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Do Young Elite Football Athletes Have the Same Strength and Power Characteristics as Senior Athletes?

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Abstract: An increasing number of young football athletes are competing in elite senior level competitions. However, comparison of strength, power, and speed characteristics between young elite football athletes and their senior counterparts, while controlling for anthropometric parameters, is yet to be investigated. Knee extension concentric peak torque, jump performance, and 20 m straight-line speed were compared between age groups of under 17 (U17: $n = 24$), under 19 (U19: $n = 25$), and senior (seniors: $n = 19$) elite, national and international level, male football athletes. Analysis of covariance was performed, with height and body mass used as covariates. No significant differences were found between age groups for knee extension concentric peak torque ($p = 0.28$–0.42), while an effect was observed when the covariates of height and body mass were applied ($p < 0.001$). Senior players had greater jump and speed performance, whereas an effect was observed only for the covariate of body mass in the 15 m and 20 m ($p < 0.001$) speed testing. No differences were observed between U17 and U19 groups for jump and speed performance ($p = 0.26$–0.46). The current study suggests that younger elite football athletes (<19 years) have lower jump and speed performance than their senior counterparts, but not for strength when height and body mass are considered as covariates. Emphasis should be on power development capacities at the late youth phase when preparing athletes for the senior competition level.

Keywords: elite soccer; anaerobic alactic; age groups; performance

1. Introduction

An elite football (i.e., soccer) match demands a high number of short and intense activities including sprints, tackles, and jumps [1,2]. Consequently, high anaerobic abilities (e.g., maximal strength and speed) are essential factors for performance, and suggest as essential to achieve high football performance levels [1]. In elite football European clubs, a considerable number of athletes start competing at an elite level (e.g., main national division) at ages <19 years. However, it is unknown if young athletes have similar anaerobic abilities as their senior counterparts at this elite level of competition.

Previous studies have reported different strength, power, and speed characteristics between age groups in football athletes [3–6]. For instance, Kellis et al. observed a clear age effect on isokinetic concentric knee extensor strength in 158 soccer male subjects from 10 to 17 years old [6]. Also, Nikolaidis (2014) observed an age effect on lower body muscle power measured by countermovement jump [7]. This age effect on the lower body power capabilities seems to affect a wide spectrum of force–velocity muscular properties, as Nikolaidis (2012) have observed an age effect on cycling power production on both extremes of the force–velocity spectrum [8]. However, previous studies have limited their analysis to ages below the senior level [3,4,6], female populations [4], non-professional populations [5], or comparisons between competition levels [9,10]. To the best of our knowledge, no study has compared the age effects on strength, power, and speed between young and senior football athletes competing at an elite professional level. In addition, body size related parameters, such as body mass and height, have been suggested as primary contributors to explain variance in anaerobic capabilities in young football athletes [11,12]. Therefore, it is important to determine whether these anthropometric characteristics can explain potential differences in anaerobic capabilities between young and senior elite football athletes.

This study aimed to compare the differences in strength, power and speed between a group of under 17 years (U17), under 19 years (U19), and senior ($\geq$19 years) elite male football athletes, while controlling for body mass and height. We hypothesized that no differences would be seen in the anaerobic capabilities between age groups, if analysis included height and body mass as covariates.

2. Materials and Methods

2.1. Participants

Sixty-nine elite male athletes from an elite Portuguese football club were invited to participate in the study. Participants were divided in three different groups according to their age: seniors, U19, and U17. Athletes from all age groups competed at the highest national (and some international) level in football, and were familiarized with all the testing protocols and procedures before taking part in the study. During a typical training week, all age group squads had between 5 and 6 technical–tactical training sessions, and 2 and 3 resistance training sessions per week. This study followed the principles of the Declaration of Helsinki, and the local Ethics recommendations. Informed consent was obtained from each participant; and parental consent was obtained for participants under 18 years old.

