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Speed, agility and dribbling of young Brazilian soccer players: normative data according to chronological age and biological maturation

Velocidade, agilidade e drible de jovens jogadores de futebol brasileiros: dados normativos segundo idade cronológica e maturação biológica

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Abstract – Physical and technical skill tests are often used in the identification and selection of soccer talent. The objective was to establish reference values for speed, agility and dribbling tests in young Brazilian soccer players, according to chronological age and biological maturation. There was a total of 327 male athletes participating, aged between 12 and 17, from a talent development program. Speed (20 m), agility and dribbling tests were performed, with the 10th, 30th, 50th, 70th, 90th and 98th percentiles being calculated. Somatic maturation was evaluated by the percentage of predicted adult stature. Reference values were reported for the age groups 12, 13, 14, 15, 16 and 17 years, stratified by maturation status. Motor performance and technical skill improve from 12 to 14-15 years and then stabilize. Maturation influences motor performance, but not technical ability. Biologically early athletes showed better performance in the 20 m sprint test when compared to on time athletes at 13 years of age (3.25 ± 0.16s vs. 3.36 ± 0.21s; p=0.01; d=0. 59) and at 14 years old (3.12 ± 0.10s vs. 3.20 ± 0.16s; p=0.049; d=0.62), respectively. Furthermore, at 17 years of age, early athletes were more agile than on time athletes (7.54 ± 0.28s vs. 8.04 ± 0.64s; p=0.03; d=1.09). Significant differences were not observed in dribbling test between biologically on time and early athletes.

Key words: Athletes; Soccer; Youth; Maturation; Reference values.

Resumo – *Testes físicos e de habilidades técnicas são frequentemente utilizados na identificação e seleção de talentos no futebol. O objetivo foi estabelecer valores de referência para os testes de velocidade, agilidade e drible em jovens futebolistas brasileiros, de acordo com a idade cronológica e a maturação biológica. Participaram 327 atletas do sexo masculino de 12 a 17 anos de um programa de desenvolvimento de talentos. Foram realizados os testes de velocidade (20m), agilidade e drible, sendo calculados os percentis 10, 30, 50, 70, 90 e 98. A maturação somática foi avaliada pelo percentual atingido da estatura adulta prevista. Valores de referência foram relatados para as faixas etárias 12, 13, 14, 15, 16 e 17 anos, estratificados pelos status de maturação. A performance motora e a habilidade técnica melhoram dos 12 aos 14-15 anos e depois estabilizam. A maturação influencia a performance motora, mas não a habilidade técnica. Os atletas biologicamente avançados apresentaram melhor desempenho no teste de velocidade de 20m quando comparados aos atletas normomaturos, aos 13 anos (3,25 ± 0,16s vs. 3,36 ± 0,21s; p=0,01; d=0,59) e aos 14 anos (3,12 ± 0,10s vs. 3,20 ± 0,16s; p=0,049; d=0,62), respectivamente. Além disso, aos 17 anos, os atletas avançados foram mais ágeis do que os normomaturos (7,54 ± 0,28s vs. 8,04 ± 0,64s; p=0,03; d=1,09). Não foram observadas diferenças significantes no drible entre atletas normomaturos e avançados.*

Palavras-chave: *Atletas; Futebol; Jovem; Maturação; Valores de referência.*

INTRODUCTION

Talent identification, selection, and development is a complex and dynamic process, especially in soccer where performance results from a combination of multiple indicators. Cross-sectional[1,2] and longitudinal[3,4] studies have shown that speed, agility, and dribbling discriminate selected and unselected young soccer players[1] from different competitive levels[2] and are important predictors for future success[3,4]. Reference data for these talent indicators are useful to assist coaches and sport professionals in the long-term athletic selection and development process[5], especially when the effect of biological maturation on motor performance is considered[6,7].

