está definido como la capacidad para cambiar de direcciones de forma rápida y es el resultado de una combinación de fuerza, velocidad, equilibrio y coordinación. **Objetivo:** demostrar la validez y confiabilidad del test modificado de Barrow en jóvenes jugadores de fútbol de 10 a 14 años, analizar la relación con la edad, maduración, experiencia y tamaño corporal y comprobar la efectividad del protocolo para distinguir cambios de rendimiento durante una temporada competitiva de 10 meses. **Métodos:** participaron 55 jugadores adolescentes vascos. Se realizaron las siguientes mediciones: edad, maduración, experiencia, composición corporal, salto vertical y sprint de 15 metros. La confiabilidad del test fue analizada mediante test replicado en un subgrupo de 34 jugadores. Otro subgrupo de 33 jugadores ($n = 18$ sub-11, $10,4 \pm 0,3$ años; $n = 15$ sub-13, $12,0 \pm 0,8$ años) fue analizado al principio y al final de la temporada. **Resultados:** la confiabilidad del test fue buena (cambios en la media = $-0,5\%$, 95% IC $-1,2$ a $0,2$, $ES-d = 0,14$; el coeficiente de variación fue $0,9\%$, 95% IC $-0,7$ a $1,5$, $ES-d = 0,25$). La edad cronológica y la

adiposidad fueron predictores del rendimiento de la agilidad ($P < 0,01$). Se observó una mejora importante del rendimiento durante los 10 meses de temporada con un efecto de grupo significativo ($P < 0,01$). Conclusión: el test de agilidad demostró lógica y validez además de ser un instrumento confiable y objetivo para evaluar la agilidad en jugadores de fútbol adolescentes.

Palabras clave: maduración sexual, adolescente, deportistas, aptitud física.

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INTRODUCTION

Soccer is the most popular sport in the world and an increasingly number of youths play soccer in organized programs¹. Although competitive soccer matches implies heavy aerobic demands on players and require them to expend energy at relatively high levels^{2,3}, specific movement patterns often rely on short, intense and repeated episodes of activity that require jumping, sprinting and rapid changes in direction over 90 min⁴. In particular, agility is of relevance as can be defined as the ability to change the direction of the body rapidly and is a result of a combination of strength, speed, balance and coordination⁵.

Agility performance is of relevance in soccer given its multidirectional nature, mostly overlooked in applied research⁴. Agility tests may be an important indicator of performance for soccer and tend to provide a differentiation between non-players, elite and recreational players^{6,7}. Moreover, allowing for protocol differences, agility performance has been noted to be a predictor of playing level in youth soccer, including differentiation of athletes that dropout the sport^{8,9}.

However, no "gold standard" reference for agility testing in soccer players is established, hence its interpretations of agility performance are limited as different tests may examine different factors associated performance⁷. The Barrow zig-zag run agility test was longtime proposed¹⁰, and it has been used in the context of physical education and also team sports^{11,12}. Besides, in some soccer clubs of the Spanish La Liga, the Barrow agility test has been routinely performed as field test^{13,14}. However, to our knowledge, despite the fact that it has been used by the aforementioned clubs for a long time, the usefulness of this test as an agility assessment tool in soccer has not been proved; moreover no reference to reliability or logic validity of the protocol is available.

Reliability, i.e. minimal measurement error of performance, of a test refers to the consistency or reproducibility of performance when someone performs the test repeatedly¹⁵. A test with poor reliability is unsuitable for tracking changes in performance between trials (e.g., usefulness of the training programme) and it lacks precision for the assessment of performance in a single trial¹⁶. Thus, the coach and researcher must make sure that any changes in performance on an agility test following training reproduce altered physical capability rather than the result of variation between or within players¹⁷. On the other hand, it is important that performance on the test represents the physical performance in the real event¹⁵. It has been pointed that analytical procedures should be carefully considered to establish the validity of a physical performance measure^{18,19}.

Talent identification test batteries using multidimensional approaches frequently include physical performance tests^{9,20,21}. Early-to mid-adolescence, about 10-14 years, is often an age range where players are exposed to selection process and prediction of success in soccer and other team sports²², in part because most boys tend to be advanced in the progression through the adolescent growth spurt, although individual differences in timing and tempo are considerable²³. Thus, the validity of agility tests may be influenced by maturation in addition to age and years of training in soccer.