2.2. Procedures

All testing was performed at the pre-season of the 2016/17 European football season. The testing sessions were performed on two consecutive days, at the same time of the day (i.e., morning). Athletes did not perform any training between testing sessions. Sprints and jump tests were performed on the first day, and the strength tests were performed on the second day. A warm-up consisting of 15-min of moderate intensity running and low intensity jumping exercises was performed at the start of each testing session.

2.3. Measures

Anthropometric measures (height and weight) were performed by the sport science and medical professionals, supervised by a member certified by the International Society for the Advancement of Kinanthropometry (ISAK). Anthropometrics measures were performed in accordance to the ISAK guidelines. Height was assessed using a stadiometer (Seca 217, Hamburg, Germany); while weight was assessed using minimal clothing and a calibrated balance ($\pm$0.1 kg, Tanita TBF 300, Tokyo, Japan).

Concentric isokinetic knee extension peak torque was assessed using an isokinetic dynamometer (Biodex System 3 research, Shirley, NY, USA) on both legs. Participants performed the testing in a seated position, while the thighs (above the knee) were stabilized by straps. The dynamometer axis was aligned with the lateral condyle of the femur. The knee range of motion limits were set between 90° and 180° (full extension). One set of six maximal knee flexion–extension (concentric/concentric) repetitions were performed for each leg at a speed of 60°/s. Torque was corrected for gravity. The peak torque output during knee extension (of each leg), measured by the Biodex software (Shirley, NY, USA, version), was used for analysis.

Vertical jump height for the countermovement jump (CMJ) followed by squat jump (SJ) and drop jump (DJ) tests was assessed using a portable optical timing system (Optojump Next; Microgate, Bolzano, Italy). Jumps were performed with the hands on the hips, and verbal encouragement was given. For the SJ, if any counter-movement action was detected by the researcher, an additional trial was performed. For the DJ, participants were required to jump from a 40-cm wooden box. Three trials were performed for each jump test (1-min rest between trials, and 5-min rest between jump tests). The best performance was used for analysis.

The time to complete 20-m in a straight-line sprint test was assessed at 5, 15, and 20 m intervals using electronic timing gates (Swift Performance SpeedLight, Queensland, Australia). The test was performed on an AstroTurf outdoor surface. Participants began each sprint from a standing position with their front foot placed 0.75 m behind the first timing gate. Participants were instructed to run as quickly as possible over the 20 m distance. Time was measured to the nearest 0.001 s. Two trials were performed, and the highest value was used for analysis.

2.4. Statistical Analysis

All data was analyzed using SPSS software (version 23.0, IBM, Chicago, IL, USA). Normal distribution was confirmed for most of independent variables using the Shapiro–Wilk test. Age, body mass, and height was compared between age groups using a one-way ANOVA followed by Bonferroni test. Analysis of strength, jumping, and speed performance between age groups were performed using one-way analysis of covariance (ANCOVA). Body mass and height were defined as covariates in the analysis. ANCOVA assumptions were confirmed using: (i) Pearson correlation coefficient between the covariates ($r < 0.8$); (ii) Levene test for determining dependent variables homogeneity; and, (iii) Shapiro–Wilk test for determining the distribution of the residuals data. When applicable, Post hoc analysis were performed using the Bonferroni test. Statistical significance was set at $p < 0.05$.

3. Results

Covariates showed a Pearson correlation coefficient lower than 0.61 for all dependent variables. Sample size, age, and anthropometric characteristics for each age group are shown in Table 1. Seniors had higher body mass than U19 ($p = 0.001$) and U17 ($p < 0.001$) groups; and were taller than the U17 group ($p = 0.01$). No differences between U19 and U17 were noted for height ($p = 0.41$) and body mass ($p = 0.92$).

Table 1. Participant characteristics. Data shown as means ± SD.

Participants Characteristics	Seniors ($n = 19$)	U19 ($n = 25$)	U17 ($n = 24$)
Age (years)	22.9 ± 4.0 $^{\#}$	17.4 ± 0.6 *	15.4 ± 0.8 $^{*,\#}$
Body Mass (kg)	78.2 ± 14.0	69.2 ± 5.0 *	67.0 ± 8.5 *
Height (cm)	181.7 ± 7.4	178.7 ± 3.8	175.9 ± 7.4 *

* Significant different compared to seniors ($p < 0.05$). # Significant different compared to U19 ($p < 0.05$).

