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Original Article

Comparison of body composition and muscle mass by age in amateur soccer players

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Abstract. [Purpose] This study aimed to elucidate the changes in body composition components associated with aging in amateur male soccer players. Specifically, we investigated the alterations in the phase angle and regional muscle mass distribution. [Participants and Methods] The study included a cohort of 163 male participants categorized into three age groups: U15 (12–15 years), U18 (16–18 years), and O19 (≥19 years). Precise body composition assessments were performed, employing the InBodyS10 body composition scale. [Results] The findings revealed substantial age-related disparities in various body composition parameters. Data revealed a consistent trend of increasing basic body composition metrics with age. Notably, the body fat percentage progressively increased with age. Muscle mass and phase angle exhibited age-related increases with nuanced variations in different anatomical regions. [Conclusion] In the general Japanese population, muscle mass tends to decrease with age after 18 years. However, in this study on amateur soccer players, we observed a plateau in the height and lower limb phase angle around the age of 18 years, whereas muscle mass exhibited an increasing trend.

Key words: Amateur soccer players, Body composition, Phase angle

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INTRODUCTION

Body composition plays a crucial role in physical development, particularly during adolescence, which is the transitional phase from childhood to adulthood and typically spans ages 8–18 years[1)]. This period is characterized by significant growth. For instance, a study involving Japanese soccer players aged 13 years to adulthood showed a substantial transformation in morphology and physique, particularly between the ages of 13 and 15 years, marked by an approximately 40% increase in muscle cross-sectional area[2)]. Although significant increases in lean body mass and thigh cross-sectional area were noted between the ages of 15 and 17 years, further growth observed in the age group of 22 was relatively modest. Such age-related developmental trends tend to plateau around the age of 17 years in both the general Japanese male population and soccer players[3)].

Although previous research has collected data regarding age-related changes in body composition among male soccer players, there is a dearth of analyses in the Japanese population, specifically focusing on emerging indices such as phase angle (PhA) and region-specific muscle mass[4)].

The primary objective of this study was to conduct a comprehensive analysis of body composition components in amateur soccer players aged 12–37 years, a period characterized by significant physical growth. Our aim was not only to elucidate morphological alterations but also to shed light on age-related changes in PhA and muscle mass across distinct anatomical regions.

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PARTICIPANTS AND METHODS

A total of 163 participants were included in this study, comprising 45 players from adult soccer teams in Tochigi Prefecture, 64 players from high school soccer teams in Tochigi and Shizuoka Prefectures, and 54 players from junior high school club teams in Tochigi Prefecture. The exclusion criteria included a history of traumatic injuries within the past 3 months, leading to the exclusion of one adult soccer team member. All soccer players engaged in specialized training sessions ≤5 times per week. Measurements were carried out on non-training days, with participants advised to have meals at least 2 h prior to the measurements. No specific restrictions were imposed on fluid intake; however, the participants were instructed to void their bowels before the measurements. Consent was obtained directly from adult participants, whereas for underage participants, consent was obtained from both their families and instructors. This study received approval from the Research Ethics Review Committee of the International University of Health and Welfare (approval number: 21-Io-34-2).

The participants were prepared for measurements in a designated area by removing their shoes and socks and donning lightweight clothing. We measured their height using a height scale and assessed their weight using a digital scale. Measures of body composition, including muscle mass, water content, and PhA, were evaluated using the InBody S10 body composition scale (InBody, Inc., Seoul, South Korea). Body composition analyzers allow for quick and convenient quantitative evaluation of body fluids, proteins, mineral content, and fat. The body composition analyzer used in this study, the InBody S10 by InBody Inc., calculates body composition based solely on height, weight, and impedance without incorporating statistical information such as gender or age for correction. During the measurements, the participants were seated without their backs touching the backrest of the chair. Their arms hung naturally, approximately 15° away from their torsos, and their feet were positioned shoulder width apart.

Participants were categorized into three groups based on their age: 12–15 years (U15 group), 16–18 years (U18 group), and ≥19 years (O19 group). This categorization enabled us to compare the body composition components. To account for variations in body size, we normalized the muscle mass in the upper limb, lower limb, and trunk regions by dividing the muscle mass of each region by the total muscle mass of the entire body. Statistical analyses were performed using the SPSS ver. 27 (IBM, Armonk, NY, USA). We conducted one-way ANOVA to assess the differences among the three groups. Multiple-group comparisons were performed using the Bonferroni test, with the significance level set at 5%.

