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Bone age and height prediction of young Brazilian goalkeepers

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Abstract

Backgroud: Football clubs select young people to begin their training as athletes. At this stage of life (childhood and adolescence) occurs the biological maturational process that can cause influences on the soccer performance of young athletes. In addition to this fact, a specificity of each position within the field is related as anthropometric and physiological characteristics of each individual, where goalkeepers are rarely included. **Objectives**:The goal of this study was to analyze the relation between the skeletal maturation and the chronological age, besides to find out the power of vertical jump in goalkeepers in different youth age divisions in an elite soccer organization. **Methods**: 31 young goalkeepers made Counter Movement Jump free arms and were evaluated through the App MY JUMP to generate data about vertical jumping. Bone maturation was estimated through the result obtained in a hand and fist teleradiography exam using the Greulich and Pyle protocol and the predicted height was estimated through the Bone Expert protocol. **Statistics:** It was used descriptive statistics to analyze the maturation stage. The normality test of the data, it was conducted the Shapiro Wilk test. The two-way ANOVA was used to compare the values of weight (kg), height (cm) predicted height (cm) and the difference between skeletal and chronological age (DIF). Then, the post-hoc test of Bonferroni was made to identify the differences between the age divisions (U-09, U-11, U-13, U-15, U-17 and U-20). The critical level of significance was $p < 0.05$. **Results**: 83,87% of the sample is in a normal stage of maturation, 16.13% may be considered early in relation to the maturational stage and no subject showed late maturation. For the mass there were significant differences observed ($p < 0.001$) among all categories. While for the height significant differences were observed ($p < 0.001$) between [(U-09) vs. (U-11, U-13, U-15, U-17 and U-20)]; [(U -11) vs. (U-13, U-15, U-17 and U-20)]; [(U-13) vs. (U-15, U-17 and U-20)]; [(U-15) vs. (U-17 and U -20)] and between U-17 vs. U-20 there were also significant differences observed ($p < 0.01$). For the My Jump test, there were significant differences observed ($p < 0.001$) between [(U-09) vs. (U-11, U-13, U-15, U-17 and U-20)]; [(U-11) vs. (U-13, U-15, U-17 and U-20)]; [(U-13) vs. (U-15, U-17 and U-20)]. However, to the predicted height and difference between skeletal age and chronological age, there were no significant differences observed ($p > 0.05$). **Conclusion**: These results indicate a positive correlation between the data of bone age and performance aspects such as anaerobic power, so both data are important in the young athlete's specialization process.

Keywords: Age Determination by Skeleton, Soccer, Athletes.

INTRODUCTION

Most soccer organizations recruit children and teenagers to their youth divisions soccer program [1]. During this phase the biological maturation process takes place, which consists in processes of specialization and cell differentiation until reaching the final growth stage [2]. From this, there is a considerable variation in size and performance of young athletes, influenced by the different stages of biological maturation each one is [3], it may interfere significantly on their functional capabilities related to soccer [4].

Beyond this influence, the hypothesis that certain anthropometric and physiologic characteristics are specific to different positions in the game is also found in the scientific literature [5]. So, goalkeepers, central backs, defensive midfielders, side backs and forwards differ among each other by the particularities present in each function. However, the studies that evaluate these variations among the positions rarely include goalkeepers, and the profiling literature related to the stages of long term sports training still has a great gap [6, 3].

In different age groups, mainly among the divisions U-13 and U-16, the athletes with an advanced maturation(biological age> chronological age) have a tendency to be taller and heavier when compared to

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athletes with late maturation(chronological age> biological age) [7]. Lago-Peñas *et al*. [5] observing athletes in U-15, U-17 and U-20 divisions, say that central backs and goalkeepers show greater height, weight and skinfolds when compared to side backs, defensive midfielders and forwards. Carling *et al.* [1] evaluating 13.4(±0.4) year old young athletes, found out that the goalkeepers did not show late maturation, most of them(78%) showed maturation in the proper time and the rest of them showed advanced maturation. Rebelo-Gonçalves *et al*. [6] found significant differences between goalkeepers and other players in body mass, fat mass, maturation, physiological parameters and soccer abilities usual in young players, besides suggesting the period before adolescence, between the U-13 and U-15 divisions seems to be the ideal in technical specialization of goalkeepers.