Figure 1 presents the estimated marginal means ± standard error for all dependent variables in the different age groups. No effect was observed for age groups in knee extension concentric peak torque in both right ($p = 0.28$) and left ($p = 0.42$) limbs, except for when values were adjusted for the covariates of height (right limb: $p < 0.001$; left limb: $p < 0.001$) and body mass (right limb: $p = 0.15$; left limb: $p = 0.06$).

An effect was seen for age groups in all the jumping tests ($p < 0.001$), without a significant effect when covariates were applied (height: $p = 0.23$–0.601; body mass: $p = 0.19$–0.85). Post hoc analysis revealed that seniors had better jump performance than U19 ($p < 0.001$) and U17 ($p < 0.001$); while no differences were seen between U19 and U17 ($p = 1.00$).

Regarding sprint performance, an effect was seen for age groups in all the distances (5 m: $p = 0.004$; 15 m: $p < 0.001$; 20 m: $p < 0.001$); and an effect was observed for the body mass covariate at 15 m

($p = 0.02$) and 20 m ($p = 0.02$), with no effect for the height covariate ($p = 0.40$–0.99). Post hoc analysis revealed that seniors were faster than U19 and U17 groups for all the distances, except compared to the U19 in the 5 m distance ($p = 0.14$). No differences were observed between U19 and U17 for all sprint distances ($p = 0.26$–0.46).