Due to the many questions related to the measurement of agility and taking into account that the Barrow agility test is used in some elite soccer teams despite the fact that it has not been proved to be a useful agility assessment tool, the purpose of the present study was to examine the reliability of the test in soccer players aged 10 to 14 years. Interrelationships of age, biological maturation, training experience and body size with agility performance were also examined. The study also examines the effectiveness of the agility protocol to distinguish adolescent soccer players' changes in performance when exposed to a 10-month season, partitioning the influence of competitive age group (construct validity).

In support of these aims, we hypothesized that the modified test would be able to detect large training-induced changes as well as distinguish between players of different age groups. This would indicate the validity of the test as an assessment of agility in soccer and, more specifically, in adolescent soccer players. Furthermore, the application of the test may become a useful tool and provide practical information to coaches involved in the talent identification processes.

METHODS

The study was based on a total sample of 51 adolescent Basque soccer players, 24 players of the under-11 and 27 players from the under-13 respectively were initially tested assuming a cross-sectional design. The measurements allowed the examination of the relationship of age, maturation, training experience, body size, vertical jump and sprint ability with agility performance. The Ethics committee of the University of The Basque Country for Research on Human Subjects approved this study and in accordance with recognized ethical standards²⁴. All participants and their families received information about the protocol and signed an informed consent form.

Reliability in the agility test was based on replicate tests in a subgroup ($n = 34$) within a day with 10-min period between replicate measurements. To examine the effectiveness of the agility protocols to distinguish adolescent soccer players training responses, as well as performance by age group (construct validity), a subsample ($n = 33$) included 18 players of the under-11 and 15 players from the under-13, aged at baseline 10.4 ± 0.3 years and 12.0 ± 0.8 years respectively. The subgroup of soccer players were evaluated on two occasions during the training-season: first, at the start of the season (pre-season) in October 2009; second, 10 months later in June 2010, the end period of the training-season (end-season). The players were measured and tested within a two week period. No injured players were included in the study.

All measurements were taken under the same external conditions in a sports hall: for the anthropometric measurements, players only wore shorts and for the performance tests they wore shorts, t-shirt and soccer boots, except from the jump test during which they wore running shoes. All testing conditions were standardized for all measurement points, including test order, time of day, hydration and pre-assessment food intake.

All measurements were taken by a single experienced observer following the guidelines outlined by the ISAK (International Society for the Advancement of Kinanthropometry). Stature was measured with a portable stadiometer (Añó Sayol, Barcelona, Spain) to the nearest 0.1 cm. Body mass was measured with a portable balance (Seca, Bonn, Germany) to the nearest 0.1 kg. Leg (subischial) length was estimated as stature minus sitting height. Skinfold thickness from the triceps, subscapular, suprailiac, abdominal, medial thigh and medial calf were measured with the Harpenden Skinfold Caliper (Baty, West Sussex, UK) and summed, as a surrogate of adiposity.

Age at peak height velocity (PHV) was estimated with the maturity offset protocol²⁵. In the determination of maturity offset it is necessary to collect the following information: chronological age (CA), stature, body mass, sitting height and leg length. CA of each player was calculated from his date of birth and the date when the first measurements were made to each player (October 2009). The result of the equation estimates the distance, in years, of an individual to the PHV: $-9.236 + (0.0002708 \times (\text{leg length} \times \text{sitting height})) - (0.001663 \times (\text{CA} \times \text{leg length})) + (0.007216 \times (\text{CA} \times \text{sitting height})) + (0.02292 \times ((\text{body mass}/\text{height}) \times 100))$

The agility test is a modification of the Barrow zig-zag run test¹⁰. The protocol in the present study is intended to measure the agility of movements of the player following a pre-determined route (figure 1). Based on a 5-m square, the players started with a run 7-m with a 90° right turn in the middle of the distance, made a 45° left turn and run a 5-m slalom (three cones 1.5-m after the turn and interspaced 1-m), made a 45° left turn and run 7-m backwards in the middle of the distance, followed by a 90° right turn left change of direction and a 5-m run and finished with a jump stop in the timing mat. The aim of the test is to run overcoming the obstacles in the less time possible. Time (s) was measured using electronic timing lights (Polifemo, Microgate, Italy) positioned at the beginning and arrival of the test. The starting position of the players was standing up. All players had a familiarization test before the first assessment.