With the changes that occur since childhood to adulthood and the ever earlier specialization, choosing goalkeepers according to body size physiological profile and technical capabilities shown in certain moment of growth may not be ideal [6]. Individuals who show advanced maturation can be identified as having superior capabilities by the coaches [7]. However, since these characteristics may vary until the effectiveprofessionalization of the player, it is important to evaluate the maturation stage of the athlete to avoid this kind of mistake.

Therefore, the present study has the objective to analyze the relation between skeletal maturation and the power of vertical jump among different age divisions of an elite soccer organization, drawing the profile of this game position throughout the years of specialization in soccer. Providing a scientific data base for coaches and physical trainers to refine their job, benefiting especially young athletes.

MATERIAL AND METHODS

Sample

The participants in the study were 31 male goalkeepers from U-09 to U-20 divisions(ages between 8 and 20 years old) from a high performance Brazilian soccer organization. All subjects were inside the inclusion criteria: 1) To be a federated athlete of the organization; 2) To be in training activity at least for 6 months; 3) Not to have any injuries in the last 6 months.

Procedure

First, it was checked the body weight and height using a weighting machine(Welmy Class III, Brasil, 2014). Afterwards, the vertical jump test Counter movement jump free arms(CMJ Free arms) was conducted, through the iPhone 5s App MY JUMP, scientifically validated with the strength platform which is considered gold standard to evaluating vertical jump.

To calculate the power of vertical jump, the MY JUMP App, uses a 120Hz high speed camera, with 720p definition to record the vertical jumps, estimating the power of the lower limbs. The necessary data to the evaluations are: weight(Kg), lower limbs length (in centimeters) and height at 90º(in centimeters), these measures were taken with an anthropometric measuring tape(SannyBrasil, 2012); and the hangtime of each jump, was measured by the App. This test was made according to the Balsalobre-Fernándezprotocol [8].

Secondly, it was tested the bone maturation through the teleradiography exam of upper limbs, specially of left hand and fist. The exams took place in a medical center close to the organization headquarter, in four different days during the month of March of 2016. To estimate the bone age it was used the Greulich and Pyle protocol (G&P) which consists to contrast the obtained image with the image of the skeletal age that most corresponds to the bone characteristics found, estimating the biological age. The difference between biological age and chronological age will define if the individual is on time mature(chronological age~biological age), early mature(chronological age<biological age) or late mature(chronological age>biological age). After this procedure it was estimated the predicted height through the Bone Expert protocol made by the platform available in the domain Bone Expert.com [9].

STATISTICAL ANALYSIS

It was used descriptive statistics to analyze the maturation stage of the goalkeepers. The normality test of the data, it was conducted the Shapiro Wilk test, where the normality of the data was observed, leading us to adopt parametric statistics. A two-way ANOVA was used to compare the values of weight(kg), height (cm) predicted height (cm) My Jump test(watts) and difference between skeletal and chronological age(DIF). Then, the post-hoc test of Bonferroni was made to identify the differences between the age divisions(U-09, U-11, U-13, U-15, U-17 and U-20). The critical level of significance adopted was $p<0.05$.

RESULTS

When it comes to the maturation stage of the volunteer subjects of the study, weobserved that the majority (83.87%) is in a normal stage of maturation (in the normality). While 16.13% of the sample may be considered early in relation to the maturational stage, no subject (0%) showed late maturation.

After two-way ANOVA, to values of mass, there were significant differences observed ($p<0.001$) between [(U-09) vs. (U-11, U-13, U-15, U-17 and U-20)]; [(U-11) vs. (U-13, U-15, U-17 and U-20)]; [(U-13) vs. (U-15, U-17 and U-20)]; [(U-15) vs. (U-17 and U-20)] and between U-17 vs. U-20.

In reference to height, significant differences were observed($p<0.001$) between[(U-09) vs. (U-11, U-13, U-15, U-17 and U-20)]; [(U -11) vs. (U-13, U-15, U-17 and U-20)]; [(U-13) vs. (U-15, U-17 and U-20)]; [(U-15) vs. (U-17 and U -20)]. Yet, in relation to height, there were also significant differences observed($p<0.01$) between U-17 vs. U-20.