There is scientific evidence of normative data for the assessment of sport potential indicators in young soccer players[2,8,9]. However, there are few studies with young athletes that considered the maturational stage to establish percentiles for physical fitness tests[10], and even fewer in soccer[11]. Reference values of physical abilities and technical skills allow for the diagnosis of athlete performance, identification of virtues and weaknesses, training prescription, goal setting, motivate, and longitudinally, analyze how the athlete evolved in different age groups.

A talented young soccer player needs to be fast and skilled to be successful in the future[3,12]. For the coach, knowing how his athlete is classified in the 20 m speed run, the agility test, and the dribbling test can assist in decision making to choose a player for a match or for the selection or (of) an athlete selection from a talent development program. When biological maturation is considered in this process, it avoids, for example, that biologically delayed, yet technically talented players are excluded precociously from the development process. In Brazil, as far as our knowledge goes, no normative studies were found for these indicators, taking into account the maturation stage of the athletes. Furthermore, there is a need for research on athletes from formative clubs that act as the first filter in the identification of talents for soccer before the elite clubs.

Therefore, the aim of this study was to establish reference values for speed, agility and dribbling tests in young Brazilian soccer players, according to their age and biological maturation.

METHOD

Sample

The study included 327 male athletes from the nucleus of training young soccer players for high performance, in the Soccer Project of the Juiz de Fora Federal University (Soccer Project- *Universidade Federal de Juiz de Fora* (UFJF)), aged between 12 and 17 years (14.8 ± 1.3 years; practice time: 7.3 ± 2.6 years), characterized as a forming club project. For the inclusion criteria, the evaluated players should have been training regularly in the last six months, from three to five times a week, with a daily training duration of around two hours and participating in regional and/or state championships. The exclusion criteria were considered to be the presentation of an injury, any acute illness on the day of the tests, or any other adverse health condition. The consent of the legal guardians and the consent of the athletes were obtained before the participation in the study. This research was approved by the Federal University of Ouro Preto (*Universidade Federal de Ouro Preto* - UFOP) Research Ethics Committee (CAAE: 32959814.4.1001.5150), and it is an integral part of the Atletas de Ouro Project ®[13].

Study design

The athletes underwent the tests on two consecutive days in their usual training schedule, between 2 and 5 pm, from September 2015 to February 2019. On the first day, demographic data and anthropometric parameters of the participants were collected. The speed, agility and dribbling tests were performed on the second day on an artificial grass field. The maturational stage assessment was performed after the battery of tests.

Instruments and procedures

The tests and measurements in the present study were described by Paula et al.[14]. Anthropometric measurements: body mass and stature were measured, according to Norton and Olds procedures[15]. Biological maturation: somatic maturation status was estimated by the percentage reached of predicted adult stature (%PAS)[16]. From reference values, the athletes were classified as late (z score < -1.0), on time (score -1.0 ≤ z ≤ 1.0) or early (z score > 1.0). The stature of the biological parents was obtained by a self-report. The 20m speed: maximum linear sprint over a distance of 20 meters. Agility: moving at a higher speed in a slalom course without the ball. Dribbling: the same course as in the agility test was performed with the ball to assess dribbling ability, according to the German Football Federation protocol[2] (Figure 1). The time of the tests was obtained by photoelectric cells (Multi-Sprint®, Hidrofit, Brazil). There were two attempts made with a 1-minute interval between them, and the best time was considered. The start was from the stopped position. The interval between tests was 5 minutes.