In order to measure the vertical jump height, participants performed a counter-movement jump (CMJ) with arm swing. The height (cm) of each jump was measured using an optical measurement system (Opto-jump, Microgate, Italy). The jump was performed on a hard, flat surface.

On artificial turf, soccer players performed a 15-m dash. Time, in seconds, was measured using electronic timing lights (Polifemo, Microgate, Italy) positioned at the beginning and 15-m. The starting position of the players was standing up, 2-m before the first timing light.

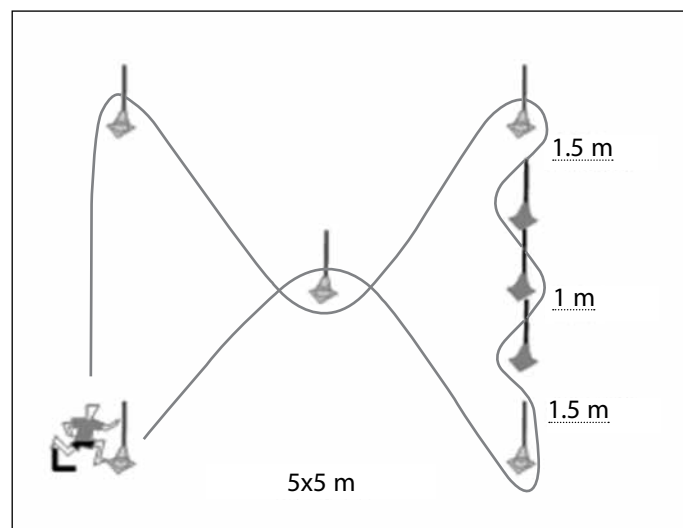


Figure 1. Schematic representation of the modified Barrow agility test.

Descriptive statistics for all measures are presented as mean \pm standard deviation. The change in mean, coefficient of variation (CV) and intraclass correlation coefficients (ICC) were calculated based on replicate tests of agility performance²⁶. Uncertainty in the difference between the first and second trials was expressed as the 95% confidence limits (CL). Data were checked for heteroscedasticity using plots of the log transformed data and reliability measurements (absolute and percent typical errors) were calculated¹⁷.

Multiple stepwise regression analysis was conducted using the linearized equation with log-transformation of variables based on proportional multiplicative models²⁷. The initial predictor variables considered were chronological age, maturity offset, years of formal training experience as exponential terms in addition to stature, body mass, leg length and sum of six skinfolds (adiposity). The models can be linearized with a log transformation, and stepwise multiple linear regression analysis was used to fit the unknown parameters. Validation of the final model was determined by examining the association between the residuals of model against the independent variables to check homoscedasticity of residuals in the log-linear regressions. The coefficient of determination (R²) provides an indication of the variance explained by the independent variables in each proportional model.

Pearson correlations were calculated between agility performance with sprint and vertical jump performances. Correlations between the agility with vertical jump and 15-m sprint were calculated first as zero order and then as partial correlations controlling for the age, growth and maturity predictors identified previously. Correlations were considered as trivial ($r < 0.1$), small ($0.1 < r < 0.3$) moderate ($0.3 < r < 0.5$), large ($0.5 < r < 0.7$), very large ($0.7 < r < 0.9$) and nearly perfect ($r > 0.9$).

The sensitiveness of the agility test to detect training effects as a consequence of a 10-month season was examined based on multi-level regression analysis, adopting proportional curvilinear models²⁸, based on logarithmic transformations of dependent and independent variables. At level 1, each participant's successive measurements over time were defined by an individual changes with season and random error. Individual changes were expressed as percent changes (dependent variables were log-transformed). At level 2, differences in trajectories between groups of individuals were examined. Competitive age group (dummy valuable – U11 coded 0, U13 coded 1) was included in the fixed component of the model to account for possible age effect. All parameters were fixed with the exception of the constant (intercept term) and time of measurement (binary variable – pre-season coded 0, post-season coded 1) parameters, which were allowed to vary randomly at level 2 (between individuals).