To the My Jump test, there were significant differences observed($p<0.001$) between [(U-09) vs. (U-11, U-13, U-15, U-17 and U-20)]; [(U-11) vs. (U-13, U-15, U-17 and U-20)]; [(U-13) vs. (U-15, U-17 and U-20)]. However, to the remaining variables(predicted height and difference between skeletal age and chronologicalage, there were no significant differences observed($p>0.05$).

Table 1: Average and standard deviation of variables: body mass, height, predicted height and vertical jump (MY JUMP) by age division.

Age Division	Weight (kg)	Height (cm)	Predicted Height(cm)	My Jump (watts)
	Average ± SD	Average ± SD	Average ± SD	Average ± SD
U-09	33.48 ± 5.25§	135.5 ± 11.49§	179.88 ± 6.9	742.2 ± 141.14*
U-11	44.3 ± 0.54||	148.7 ± 3.77||	184.3 ± 6.43	1014 ± 168.15†
U-13	56.12 ± 11.15¶	170 ± 10.19¶	186.53 ± 4.63	2119.4 ± 674.38‡
U-15	76.71 ± 9.19**	184 ± 4.32**	189.9 ± 5.31	2809 ± 667.34
U-17	83.2 ± 11.46††	193.5 ± 4.95‡‡	194.65 ± 5.02	3252 ± 12.7
U-20	91.65 ± 7.97	189.67 ± 5.51	190.07 ± 5.61	3039.7 ± 361.5

Abbreviations: kg = kilograms; cm = Centimeters; SD = Standard Deviation.* Represents significant difference ($p < 0.001$) between U-09 vs. U-13, U-15, U-17 and U-20. † Represents significant difference ($p < 0.001$) between U-11 vs. U-13, U-15, U-17 and U-20. ‡ Represents significant difference ($p < 0.001$) between U-13 vs. U-15, U-17 and U-20. §significant difference ($p < 0.001$) between U-09 vs. U-11, U-13, U-15, U-17 e U-20.|| Represents significant difference ($p < 0.001$) between U-11 vs. U-13, U-15, U-17 and U-20. ¶ Represents significant difference ($p < 0.001$) between U-13 vs. U-15, U-17 and U-20. ** Represents significant difference ($p < 0.001$) between U-15 vs. U-17 and U-20.†† Represents significant difference ($p < 0.001$) between U-17 vs. U-20.‡‡ Represents significant difference ($p < 0.01$) between U-17 vs. U-20.

Table 2: Average and standard deviation of variables: chronological age, biological age and difference between them besides the maturation stage of each age division.

Age Division	*n (31)*	Chronological Age	Biological Age	Difference	Maturation
		Average ± SD	Average ± SD	Average ± SD	
U-09	5	8.6 ± 0.66	8.4 ± 2.3	-0.2 ± 1.78	On time
U-11	5	10.59 ± 0.51	10.2 ± 1.79	-0.39 ± 1.8	On time
U-13	6	12.39 ± 0.47	13.67 ± 1.37	1.28 ± 1.33	Early
U-15	4	14.43 ± 0.18	15.25 ± 0.5	0.82 ± 0.6	On time
U-17	5	17.45 ± 0.16	17.1 ± 0.9	-0.35 ± 0.13	On time
U-20	6	19.02 ± 0.43	18.67 ± 0.51	-0.35 ± 0.12	On time

Abbreviations: Difference = difference between skeletal age and chronologicalage; SD = Standard Deviation

DISCUSSION

The aim of this study is to analyze the maturational situation of the goalkeepers from the youth divisions in a Brazilian elite soccer organization, besides analyzing the power of vertical jump evaluating in comparison to the results found in the literature, still scarce in this scientific specification. To a better comparative standard, the variable high was problematized due to its grater incidence in studies in the area, appointing important quantitative data inference in this study. Furthermore there was a qualitative comparison of the results of metabolic rates that indicate anaerobic power(PAn) through the MY JUMP test, evaluating the bone development analyzed by the difference between the measured height and the predicted- assuming the pubertal period of the individual and correlating to the consequent implications in results of such metabolic variable.

