ISAK INTERNATIONAL JOURNAL OF KINANTHROPOMETRY

DOI: 10.34256/ijk2317

Effect of Maturity Status and Relative Age Effect on Anthropometrics and Physical Performance of Soccer Players Aged 12 to 15 Years

Seyed Houtan Shahidi [1,*], Levent Yilmaz [1], Joseph Esformes [2]

[1] Faculty of Sport Sciences, Department of Sports Coaching, Istanbul Gedik University, Istanbul, Turkey
[2] Cardiff School of Sport and Health Sciences, Cardiff Metropolitan University, Cardiff, United Kingdom.
* Corresponding authors email: houtan.shahidi@gedik.edu.tr

DOI: https://doi.org/10.34256/ijk2317
Received: 12-04-2023; Revised: 28-05-2023; Accepted: 07-06-2023; Published: 30-06-2023

Resumen

Introducción: Existe un interés creciente en la relación entre la maduración biológica, el efecto de la edad relativa y el rendimiento deportivo en el fútbol. Según el efecto relativo de la edad y la maduración de su cohorte, los jugadores de fútbol relativamente mayores pueden verse favorecidos para ser seleccionados para equipos de alto nivel. Por lo tanto, el presente estudio examinó el efecto de la madurez y la edad relativa en las pruebas antropométricas y de rendimiento físico. **Métodos:** un estudio transversal que involucró a 82 niños (edad M: 13,4 ± 1,1; masa corporal M: 51,9 ± 9,9; altura corporal: 162 ± 10,5; porcentaje de grasa corporal: 9,7 ± 1,1) fueron evaluados para antropometría, flexibilidad, mano, y la fuerza de las piernas, y el rendimiento del salto con contramovimiento. Se utilizó la determinación de la velocidad máxima de altura (PHV) para estimar el estado de madurez. Las distribuciones de fechas de nacimiento se clasificaron en cuatro cuartiles (enero-marzo, Q1; abril-junio, Q2; julio-septiembre, Q3; octubre-diciembre, Q4). Se realizó un análisis MANOVA en todas las evaluaciones antropométricas y de rendimiento físico para examinar las diferencias dentro de los grupos de edad y los grupos de estado de madurez. Se revelaron diferencias entre todos los grupos, con puntuaciones altas en el grupo de mayor edad (Sub-15). **Resultados:** La maduración biológica influye en las diferencias en la evaluación del rendimiento físico y antropométrico con un efecto significativo en los futbolistas de maduración temprana en comparación con los de maduración tardía. Los jugadores maduros tempranos estaban sobrerrepresentados y estadísticamente tenían mejores resultados antropométricos y de rendimiento físico. **Conclusión:** Sin embargo, no hubo una representación significativa de jugadores en el primer cuarto en comparación con el tercero y cuarto para todas las evaluaciones antropométricas y de rendimiento. Los hallazgos actuales pueden usarse para cuantificar y controlar los datos de rendimiento de los jugadores de fútbol ajustados a los requisitos biológicos utilizados en el proceso de entrenamiento.

Palabras Clave: Madurez, Fútbol, Antropometría, Rendimiento Físico, % Grasa Corporal

Abstract

Introduction: There is a growing interest in the relationship between biological maturation, relative age effect, and soccer sports performance. Based on their cohort's relative age effect and maturation, relatively older soccer players can be favored to be selected for high-level teams. Therefore, the current study examined the effect of maturity and relative age on anthropometric and physical performance tests. **Methods:** A cross-sectional study involving 82 boys (M age: 13.4 ± 1.1; M body mass: 51.9 ± 9.9; body height: 162 ± 10.5; body fat%: 9.7 ± 1.1) were assessed for anthropometric, flexibility, hand, and leg strength, and countermovement jump performance. Peak height velocity (PHV) determination was used for maturity status estimation. The birthdate distributions were categorized into four quartiles (January-March, Q1; April-June, Q2; July-September, Q3; October-December, Q4). MANOVA analysis was performed on all anthropometric and physical performance assessments to examine differences within age groups and maturity status groups. Differences among all groups were revealed, with high scores in the older group (U-15). **Results:** Biological maturation influences the differences in the anthropometric and physical performance assessment with a significant effect on the early matured soccer players compared to the late matured. Early matured players were overrepresented and statistically had better anthropometric and physical performance results.