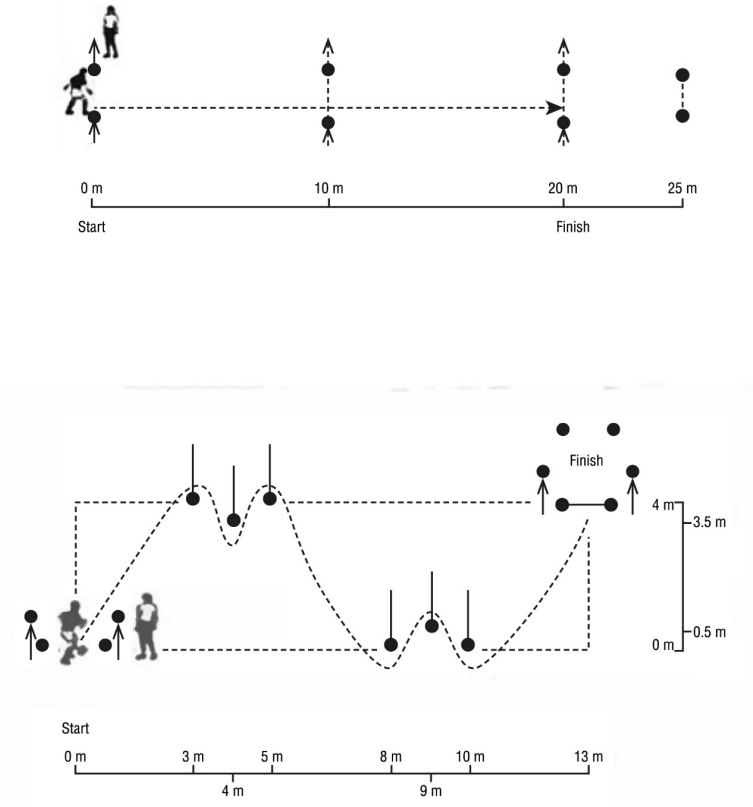

Figure 1. Representation of the 20 m speed, agility, and dribbling test, according to the protocol used by the German Football Federation, adapted from Honer et al.[2].

Statistical analysis

The data were presented as mean and standard deviation and a 95% confidence interval of the mean. The parametric assumptions of normality and equality of variances were evaluated by the Kolmogorov-Smirnov (KS) test and the Levene's test, respectively. The differences between on time and early players were analyzed by the Student t-test for independent samples within each age group. The effect size (EF) was assessed by the *d* of Cohen[17], adopting the following classification: small: 0.20 - 0.49; moderate: 0.50 - 0.79; high: ≥ 0.80. The 10th, 30th, 50th, 70th, 90th, and 98th percentiles were calculated according to age and maturation status. The statistical software IBM SPSS® version 24.0 (IBM Corp., Armonk, NY) was used, adopting a significance level of 5%.

RESULTS

Table 1 presents the morphological characteristics, biological maturation status, and the performance of soccer players by age group in the 20 m speed, agility, and dribbling tests. It was found that 20 m speed, agility and dribbling improve from age 12 to 14-15 and then stabilize. In Table 2, the reference values of the 10th, 30th, 50th, 70th, 90th, and 98th percentiles were presented for the 20 m speed, agility, and dribbling tests according to the chronological age, considering the whole sample and stratified by maturation status. The percentiles were inverted, such that lower absolute times in the tests represented the highest percentile.

Table 3 demonstrates the mean performance times of on time and soccer players within each age group. Biologically early 13- and 14-year-old soccer players performed better in the 20 m speed when compared to on time players (13 years: 3.25 ± 0.16s vs. 3.36 ± 0.21s; p=0.01; d=0.59) and (14 years: 3.12 ± 0.10s vs. 3.20 ± 0.16s; p=0.05; d=0.62), respectively. In both categories, the effect size was moderate. In agility, biologically early 17-year-old athletes were more agile than on time athletes (7.54 ± 0.28s vs. 8.04 ± 0.64s; p=0.03; d=1.09). From a practical point of view, the difference observed in this variable was high. No statistically significant differences were found in dribbling according with the maturation status of the athletes

DISCUSSION

This study established reference values for the 10th, 30th, 50th, 70th, 90th, and 98th percentiles of the 20 m speed, agility, and dribbling tests, from a sample of young Brazilian soccer players in a training club, aged 12 to 17 years, considering maturation status. In general, motor performance (speed and agility) and technical ability (dribbling) improved from age 12 to 14-15 and then stabilized. Furthermore, biological maturation was found to influence motor performance, but not technical ability.