RESULTS

Characteristics of the total sample are presented in table 1. Maturity offset values were all negative. Table 2 and figures 2 and 3 show the differences between means of the two test sessions, and CVs and ICCs of the agility test²⁹.

Estimates of the relative contribution of chronological age, maturity offset, years of formal training, stature, body mass, leg length, adiposity, vertical jump and 15-m sprint to agility performance are given in table 3. Independent variables explained approximately 53% of variance in the agility test. The stepwise regression identified chronological age ($P < 0.01$) was positive predictors while adiposity ($P < 0.01$) was negative predictor of agility performance. Zero-order correlations between agility test time with vertical jump ($r = -0.44$, 95% CL -0.64 to -0.19) and 15-m sprint ($r = 0.54$ 95% CL 0.31 to 0.71) were moderate to large

($P < 0.01$). Controlling for chronological age and adiposity the correlation between agility test time with 15-m sprint ($r = 0.26$, 95% CL -0.02 to 0.50, $P < 0.01$) and vertical jump ($r = -0.19$, 95% CL -0.44 to 0.27 $P > 0.05$) became small at best.

The multilevel models showed that the agility test performance presented a significant improvement ($P < 0.01$), suggesting a possible beneficial effect of soccer specific training in agility (table 4). Also, accounting for the influence of age group revealed that older players had significantly better performances, but the rate of improvements appears to be similar by age group (figure 4).

Table 1. Descriptive statistics for the total sample ($n = 51$).

	Mean	Standard deviation	Range
Chronological age, years	11.2	0.8	9.8 – 13.7
Age at peak height velocity, years	14.5	0.39	13.5 – 15.4
Maturity offset, years	-3.32	0.62	-4.35 – -1.57
Years of training, years	4.4	1.3	2.0 – 7.0
Stature, cm	146.9	7.2	129.9 – 162.8
Mass, kg	38.0	5.7	26.8 – 50.3
Sitting height, cm	72.4	3.7	64.0 – 79.0
Leg length, cm	74.9	4.7	65.9 – 85.9
Sum of skinfolds, mm	55.5	22.9	25.0 – 140.0
Vertical jump, cm	34.2	6.0	20.8 – 49.9
15-m sprint, s	2.53	0.11	2.28 – 2.72
Agility test, s	11.74	0.51	10.73 – 13.11

Table 2. Reliability estimates of Agility test measured two trials in 10 to 14 years old male soccer players ($n=34$).

	Trial 1 mean (SD)	Trial 2 mean (SD)	Mean differences (%) (95% CL)	Coefficient of variation (%) (95% CI)	ICC (95% CI)
Agility test, s	11.60 (0.43)	11.54 (0.43)	-0.5 (-1.2 to 0.2)	0.9 (0.7 to 1.5)	0.94 (0.83 to 0.98)

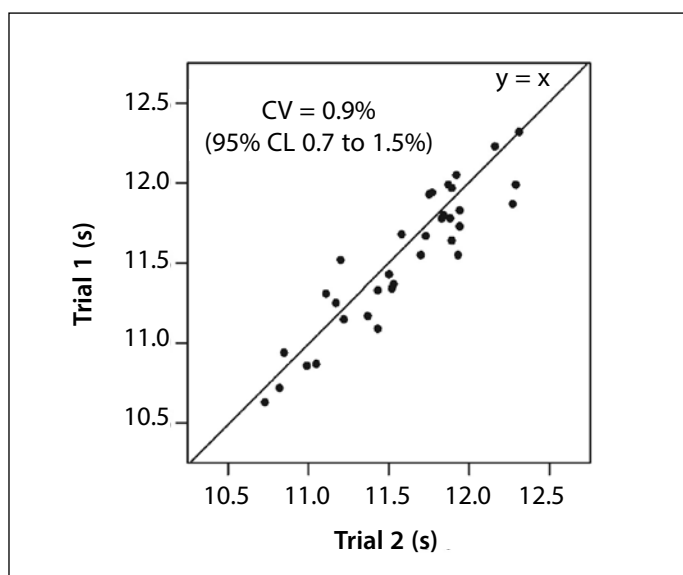


Figure 2. Difference (mean of mean differences) between trials of the Agility test. Full Line is the identity line ($x=y$).