RESULTS

The results of the multiple comparison test (Table 1) indicated significant differences among the three groups in terms of age, body weight, body water content, lean body mass, muscle mass, upper limb muscle mass, trunk muscle mass, lower limb muscle mass, PhA, right arm PhA, and left arm PhA ($p<0.001$ for all combinations). Furthermore, significant differences were noted between the U15 and U18 groups, as well as between the U15 and O19 groups, in height, right leg PhA, and left leg PhA ($p<0.001$). Notably, significant disparities were detected in fat mass and body trunk PhA between the U15 and O19 groups as well as between the U18 and O19 groups ($p<0.001$). Moreover, a significant difference in body fat percentage was observed between the U15 and O19 groups ($p=0.025$).

To address the effect of body size on our comparisons, we normalized the muscle mass of each specific region by dividing it by the total body muscle mass (Table 2). For upper limb muscle mass, significant differences were observed among all groups ($p<0.001$). Additionally, trunk muscle mass was significantly different between the U15 and O19 groups ($p<0.001$) and between the U18 and O19 groups ($p=0.015$). Finally, a significant difference in lower limb muscle mass was observed between the U18 and O19 groups ($p<0.001$).

DISCUSSION

Significant differences in the height of the amateur soccer players, the participants of this study, were observed between the U15 and O19 groups. Additionally, a significant difference in body weight was noted across all age groups, indicating an increasing trend in basic body composition with age.

The average overall body fat percentage of all the participants was 12.2%, with higher values observed with increasing age. In contrast, a study examining elite French soccer players reported that the body fat percentage in the U15 group was notably higher than that in older age groups[5]. Furthermore, Hoshikawa et al. investigated the body composition of soccer players and reported that professional players had a body fat percentage of 8.8%, which was approximately 3.5% lower than that of the participants in our study[2]. These differences in the results between the previous and present studies could be attributed to differences in activity levels, competition levels, age at which measurements were taken, and measurement equipment.

Previous studies reported that soccer players tend to experience an increase in lean body mass, whereas the general population exhibits a decrease[6]. Soccer is primarily an aerobic exercise-based sport, leading players to increased fat consumption[7]. In line with previous research, we observed an increase in lean body and muscle mass with age[8].

Table 1. Body composition data by age group

n	U15 64	U18 54	O19 44	ALL 162	
Age (years)	13.9 ± 0.9	16.5 ± 0.5	26.2 ± 4.8	18.1 ± 5.7	*#†
Height (cm)	163.5 ± 7.6	171.4 ± 5.6	172.5 ± 5.6	168.6 ± 7.6	*†
Weight (kg)	51.1 ± 7.7	61.4 ± 6.5	69.7 ± 7.5	59.6 ± 10.5	*#†
Body Fat Percentage (%)	11.5 ± 5.1	11.8 ± 4.7	14.0 ± 4.9	12.3 ± 5.0	†
Body water content (L)	33.0 ± 4.7	39.3 ± 3.7	43.9 ± 3.6	38.1 ± 6.1	*#†
Lean body mass (kg)	45.1 ± 6.4	53.8 ± 5.1	59.7 ± 5.1	52.0 ± 8.2	*#†
Fat mass (kg)	6.0 ± 3.2	7.3 ± 3.3	10.0 ± 4.3	7.5 ± 3.9	#†
Muscle mass (kg)	42.5 ± 6.1	50.6 ± 4.7	56.2 ± 4.7	48.9 ± 7.8	*#†
Upper limb muscle mass (kg)	4.1 ± 0.9	5.3 ± 0.7	6.3 ± 0.7	5.1 ± 1.1	*#†
Trunk muscle mass (kg)	18.6 ± 2.8	22.3 ± 2.1	25.1 ± 2.0	21.6 ± 3.6	*#†
Lower limb muscle mass (kg)	14.5 ± 2.5	17.6 ± 1.9	18.7 ± 1.9	16.6 ± 2.8	*#†
Phase angle (°)	5.6 ± 0.6	6.5 ± 0.6	7.2 ± 0.6	6.3 ± 0.9	*#†
Right arm PhA (°)	5.0 ± 0.5	5.6 ± 0.5	6.5 ± 0.5	5.6 ± 0.8	*#†
Left arm PhA (°)	4.8 ± 0.5	5.4 ± 0.5	6.4 ± 0.6	5.5 ± 0.8	*#†
Trunk PhA (°)	8.6 ± 1.2	8.9 ± 1.0	11.3 ± 2.0	9.4 ± 1.8	#†
Right Leg PhA (°)	6.3 ± 0.9	7.6 ± 0.9	7.7 ± 0.7	7.1 ± 1.1	*†
Left Leg PhA (°)	6.1 ± 0.8	7.6 ± 0.9	7.6 ± 0.8	7.0 ± 1.1	*†

Values are mean ± standard deviations.
One-way ANOVA to compare the three groups, followed by Bonferroni tests for multiple comparisons.
*p<0.05. U-15 significantly different from U18.
#p<0.05. U-18 significantly different from O19.
†p<0.05. U-15 significantly different from O19.
U15: 12–15 years; U18: 16–18 years; O19: ≥19 years; ANOVA: analysis of variance.