The mean values obtained in the present study for the 20 m speed test were similar to those of the German national level soccer players in the age group from 12-15 years old[2] and of young Austrian soccer players from 14-17 years old[18]. Furthermore, the reference values of the 30th and 70th percentiles were better than those found in German soccer players aged 12 to 15 years old[2] both in relation to the competence center teams as well as the junior academy teams, which are considered to be of high potential. Soccer players who perform at or above the 90th percentile in the speed test can be considered motor talents for this characteristic[13].

Table 1. Mean ± standard deviation (95% CI of the mean) and characteristic percentages (%) of soccer players according to the age group.

	12 years (n =25)	13 years (n = 80)	14 years (n = 73)	15 years (n = 73)	16 years (n = 57)	17 years (n = 19)
Anthropometry						
Body Mass (kg)	46.04 ± 9.36	50.61 ± 8.50	56.05 ± 9.72	60.85 ± 9.17	65.15 ± 9.50	65.09 ± 6.43
Stature (cm)	154.81 ± 9.41	162.44 ± 8.16	168.03 ± 8.44	172.99 ± 7.06	175.76 ± 6.66	173.52 ± 4.98
Biological Maturation						
Predicted Adult Stature (PAS)	175.94 ± 7.87	177.75 ± 5.45	177.64 ± 5.49	177.13 ± 4.59	175.86 ± 5.69	170.52 ± 4.08
PAS reached (%)	87.26 ± 2.48	90.91 ± 2.89	94.33 ± 2.71	97.46 ± 2.69	99.89 ± 2.78	101.69 ± 2.43
Z-score	0.98 ± 0.95	0.71 ± 0.83	0.65 ± 0.69	0.64 ± 0.72	1.02 ± 1.14	2.09 ± 1.76
Maturational Status						
Late	0.0%	1.3%	1.4%	2.8%	1.8%	0.0%
On time	52.0%	60.8%	69.9%	65.3%	47.4%	36.8%
Early	48.0%	38.0%	28.8%	31.9%	50.9%	63.2%
Physical Performance and Technical Ability						
20m speed (s)	3.45 ± 0.21 (3.34 – 3.56)	3.32 ± 0.19 (3.28 – 3.36)	3.18 ± 0.15 (3.14 – 3.21)	3.08 ± 0.15 (3.04 – 3.11)	3.05 ± 0.14 (3.02 – 3.09)	3.05 ± 0.15 (2.98 – 3.12)
Agility (s)	8.34 ± 0.47 (8.10 – 8.58)	8.00 ± 0.44 (7.89 – 8.10)	7.69 ± 0.38 (7.60 – 7.78)	7.66 ± 0.43 (7.55 – 7.76)	7.69 ± 0.58 (7.53 – 7.84)	7.72 ± 0.50 (7.48 – 7.96)
Dribbling (s)	12.60 ± 1.23 (11.96 – 13.23)	11.36 ± 0.92 (11.15 – 11.57)	10.77 ± 0.82 (10.58 – 10.96)	10.78 ± 0.66 (10.63 – 10.94)	10.58 ± 0.61 (10.41 – 10.74)	10.69 ± 0.87 (10.28 -11.11)

Note. kg = kilogram; cm = centimeter; PAS (%) = percentage of predicted adult stature; m = meters; s = seconds.

Table 2. Reference values (10th, 30th, 50th, 70th, 90th, and 98th percentiles) for the 20 meters speed, agility, and dribbling tests in young male soccer players according to age and maturational status (n = 327).