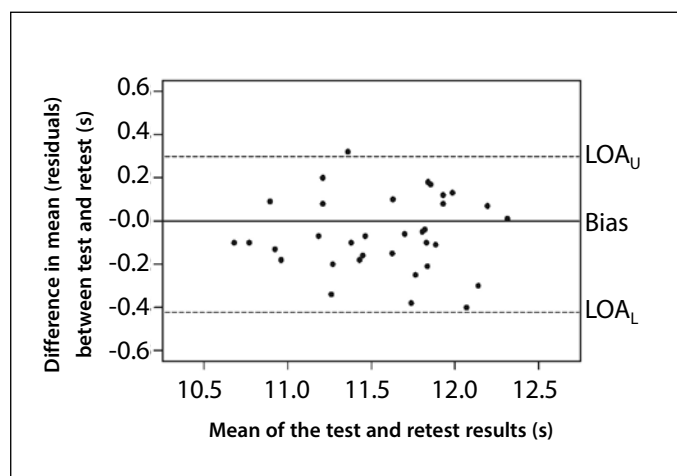


Figure 3. Differences between Agility test and retest measured against average performance (s) for both test sessions verified by Bland and Altman plot²⁹. The bias line and the upper and lower 95% limits of agreement (LOAU and LOAL, respectively) are also presented.

Table 3. Predictors of agility performance estimated R^2 in adolescent soccer players ($n = 51$).

	R^2	Adjusted R^2	P	Predictors	Exponent (Standard error)
Agility test	0.55	0.53	< 0.01	Age	0.03 (0.01)
				Adiposity	-0.05 (0.01)

All predictor variables are significant at $P < 0.05$; Signs are reversed since a lower time on the running tests indicates a better performance.

Table 4. Multilevel regression analysis of log-transformed agility performance of a sub-sample of adolescent soccer Basque players by age group ($n = 33$).

Fixed explanatory variables	Exponent (Standard error)	Exponent (Standard error)
Intercept	-2.45 (0.01)	-2.48 (0.01)
Changes with training season	0.03 (0.01)	0.03 (0.01)
Age group	-	0.06 (0.01)

All explanatory variables are significant at $P < 0.01$; signs are reversed since a lower time on the running tests indicates a better performance.

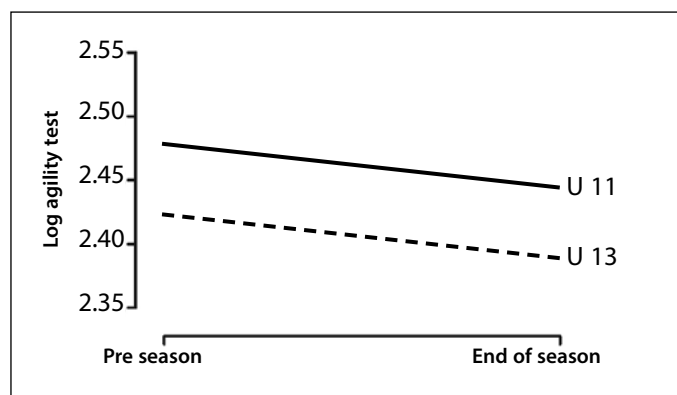


Figure 4. Mean changes in log-transformed Agility test scores during a 10-month season in adolescent Basque soccer players by age group (under-11 and under-13).

DISCUSSION

Given the potential importance of agility to soccer performance, the reliability and validity of the agility protocol under standardized conditions was examined in the context of youth soccer. In support of the hypothesis, the agility test had high reliability and acceptable validity to measure changes in performance with training exposure (construct validity). These results suggest that this agility test is thus an appropriate field test in adolescent soccer players.