Initially, the main finding of this study was the normality of the sample, as it is shown on table 2, it was found a high incidence of on timeprofile of skeletal age (83.87%) and the remaining individuals with early maturation, confirming the result found by Carling *et al*. [1] in their study oh physical characteristics of young soccer players with 78% of goalkeepers integrating the on time profile of skeletal age(SA),when the values of bone age and chronological age are close, while the rest of them showed early maturation. These statistically similar results align to the one found by Malina *et al.* [10] Romann&Fuchslocher [11] and Sherar *et al*. [12] which advocates how much the concentration of the athletes in a determined category of maturation(late, on timeand early) is an important aspect to practical application by coaches in the processes of drafting and development inside the sports category.

Furthermore, the variation found in this study shows evidence found in a posterior study of Malina [13]. Early posterior skeletal maturation compared to the identified chronological age cut that characterize the age groups of the individuals, treated sporadically as a category of athletes, with age cut younger than skeletal age; or false positive - with the identification of younger athletes regarding the value of bone age compared to chronological age due to late skeletal maturation, translated by bone age below the chronological age of a valid category of athletes. Thus, convergent results can be identified in the standardized norm presented by the most advanced categories, contrary to the pattern of higher incidence of false negatives found in young players aged between 15 and 17 years. Nevertheless, the conclusion must be respected because this study corroborates that the observed risk of false positives and false negatives implies that bone age is not a valid indicator of chronological age, and precisely because of this differentiation it becomes important to propose the test for the follow-up of athletes and the differentiated intervention profiles that we can choose from the inference of these data.

Considering the recommendations of Le Gall *et al*. [14] the method of Greulich and Pyle has large international utilization as the standard to analysis and determination of skeletal age, showing adequacy and reliability. The results are aligned with Malina& Bar-Or [10] and Silva *et al*. [15] when observing the results that the timing - terminology for the moment in which a given maturational event occurs and time - being the terminology that indicates the rhythm with which this event manifests itself. These two parameters evaluated in this study showed indicators of biological maturation with relative dependence on chronological age, confirmed by the peculiar characteristic presented by a significant part of the sample with anon time profile, with approximation of the chronological age statistical data with G&P results for bone age. The parameterized statistics of this study contradict the one found by Schmidt *et al*. [16] which indicates the application of the TW3 method, arguing that several protocols of radiology analysis were not adequate due to the risk of overestimating values.

Height is an important anthropometric marker in sports performance, as evidenced by Wong *et al*. [17], which found a significant correlation between height and vertical jump, due to the fact that it is a positive intervening biomechanical factor in the movement lever for force production. This study approximates results to those presented in a national study by Berto *et al*. [18] in terms of homogeneity of relative height in the age groups compared to U-14 to U-20 divisions, but having absolute values higher than the related study. In international comparison, it presented significantly higher numbers than those found by Nikolaidis *et al*. [19] for goalkeepers in their sample in the U-14 age group; And, also significantly higher results than those presented by Gil *et al*. [20] in their study which comprehended athletes from 14 to 23 years as sample. Already in comparative analysis to the study with samples with minor chronological age, Gil *et al*. [21] presented inferior results in stature levels of the athletes of their sample U-8 to U-10. Rebelo-Gonçalves *et al*. [6] also found significantly lower results regarding the stature of the individuals in the sample compared to the results obtained here. These notes generate indications that the parameter, stature, whether measured or predicted, has greater relevance and results in Brazilian studies than in international studies, revealing a characteristic of talent selection that is practiced and the peculiar management of athletes' career management by professionals Involved.

The information on the physical characteristics obtained in these evaluations are relevant and extremely important for the professionals involved, who should use them effectively for preparation and proposal of the training programs, as stated by Zig &Lidor [22] and, as TourinhoFilho&Tourinho points out [23], it is clear that the knowledge about the events that mark puberty and the consequent individual variability in which they occur, generating different impacts on each individual, is of extreme relevance for an efficient method of intervention, with greater effectiveness of the results when working with this sensitive and specific population of pre and post pubertal individuals. Indicatives of Teixeira *et al*. [24] consider that the growth of the physiological variable of anaerobic power(PAn) is influenced by biological maturation, and advances correlated to the maturational stage, which can be identified by the bone age conjugated to the difference between the measured and predicted stature: the lesser is the quantitative results, the earlier is the maturational stage of the individual. He also reiterated that the development of anaerobic power occurs when submitted to systematic training and specialized sports, which makes it extremely important for the evaluation and follow-up of the athlete to obtain the rates of bone maturation, as a determining factor of the sports performance that will influence In the planning of the training load for better accuracy in the individualization, mainly in terms of methods and intensity. Following this line of reasoning, this study recommended the statistical comparison with the anaerobic power variable obtained by the MY JUMP vertical jump test, validated in the Balsalobre-Fernández study [8], which showed a peak of out-of-curve performance for the U-13 category, and came to contradict reference data from a large retrospective study by Deprez *et al*. [25] that found statistical evolution of the performance of the physiological variable and anaerobic power only from the age of 16 years old on; That, above this age group, the results obtained here are aligned with the exponential development progression in this maturational period, which reflects the reach of the final stages, maintaining a better constancy of results and responsiveness to the training intervention.