Test / Age		P10			P30			P50			P70			P90			P98		
		All	O	E	All	O	E	All	O	E	All	O	E	All	O	E	All	O	E
20m speed	12	3.76	3.78	-	3.53	3.55	3.55	3.47	3.45	3.49	3.40	3.40	3.20	3.05	3.11	3.04	3.04	-	-
	13	3.61	3.63	3.48	3.41	3.47	3.33	3.29	3.38	3.21	3.19	3.20	3.17	3.10	3.11	3.05	2.97	-	-
	14	3.37	3.48	2.97	3.21	3.22	3.07	3.18	3.18	3.12	3.09	3.12	3.07	3.01	3.01	2.97	2.89	-	-
	15	3.25	3.25	3.26	3.18	3.18	3.18	3.06	3.07	3.02	3.01	3.01	2.94	2.90	2.94	2.79	2.72	-	-
	16	3.22	3.24	2.88	3.13	3.17	2.95	3.06	3.08	3.02	2.98	3.02	2.95	2.85	2.83	2.88	2.75	-	-
	17	3.24	-	3.21	3.13	3.21	3.10	3.07	3.13	3.02	2.98	3.02	2.88	2.82	2.98	2.80	2.79	-	-
Agility	12	9.05	9.41	-	8.44	8.60	7.95	8.28	8.31	8.23	8.09	8.08	8.08	7.71	7.68	7.95	7.68	-	-
	13	8.63	8.75	8.63	8.26	8.26	8.23	7.87	7.88	7.85	7.70	7.72	7.69	7.46	7.45	7.47	7.19	-	-
	14	8.22	8.27	7.94	7.83	7.87	7.82	7.63	7.64	7.63	7.48	7.51	7.46	7.17	7.27	7.04	6.93	-	-
	15	8.13	8.24	8.04	7.83	7.86	7.73	7.59	7.60	7.56	7.47	7.49	7.34	7.07	7.17	6.96	6.80	-	-
	16	8.50	8.41	8.91	7.91	7.91	7.95	7.63	7.63	7.63	7.31	7.29	7.34	6.99	6.99	6.95	6.69	-	-
	17	8.63	-	7.98	8.00	8.55	7.67	7.66	8.10	7.63	7.34	7.77	7.34	7.12	6.87	7.14	6.87	-	-
Dribbling	12	14.82	15.02	-	12.89	13.30	12.82	12.60	12.60	12.61	12.12	11.90	12.35	10.67	10.47	11.37	10.40	-	-
	13	12.58	12.54	12.80	11.76	11.76	11.74	11.28	11.27	11.31	10.88	10.83	10.90	10.35	10.35	10.28	9.25	-	-
	14	11.94	11.65	12.85	11.02	10.84	11.65	10.63	10.58	10.90	10.30	10.30	10.40	9.87	9.89	9.53	9.32	-	-
	15	11.69	11.50	12.08	11.06	11.00	11.26	10.72	10.66	10.90	10.35	10.31	10.43	9.94	9.98	9.87	9.68	-	-
	16	11.22	11.16	11.57	10.77	10.74	10.86	10.60	10.60	10.60	10.35	10.51	10.30	9.78	9.73	9.79	8.98	-	-
	17	11.33	-	11.32	11.10	10.61	11.12	10.74	10.16	11.04	10.09	9.94	10.65	9.73	9.73	9.65	9.62	-	-

Note. O = on time; E = early.

Table 3. Mean ± standard deviation of the performance in the tests of 20 meters speed, agility and dribbling of young male soccer players of different age groups, classified according to maturation stage (n=327).

Age	Maturational Status	20 m speed (s)	*p*-value	TE	Agility (s)	*p*-value	TE	Dribbling (s)	*p*-value	TE (*d*)
12 years	On time	3.47 ± 0.19	0.63	0.22	8.38 ± 0.55	0.67	0.27	12.65 ± 1.49	0.83	0.13
	Early	3.42 ± 0.26			8.27 ± 0.28			12.51 ± 0.64		
13 years	On time	3.36 ± 0.21	0.01*	0.59	8.00 ± 0.45	0.85	0.04	11.34 ± 0.94	0.76	0.07
	Early	3.25 ± 0.16			7.98 ± 0.45			11.41 ± 0.93		
14 years	On time	3.20 ± 0.16	0.049*	0.62	7.72 ± 0.39	0.28	0.30	10.64 ± 0.64	0.09	0.51
	Early	3.12 ± 0.10			7.61 ± 0.34			11.08 ± 1.09		
15 years	On time	3.08 ± 0.12	0.35	0.26	7.72 ± 0.43	0.09	0.41	10.69 ± 0.61	0.17	0.34
	Early	3.04 ± 0.19			7.54 ± 0.44			10.92 ± 0.76		
16 years	On time	3.08 ± 0.15	0.22	0.36	7.61 ± 0.50	0.31	0.28	10.55 ± 0.50	0.74	0.08
	Early	3.03 ± 0.13			7.77 ± 0.65			10.60 ± 0.72		
17 years	On time	3.12 ± 0.12	0.08	0.89	8.04 ± 0.64	0.03*	1.09	10.61 ± 1.22	0.75	0.15
	Early	3.00 ± 0.15			7.54 ± 0.28			10.75 ± 0.64		