The CV in the present study, 0.9%, and change in mean, -0.5%, were comparable with agility test bias in youth soccer²¹, allowing

for protocol differences, and similar or somewhat better than reported for power output tests with similar duration¹⁵, suggesting relatively little within-subject variation between trials. Although the agility test had good reliability in the subsample of 34 players, performances tended to improve slightly, on average, from the first to the second trials. The effect size of the change of mean, 0.14, in addition to the slope and intercept values and respective 95% CL (results not presented) and the distribution of residuals between trials (figures 2 and 3) indicates that the test may be able to identify “real” changes from systematic and random error. Previous experience with protocol procedures may have contributed to the high reliability since the test is often used in the soccer academy. However, intra- and inter-individual differences in motivation and fatigue may be potential factors that need to be considered when using this agility test, likewise other field maximal short-term testing procedures³⁰. Both intra- and inter-individual variation are replicated in the ICC, which shows the maintenance of group position (rank order) on the tests. Overall, the agility test showed sufficient reliability to detect at least large training-induced changes. Caution should be taken if generalization of the test reliability to higher levels of performance (elite athletes), as the present estimates are limited to detect the smallest worthwhile change, defined as 0.2 x the between-subject standard deviation¹⁶.

Variation in body size for the total sample was considerable (table 1). Mean statures and body masses ranged around the age-specific 75th percentile of Basque reference data³¹, and ranged between the age-specific 50th and 75th percentiles of U.S. reference data³². The growth characteristics of this sample of Basque adolescent soccer players were consistent with other reports with heterogeneous samples of young male athletes³³.

The contribution of years of sport-specific training, chronological age, somatic maturation, body size and estimated leg length and adiposity to variation in agility performance among adolescent soccer players was considered to examine content validity. The independent variables in the regression model explained 53% of variance for agility. Chronological age and adiposity were the significant predictors for agility identified in the stepwise regression models. The results suggest that older and leaner players are faster in the agility protocol. Allowing for protocol differences, the results are consistent with previous observations in youth soccer³⁴. The correlations of agility performance with vertical jump height and 15-m sprint were moderate to high, and mediated mainly via the chronological age effect. Agility is a result of a number of neurophysiological factors, it is difficult to determine exactly which factors contribute to a changed result on a test³⁵. Although no direct measurement was made to determine metabolic profile of the agility test, the duration of the protocol and association with short-term maximal performance suggests that the test may have a high anaerobic contribution. Anaerobic ATP production during single short-duration maximal efforts (< 10s) is provided by considerable contributions from both phosphorylcreatine degradation and anaerobic glycolysis³⁶. Short-term maximal performance tends to be lower in children than adolescents and adults and it has been suggested that limitations of glycolysis, phosphorylcreatine breakdown, and oxidative re-phosphorylation confines performance throughout pubertal development³⁷. Thus, potentially confounding factors in explaining the determinants of agility performance in adolescent soccer players may include maturity-related variation in short-term muscle power outputs and also sprinting ability, the non-linear anaerobic energy supply improvement during the

adolescent growth spurt, the trainability of muscle power during adolescence, and the established relationship between body size and muscle power³⁸.

The multilevel modeling results indicate a linear improvement in agility performance, on average, suggesting a perhaps beneficial influence of soccer-specific training programs on the physical fitness parameter. Consistent with the stepwise regression results, a substantial group age effect on the agility performance pre- and end-season. Older adolescent players appear to perform better compared to younger players but the rate of improvements was similar in both age groups. This may be partially attributed to linear growth and gains in muscle mass with pubertal growth, as evidence drawn from longitudinal data in youth soccer players' shows gains in running speed and agility, on average, close to the time of peak height velocity³⁹. Given that the agility protocol requires displacement of the body with multidirectional nature, changes with pubertal growth that include enhancements in neural function, multi-joint coordination, muscle stiffness, changes in muscle architecture, and increases in muscle power associated with the rise in circulating concentrations of testosterone and growth hormone from childhood to adolescence^{39,40}, may have a contribution to agility performance. Overall, the differences found between players of different age groups and changes in performance in response to 10-month season exposure further support the construct validity of the protocol examined in the present study for measuring the agility performance in soccer players aged 10 to 14 years.