CONCLUSIONS

The greater evidence found was the normality of the sample showing skeletal maturation with anon time standard of skeletal age. The height was showed to be a superlative data in the study when compared to international results, however appropriate to the results found in national studies, leading to conclude a possible super estimation of this variable in a national level selection of talents. Skeletal ageand the PAn'sdata shows evidence that both are important to determine the success of the athletic adequacy of the individual to the standards demanded by the game. The researches on the specific theme showed low quantity of specific data to the object of study, the specificity of goalkeepers. There should be future analyses to densify the results in the area in order to provide a wider and reliable comprehension.

Whatisalreadyknownonthistopic
▪ The majority of young players are selected for the potential they present at a given moment, occurring generally in the stage of childhood and adolescence of the individuals, which can disrupt the process of talent selection. ▪ Each game position has its own physical and anthropometric characteristics, however, goalkeepers are rarely included in position studies. ▪ The identification and selection of young athletes are complicated because they are influenced by several factors, such as the differences triggered by the maturational process of each individual.

Whatthisstudyadds
▪ Brazilian goalkeepers have a different stature of goalkeepers from other countries, so young athletes must be compared according to their country of origin. ▪ There is a positive correlation between the maturational state on time and performance aspects, making them important characteristics in the specialization process of the young athletes. ▪ It is necessary to take into account the playing position, maturational stage and place of origin of the individuals in the process of identification and selection of new talents.

Conflicts of Interest: We declare that there is no conflict of interest.

Authors' Contribution

SARAH RAMOS:Main author responsible for data collection and writing of all text.

RODRIGO PINHEIRO:Collaborating author in revision of the discussion, revision of all text.

ROBERTO SIMÃO: Collaborating author in reviewing the text.

RAFAEL TEIXEIRA: Collaborating author in data collection, revision of the methodology, revision of all text.

GABRIEL COSTA E SILVA: Collaborating author in the revision of the whole text, statistical analysis.

ALEX EVANGELISTA: Collaborating author in reviewing the text.

CARLOS HERDY: Collaborating author in data collection,the revision of the whole text and revision of the statistical part.

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REFERENCES

1. Carling C, Gall FL, Malina RM. Body size, skeletal maturity, and functional characteristics of elite academy soccer players on entry between 1992 and 2003. J Sport Sci. 2012; 30(15):1683-1693.
2. Guedes DP. Crescimento e desenvolvimento aplicado à Educação Física e ao Esporte. Rev Bras EducFísEsporte. 2011; 25(1):127-140.