Table 2. Age-dependent distribution of muscle mass by region

n	U15 64	U18 54	O19 44	ALL 162	
Upper limb muscle mass (%)	9.8 ± 0.9	10.5 ± 0.6	11.0 ± 0.5	10.3 ± 0.9	*#†
Trunk muscle mass (%)	43.6 ± 1.1	44.1 ± 1.2	44.7 ± 1.3	44.1 ± 1.2	#†
Lower limb muscle mass (%)	33.9 ± 1.9	34.6 ± 1.6	33.3 ± 1.4	34.0 ± 1.7	#

Values are mean ± standard deviations.
One-way ANOVA to compare the three groups, followed by Bonferroni tests for multiple comparisons.
*p<0.05. U-15 significantly different from U18.
#p<0.05. U-18 significantly different from O19.
†p<0.05. U-15 significantly different from O19.
U15: 12–15 years; U18: 16–18 years; O19: ≥19 years; ANOVA: analysis of variance.

PhA is associated with muscle mass, and studies in Americans have suggested that PhA remains low until adulthood, peaks between the ages of 20 and 30 years, and subsequently declines[9, 10]. In our study, the average PhA values were 5.6° (U15), 6.5° (U18), and 7.2° (O19). The mean age of the patients in the O19 group was 26.2 years. Although it cannot be conclusively determined whether PhA plateaus, it is evident that PhA increases with age. Regarding specific body regions, significant differences were observed in the upper limb PhA among all age groups, whereas the trunk PhA showed significant differences between the O19 and other age groups, and the lower limb PhA displayed significant differences between the U15 and other age groups. The PhA in the lower limbs increased between the U15 and U18 groups, whereas both the PhA in the upper limbs and trunk increased between the U15 and O19 groups. Although the overall body PhA peaks during adulthood, our results suggest the possibility that lower limb PhA reaches its peak around the ages of 16–18 years.

Table 1 shows the significant differences in muscle mass among the various regions. However, when we normalized the muscle mass of each region by dividing it by the total body muscle mass (Table 2), we observed significant differences only in the upper limb muscle mass among all groups. Additionally, we noted significant differences in trunk muscle mass between the O19 and other groups, and in the lower limb muscle mass between the U18 and O19 groups. Concerning age-related changes in muscle mass among Japanese individuals, upper limb muscle mass has been reported to gradually decrease after the age of 18 years[11]. For Japanese males aged 18–24 years, the average upper limb muscle mass was found to be 5.5 ± 0.7 kg[11]. However, our study found that the muscle mass for the O19 group was notably higher, at 6.25 ± 0.65 kg[11]. These results suggest an increasing trend in upper limb muscle mass when participants continue to participate in competitive sports after the age of 18 years.

In summary, our results suggest that the height and lower limb PhA of Japanese amateur soccer players tend to stabilize around the age of 18 years. Furthermore, the muscle mass of both the upper and lower limbs, particularly the former, tends to increase with continued participation in competitive sports as the players age.

However, this study has several limitations. First, there are constraints within the sample range. The findings of this study may apply primarily to certain regions and competition levels, limiting their applicability to athletes from elsewhere or at different competition levels.

Second, longitudinal assessments were lacking. This was a cross-sectional study and did not track the changes in muscle mass or body composition components over time.

Third, this study focused exclusively on male soccer players and did not include data pertaining to female soccer players.

Fourth, the study did not consider the training or dietary conditions of the individual players.

Fifth, exploration of the specific clinical significance of PhA has been insufficient. Although this study discusses the changes in PhAs, it does not delve deeply into their specific clinical implications and health effects.

To address these limitations, future studies should target a broader sample, conduct long-term follow-up, include female athletes, collect data on individual lifestyles and training, and explore the clinical significance of specific biological indicators.

Conflicts of interest

The authors have no conflicts of interest to declare.

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