In summary, the modified Barrow agility test adopted in the present study provides reliable data and has the ability to observe a “worthwhile” change or improvement in test performance in 10 to 14 years old soccer players. Extrapolation of the results of the present study from adolescent athletes to adult athletic performance warrants caution. Consequently, future research on agility performance in soccer players should be considered. Per se, the results should be of interest to coaches, sport scientists and others involved in the selection and development of youth soccer players.

CONCLUSION

The results from this study indicate that the modified Barrow test is a valid assessment of agility in youth soccer players and reliable when considering ICC and CV. Hence, soccer coaches and scientists should use this test with the understanding that it is a valid agility assessment for youth soccer players. Given that the test was able to distinguish between players of different age groups and changes in performance in response to 10-month season exposure, the application of the modified Barrow test may become a useful tool to improve objectivity in the recruitment of youth soccer players. Therefore, the application of the test may provide practical information to coaches involved in the talent identification processes.

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REFÊRENCIA

1. Malina RM, Ribeiro B, Aroso J, Cumming SP. Characteristics of youth soccer players aged 13-15 years classified by skill level. *Br J Sports Med.* 2007;41(5):290-5.
2. Bangsbo J, Mohr M, Krstrup P. Physical and metabolic demands of training and match-play in the elite football player. *J Sports Sci.* 2006;24(7):665-74.
3. Mohr M, Krstrup P, Bangsbo J. Match performance of high-standard soccer players with special reference to development of fatigue. *J Sports Sci.* 2003;21(7):519-28.
4. Wragg CB, Maxwell NS, Doust JH. Evaluation of the reliability and validity of a soccer-specific field test of repeated sprint ability. *Eur J Appl Physiol.* 2000;83(1):77-83.
5. Draper JA, Lancaster MG. The 505 test: A test for agility in the horizontal plane. *Aust J Sci Med Sport.* 1985;17(1):15-8.
6. Reilly T, Williams AM, Nevill A, Franks A. A multidisciplinary approach to talent identification in soccer. *J Sports Sci.* 2000;18(9):695-702.
7. Svensson M, Drust B. Testing soccer players. *J Sports Sci.* 2005;23(6):601-18.
8. Figueiredo AJ, Gonçalves CE, Coelho E Silva MJ, Malina RM. Characteristics of youth soccer players who drop out, persist or move up. *J Sports Sci.* 2009;27(9):883-91.
9. Gil S, Ruiz F, Irazusta A, Gil J, Irazusta J. Selection of young soccer players in terms of anthropometric and physiological factors. *J Sports Med Phys Fitness.* 2007;47(1):25-32.
10. Barrow HM. Test of motor ability for college men. *Res Q.* 1954;25:253-60.
11. Hopkins DR. Factory analysis of selected basketball skill tests. *Res Q.* 1977;48(3):535-40.
12. Hopkins DR. Using skill tests to identify successful and unsuccessful basketball performers. *Res Q.* 1979;50(3):381-7.
13. Gómez M, Barriopedro M, Pagola, I. Evolución de la condición física de las jugadoras de fútbol del Atlético Femenino B durante la temporada. *EFDeportes* (Buenos Aires). 2006;10(93). Available from: <http://www.efdeportes.com/efd93/feminas.htm>.
14. Bidaurreaga-Letona I, Lekue JA, Amado M, Santos-Concejero J, Gil SM. Identifying talented young soccer players: conditional, anthropometrical and physiological characteristics as predictors of performance. *Rev Int Cienc Deporte.* 2006;39:79-95.
15. Hopkins WG, Schabert EJ, Hawley JA. Reliability of power in physical performance tests. *Sports Med.* 2001;31(3):211-34.
16. Hopkins WG. Measures of reliability in sports medicine and science. *Sports Med.* 2000;30(1):1-15.
17. Atkinson G, Nevill AM. Selected issues in the design and analysis of sport performance research. *J Sports Sci.* 2001;19(10):811-27.