3. Valente-dos-Santos J, Coelho-e-Silva MJ, Simões F, Figueiredo AJ, Leite N, Elferink-Gemser MT, *et al*. Modeling Developmental Changes in Functional Capacities and Soccer-Specific Skills in Male Players Aged 11-17 Years. PediatrExercSci. 2012; 24(4):603-621.
4. Malina RM, Eisenmann JC, Cumming SP, Ribeiro B, Aroso J. Maturity-associated variation in the growth and functional capacities of youth football (soccer) players 13-15 years. Eur J ApplPhysiol. 2004; 91(5-6):555-562.
5. Lago-Peñas C, Casais L, Dellal A, Rey E, Domínguez E. Anthropometric and physiological characteristics of young soccer players according to their playing positions: relevance for competition success. J Strength Cond Res. 2011; 25(12):3358-3367.
6. Rebelo-Gonçalves R, Coelho-e-Silva MJ, Severino V, Tessitore A, Figueiredo AJ. Anthropometric and Physiological Profiling of Youth Soccer Goalkeepers. Int J Sports Physiol Perform. 2015; 10(2):224-231.
7. Figueiredo AJ, Gonçalves CE, Coelho-e-Silva MJ, Malina RM. Youth soccer players, 11–14 years: Maturity, size, function, skill and goal orientation. Ann Hum Biol. 2009; 36(1):60-73.
8. Balsalobre-fernández C, Glaister M, Lockey RA. The validity and reliability of an iPhone app for measuring vertical jump performance. J Sport Sci. 2015; 33(15):1574-1579.
9. Thodberg HH, Kreiborg S, Juul A, Pedersen KD. Bonexpert method for automated determination of skeletal maturity. Trans Med Imag. 2009; 28(1):52-66.
10. Malina RM, Bouchard C, Bar-Or O. Growth, maturation, and physical activity. (2nd Edition). EstadosUnidos da América: Human kinetics, 2004.
11. Romann M, Fuchslocher J. Assessment of skeletal age on the basis of DXA-derived hand scans in elite youth soccer player. Res Sports Med. 2016; 23(3):200-211.
12. Sherar LB, Cumming S, Eisenmann JC, Malina RM. Adolescent biological maturity and physical activity: biology meets behavior. PediatrExercSci. 2010; 22(3):332-349.
13. Malina RM. Skeletal age and age verification in youth sport. Sports Med. 2011; 41(11):925-947.
14. Le Gall F, Carling C, Williams M, Reilly T. Anthropometric and fitness characteristics of international, professional and amateur male graduate soccer players from an elite youth academy. J SciMed Sport. 2010; 13(1):90-95.
15. Silva SP, Freitas DL, Beunen GP, Maia JAR. Maturação biológica: da sua relevânciaà aprendizagem do método TW3. Rev Bras Cineantropom Desempenho Hum. 2010; 12(5):352-358.
16. Schmidt S, Nitz I, Schulz R, Schmeling A. Applicability of the skeletal age determination method of Tanner and Whitehouse for forensic age diagnostics. Int J Legal Med. 2008; 122(4):309-314.
17. Wong PL, Chamari K, Dellal A, Wisløff U. Relationship between anthropometric and physiological characteristics in youth soccer players. J Strength Cond Res. 2009; 23(4):1204-1210.
18. Berto ESM, Magalhães FCO. A estatura como critério de seleção na captação e formação do goleiro de futebol de campo. Revista Brasileira de Futsal e Futebol. 2014; 6(20):88-94.
19. Nikolaidis P, Ziv G, Lidor R, Arnon M. Inter-individual Variability in Soccer Players of Different Age Groups Playing Different Positions. J Hum Kinet. 2014; 40(1):213-225.
20. Gil SM, Gil J, Ruiz F, Irazusta A, Irazusta J. Physiological and anthropometric characteristics of young soccer players according to their playing position: relevance for the selection process. J Strength Cond Res. 2007; 21(2):438-445.
21. Gil SM, Zabala-Lili J, Bidaurrazaga-Letona I, Aduna B, Lekue JA, Santos-Concejero J, Granados C. Talent identification and selection process of outfield players and goalkeepers in a professional soccer club. J Sport Sci. 2014; 32(20):1931-1939.
22. Ziv G, Lidor R. Physical characteristics, physiological attributes, and on-field performances of soccer goalkeepers. Int J Sports Physiol Perform. 2011; 6(4):509-524.
23. Tourinho Filho H, Tourinho LSPR. Crianças, adolescentes e atividade física: aspectos maturacionais e funcionais. Rev Paul EducFís. 1998; 12(1):71-84.
24. Teixeira AS, Valente-dos-Santos J, Coelho-E-Silva MJ, Malina RM, Fernandes-da-Silva J, Cesar do Nascimento Salvador P, *et al*. Skeletal Maturation and Aerobic Performance in Young Soccer Players from Professional Academies. Int J Sport Med. 2015; 36(13):1069-1075.
25. Deprez D, Fransen J, Lenoir M, Philippaerts RM, Vaeyens R. A retrospective study on anthropometrical, physical fitness, and motor coordination characteristics that influence dropout, contract status, and first-team playing time in high-level soccer players aged eight to eighteen years. J Strength Cond Res. 2015; 29(6):1692-1704.