Note. * statistically significant difference $p \leq 0.05$; TE = effect size, Cohen's *d*.

Speed is a trainable functional capacity during childhood and adolescence[5] that discriminates players already selected and exposed to systematic training, being used as a criterion for the selection and development of young soccer players[19], mainly for its prognostic value of future success, starting at U14[20]. However, considering that performance is multifactorial, it is necessary to be cautious when using only one test with predictive purposes[3], besides the need to take the biological maturation[19] into account.

Regarding agility, it was observed that Brazilian soccer players when compared to German soccer players[20] showed a better performance than non-selected athletes for all age categories and a better performance than the selected athletes in U13, U14 and U15. Furthermore, the reference values of the 30th and 70th percentiles found in the present study were similar to those of German soccer players aged 12 to 15 years old[2]. In the longitudinal study by Leyhr et al.[4] with 1.134 German players in the U12 to U15 category, it was observed that motor performance in the agility test was predictive of the success for the senior athletes eight years after the diagnosis. However, Höner et al.[20] found only a small effect size for future successful players in relation to agility. For the English soccer players, Saward et al.[12] found that although future professionals are faster and more agile compared to non-professionals, the development of these variables is non-linear and does not occur in the same way for professional and non-professional players. This result contradicts the findings of Leyhr et al.[4]. One possible explanation for the divergence in these studies lies in the difficulty of establishing how much age, maturation, or both influence agility, since this ability has subcomponents, such as change of direction in speed and cognitive function[5].

In general, physical fitness increases with chronological age and maturation status[10]. The effect of biological maturation on physiological indicators, such as speed and agility, is well known in the literature. Biologically early young soccer players are faster, more agile, and sometimes more skilled, leading to selection advantages [5]. In the present study, biologically early from 13- and 14-years-old soccer players showed better performances than on time soccer players in the 20 m speed, corroborating the findings of Murtagh et al.[21]. In agility, biologically early athletes showed better performance at 17 years of age, corroborating the results found in young Slovakian[22] and Brazilian[23,24] soccer players. However, coaches should avoid to precociously exclude athletes who present low motor performance from development programs, due to possible maturational biases, especially between 13-15 years of age. In this age group, greater emphasis should be placed on technical ability, due to the lesser influence of maturation[6].

The influence of maturation on technical skills is still a matter of debate in the literature. Some studies indicate that maturation does not influence technique in young players[24-26]. However, other studies indicate that maturation does influence technical skills[1,7,27]. In the present study, no statistically significant differences were found in dribbling as a function of maturation status. The divergence between studies may be due to different methods of maturation assessment, as well as possible intervening variables that were not controlled. According to Huijgen et al.[28], the age, lean body mass, and the number of practice hours are the main determinants of dribbling performance. These authors conducted a longitudinal study with 12–19-year-old soccer players and also found that dribbling varies according to playing position and improves mainly after the age of 16.

Our results suggest that at the age of 14, for example, maturation may negatively influence the dribbling performance. This result could be explained by a compensation effect. Generally, biologically early athletes use the physical component to obtain better performances[27]. Thus, on time athletes, due to physical disadvantages, seek to develop a more technical ability as a compensation strategy to compete with early players[27,29]. When comparing the 30th and 70th percentile values of German soccer players from the competence center and the junior academy[2] as well as the mean values of selected and non-selected soccer players[20], it was observed that the dribbling performance of the Brazilian sample in this study was lower. A possible explanation for these findings may lie in the familiarity that the German soccer players have with the test protocol.