18. George K, Batterham A, Sullivan I. Validity in clinical research: a review of basic concepts and definitions. *Phys Ther.* 2000;1(1):19-27.
19. Hopkins WG, Hawley JA, Burke LM. Design and analysis of research on sport performance enhancement. *Med Sci Sports Exerc.* 1999;31(3):472-85.
20. Elferink-Gemser MT, Visscher C, Lemmink KA, Mulder TW. Relation between multidimensional performance characteristics and level of performance in talented youth field hockey players. *J Sports Sci.* 2004;22(11-12):1053-63.
21. Hulse MA, Morris JG, Hawkins RD, Hodson A, Nevill AM, Nevill ME. A field-test battery for elite, young soccer players. *Int J Sports Med.* 2013;34(4):302-11.
22. Vaeyens R, Malina RM, Janssens M, Van Renterghem B, Bourgeois J, Vrijens J, et al. A multidisciplinary selection model for youth soccer: the Ghent Youth Soccer Project. *Br J Sports Med.* 2006;40(11):928-34.
23. Malina RM, Bouchard C, Bar-Or O. Growth, maturation, and physical activity. 2nd ed. Champaign, IL: Human Kinetics;2004.
24. Harriss DJ, Atkinson G. International Journal of Sports Medicine – ethical standards in sport and exercise science research. *Int J Sports Med.* 2009;30(10):701-2.
25. Mirwald RL, Baxter-Jones AD, Bailey DA, Beunen GP. An assessment of maturity from anthropometric measurements. *Med Sci Sports Exerc.* 2002;34(4):689-94.
26. Hopkins WG. A Scale of Magnitudes for Effect Statistics. 2002. Disponível em: <http://www.sportssci.org/resource/stats/index.html>. Acesso em: 26/12/2014
27. Nevill A, Holder R. Modelling maximum oxygen uptake. A case study in non-linear regression model formulation and comparison. *J R Stat Soc.* 1994;43:653-66.
28. Nevill AM, Holder RL, Baxter-Jones A, Round JM, Jones DA. Modeling developmental changes in strength and aerobic power in children. *J Appl Physiol* (1985). 1998;84(3):963-70.
29. Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. *Lancet.* 1986;1(8476):307-10.
30. Carvalho HM, Coelho e Silva MJ, Figueiredo AJ, Gonçalves CE, Castagna C, Philippaerts RM, et al. Cross-validation and reliability of the line-drill test of anaerobic performance in basketball players 14-16 years. *J Strength Cond Res.* 2011;25(4):1113-9.
31. Hernández M, Castellet J, Narvaiza JL, Rincón JM, Ruiz I, Sánchez E. Curvas y tablas de crecimiento. Madrid: Garsi;1988.
32. Kuczumski RJ, Ogden CL, Grummer-Strawn LM, Felgal KM, Guo SS, Wei R. CDC growth charts: United States. 2000. Disponível em: www.cdc.gov/growthcharts.htm. Acesso em: 26/12/2014
33. Malina RM. Physical growth and biological maturation of young athletes. *Exerc Sport Sci Rev.* 1994;22:389-433.
34. Figueiredo AJ, Coelho e Silva MJ, Malina RM. Predictors of functional capacity and skill in youth soccer players. *Scand J Med Sci Sports.* 2011;21(3):446-54.
35. Buttifant D, Graham K, Cross K. Agility and speed in soccer players are two different performance parameters. In: Spinks W, Reilly T, Murphy A. Science and football IV: London: Routledge;2002. p. 329-32.
36. Dawson B, Goodman C, Lawrence S, Preen D, Polglaze T, Fitzsimons M, et al. Muscle phosphocreatine repletion following single and repeated short sprint efforts. *Scand J Med Sci Sports.* 1997;7(4):206-13.
37. Beneke R, Hütler M, Leithäuser RM. Anaerobic performance and metabolism in boys and male adolescents. *Eur J Appl Physiol.* 2007;101(6):671-7.
38. Carvalho HM, Coelho e Silva MJ, Figueiredo AJ, Gonçalves CE, Philippaerts RM, Castagna C, et al. Predictors of maximal short-term power outputs in basketball players 14-16 years. *Eur J Appl Physiol.* 2011;111(5):789-96.
39. Philippaerts RM, Vaeyens R, Janssens M, Van Renterghem B, Matthys D, Craen R, et al. The relationship between peak height velocity and physical performance in youth soccer players. *J Sports Sci.* 2006;24(3):221-30.
40. Armstrong N, McManus AM. Physiology of elite young male athletes. *Med Sport Sci.* 2011;56:1-22.