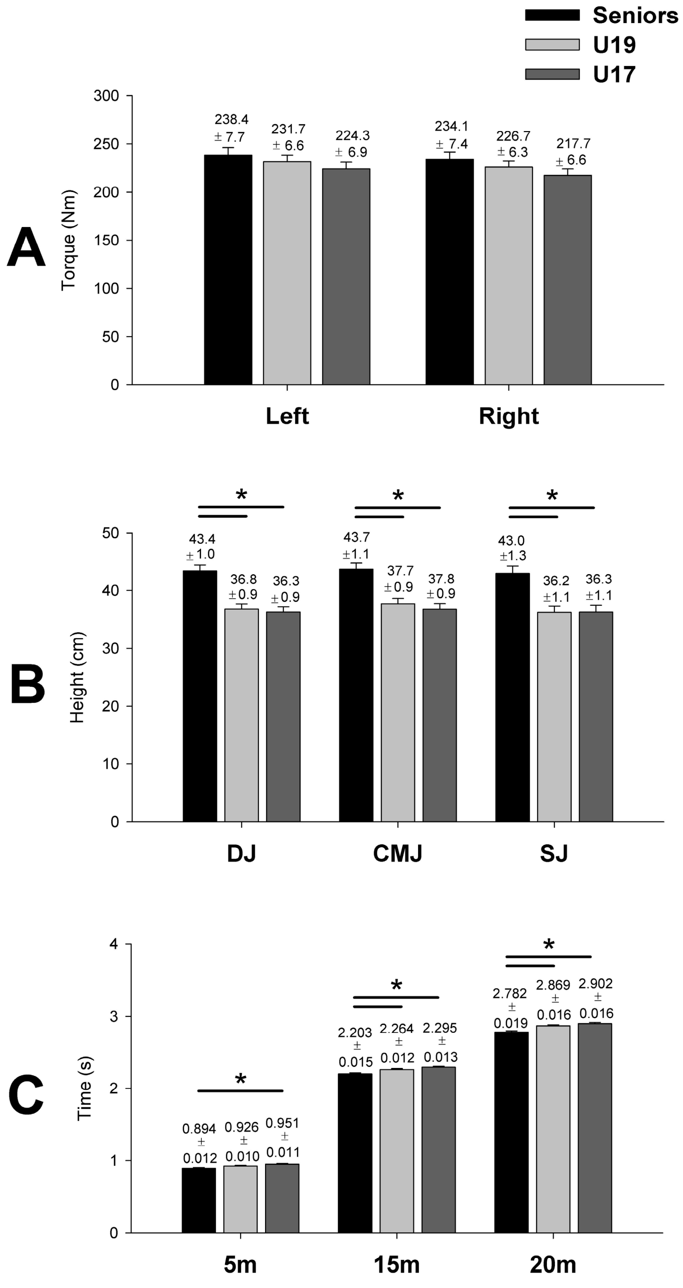

Figure 1. Estimated marginal means ± standard deviations of (**A**) knee extension peak torque of both lower limbs; (**B**) vertical jump height in three jump tests, and (**C**) sprint times at 5, 15, and 20 m for the different age groups. * $p < 0.05$. Legend: DJ; drop jump; SJ; squat jump; CMJ; countermovement jump.

4. Discussion

This study compared the anaerobic physical performance between young and senior athletes that compete at an elite level, while controlling for body mass and height. The main study findings were: (i) no differences were found between age groups for knee extension concentric peak torque, after controlling for body mass and height; (ii) jumping performance was higher for seniors compared to

U17 and U19, without influence of body mass and height; (iii) seniors were faster than younger athletes, whereas the covariate of body mass was closely related to performance at 15 and 20 m distances; and, (iv) overall, no differences were seen between U17 and U19 age groups.

The results for knee extension concentric peak torque observed in the present study were similar to those reported in previous studies examining the senior [13], U19 [5,6], and U17 [14] elite football athletes. According to our initial hypothesis, no differences were observed in knee extension concentric peak torque between age groups, when controlling for the body mass and height. This result is suggestive that the factors related to body size that affect the muscular force production may not be fully developed in athletes under 19 years old. Skeletal muscle mass, which is associated with muscle power to a greater extent than body mass [7], is a potential factor which development may not been maximized in athletes at this age; since the potential for muscle mass development is likely to still be occurring up to this age [15]. However, since we have not assessed the skeletal muscle mass, the present study does not allow us to conclude whether this factor could explain the present results, and therefore, remains speculative. Nevertheless, a potential practical implication obtained in this study is that analysis of strength performance between young and senior elite football athletes should be made by normalizing the strength to a body-size related factor, in particular to the body mass.

Moreover, previous research has suggested that some basic anthropometric characteristics, such as body mass and height, significantly contribute to explain the jumping and speed performance differences between athletes at a young age [11,12]. Thus, it would be expected that such anthropometric characteristics could explain potential performance differences between elite football athletes at a late youth phase and their senior counterparts. However, the present results do not support such rationale, since only the covariate of body mass influenced the speed at 15 m and 20 m distances. It should be noted that jumping performance has similar physiological demands than speed performance at a 5 m distance, i.e., high energy, alactic demand for a short and explosive motion involving muscular recruitment for a high rate of force production. In addition, both the jump and speed performance observed in the present study is in agreement to data of previous studies examining senior [5,10], U19 [10,16,17], and U17 [3,18] elite football athletes. Also, we observed that senior athletes presented a greater jump and speed performance than younger athletes, which suggests that these physical capacities should be considered a priority in the training of young athletes. Considering the relationship often reported between maximum strength and power [19], and since no significant effect was found for height and weight as covariates, it is possible that these anaerobic performance differences may be explained by neural factors, which may be related to maturation processes [20]. For instance, Paus et al. observed an effect of age on the increase of the axon diameter and myelination within children and adolescents [21]. These neural cell structure characteristics are known to influence action potential transmission speed [22], that contribute to the differences in short and explosive actions observed with maturation [20]. Future research is needed to examine the physiological basis of anaerobic performance deficit at this young age phase (compared to senior age groups).

5. Conclusions

In conclusion, the current study suggests that younger elite football athletes have lower jump and speed performance than their senior counterparts, but not for strength when height and body mass were considered as covariates. Based on the rationale for the development of the physical performance abilities in an athletic population [16], we would recommend that: firstly, football coaches and strength and conditioning professionals should monitor the power and strength of younger athletes in order to decide for their inclusion in senior level competition; and, secondly, priority should be given to power training for young athletes who are close to participating at a senior level of competition.

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