The performance in motor tests generally improve with age, but not always in a linear manner. In the present study, we observed a stable performance in the 20 m speed starting at age 16, a drop in performance in agility at age 16 followed by a stabilization at age 17, as well as greater variability in performance in dribbling from age 15 to 17. Currently, training sessions in soccer have a predominantly tactical-technical character[30]. Thus, it may be that physical valences, such as speed and agility, do not have an optimal training load for their continued development. Indirectly, this could also influence the performance of dribbling, since it is performed in speed. According to Sarmento et al.[19], an optimal balance between specialization (deliberate practice) and diversification (deliberate play) is associated with higher performance levels both at precocious ages as well as in adults.

The normative tables of the present study can be used by coaches as benchmarks for talent identification and development. Players classified in the 98th percentile show an important level of physical and technical excellence to be a future soccer athlete. The players classified between the 70th and 90th percentiles are above average in relation to their reference group and when they present this performance in most indicators, they also increase their chance of selection. On the other hand, the players classified in the 10th, 30th, and 50th percentiles have deficiencies in their profile and a greater need for development. It should be noted, however, that the retention of talented young players in training programs should be emphasized during puberty and selection decisions should be made only after adolescence, adopting a multidimensional approach[7].

As the limitations of the study, a convenience sample was used and the number of athletes aged 12 and 17 was small. The results obtained at these ages should be analyzed with caution. Another limitation was the non-performance of the test-retest, which prevented the estimation of the reproducibility of the variables. It is worth mentioning that, although the results found in this sample are similar to the performance of soccer players in higher competitive levels, according to the available literature, our results should only be generalized for the Brazilian athletes in the same competitive level. Athletes from A and B series clubs from the Brazilian Championship, for example, will probably present higher reference values for the indicators evaluated in the present study.

Further studies are needed in professional clubs and also with samples of young female soccer players, given the growing popularity of female soccer players in Brazil. Also, the expansion in the number of tests conducted is suggested in order to evaluate other indicators that make up the multidimensional profile of young soccer players, as well as to performance of longitudinal studies.

We highlight the practicality of applying the battery of tests. Its regular use makes it possible to create a database of the athletes in the club, aiming to help in the selection process, identification, and development of the soccer players. It is known that the talent prediction in soccer is a very difficult task, but this does not mean it is impossible, since it is part of the daily routine of the coaches[2]. Therefore, it is up to the researchers to find a way to optimize this process, through scientific data that support the practice. The reference tables presented in this study are a good starting point.

CONCLUSION

In conclusion, this study presented specific normative values for the 20 m speed, agility and dribbling tests of young Brazilian soccer players aged 12-17 years and according to maturation status. Motor performance and technical ability improved from 12 to 14-15 years old and then stabilize. Maturation influenced motor performance, but not technical ability. These results may be useful to help quantify and monitor the performance of the athletes over time, adjusting development programs according to biological demands.

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COMPLIANCE WITH ETHICAL STANDARDS

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Data Availability Statement

The data that support the findings of this study are available from the corresponding author, upon reasonable request.

Ethical approval

This study is part of the Projeto Atletas de Ouro: Multidimensional and Longitudinal Evaluation of the Young Athletes Sport Potential", approved by the Research Ethics Committee at the Federal University of Ouro Preto (CAAE: 3295814.4.1001.5150).

Conflict of interest statement

The authors have no conflict of interest to declare.

Author Contributions

Conceived and designed experiments: HLBP, FZW, EFC, JCBM; Performed experiments: HLBP, FZW, EFC; Analyzing data: HLBP, FZW, JCBM; Contributed with reagents/materials/analysis tools: HLBP, FZW, EFC, LCRS, DBRJ; Wrote the paper: HLBP, FZW, LCRS, DBRJ, JCBM. All authors have read and approved the final version of the manuscript.

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