Conclusion: However, there was no significant representation of players in the first quarter compared to the third and fourth quarters for all the anthropometric and performance assessments. The current findings can be used for quantifying and controlling performance data of soccer players adjusted to biological requirements used in the training process.

Keywords: Maturity, Soccer, Anthropometry, Physical Performance, Body fat %

Introduction

In soccer, clubs aim to identify players that will potentially succeed at an early age to ensure they receive specialized coaching and training to accelerate the development process (Shahidi, Kingsley, & TAŞKIRAN, 2022). However, relative age and biological maturity are two factors that impact player selection and deselection (Zuber et al., 2016). To guarantee fair competition and reflect age-related development, youth athletes in many sports are separated into competition categories by chronological age (Trecroci et al., 2019; Viero et al.,2020). Relative age is the difference in chronological age between the oldest and youngest individuals within an age group determined by the date of birth and age group cut-off dates (Boucher & Mutimer, 1994; Jakobsson et al., 2021). The relative age effect (RAE) is a selection bias in favor of those born earlier in the election year, whereby those born toward the start of the selection year (1st January) who are chronologically older than those born toward the end of the selection year (31st December), are disproportionately overrepresented within talent pathways (Smith et al.,2018; Werneck et al., 2016). The relative age effect describes a phenomenon whereby those players born early in the selection year are more likely to be represented and succeed in youth sports programs (Kelly et al., 2020). Therefore, based on the RAE, the birthdate distributions have been categorized into four quartiles (January-March, Q1; April-June, Q2; July-September, Q3; October-December, Q4) (Cobley et al., 2009; Gil et al., 2014). A recent study showed that a significantly higher proportion of soccer players, from youth to professional levels, are born in the first quarter of the birth year (Pérez-González et al., 2021). Therefore, from a talent development perspective, older players (Q1, Q2) may hold the greatest potential for success at the senior level than the young player (Q3, Q4), a phenomenon termed the "underdog hypothesis" (Götze & Hoppe, 2021). A recent study (2022) examined the birth date of 20401 soccer players participating in 47 different tournaments from 2006 to 2019, showing the selection process was associated with the RAE, with the strongest effect among males U-17 years old. In contrast to chronological age, biological age or biological maturation refers to the progression toward the mature state, defined in timing, tempo, and intensity (Shahidi et al., 2021). Inter-individual variation in growth and maturation is considerable during childhood and especially adolescence. Individual variation in maturation is determined by hereditary and environmental factors (Christopher et al., 2022). Children of the same chronological age have been shown to vary by as much as five to six years in biological age. For example, a child with a chronological age of 12 could have a biological age between 9 and 15 years (Segueida-Lorca et al., 2022; Chris & Cumming, 2022). Advanced biological maturity within single-year chronological age groups of males from late childhood through mid-adolescence (about 9 – 16 years of age) is associated with advantages in body size, body height, fat-free mass, and physical fitness including muscular strength, power, aerobic capacity, and speed (Chris et al., 2021). The estimation of the age of peak height velocity (APHV) or percentage of final estimated adult stature attainment (%EASA) is typically used to inform the training process in young athletes (Götze & Hoppe, 2021). In youth soccer, maturity-related changes in anthropometric and physical fitness characteristics are diverse among individuals, particularly around PHV (Albaladejo-Saura et al., 2021). Indeed, a significant difference between the distribution of early, normal, and late maturing groups was found when dividing players into maturity groups based on estimated age at peak height velocity (APHV) (Chris et al., 2021). Early maturing males tend to be taller and heavier than normal or later maturing males and are stronger, faster, and more powerful (Johnson et al., 2022; Pedersen et al., 2022). Late-maturing soccer players are more likely to be overlooked or excluded from soccer academies, denying them access to specialist coaching, training resources, and high levels of challenge and competition (D'Hondt et al., 2011; Heilmann et al., 2022). Therefore, the relative age effect (RAE) and biological maturation are critical factors in youth soccer player selection and deselection. Finally, the assessment of maturity status is also an essential factor in explaining anthropometric differences among peers. A cross-sectional study on 191 boys aged from U-12 to U-15 that examined the effect of maturity level using the Mirwald equation on anthropometrics in soccer players demonstrated that maturation status affects physical dimensions and body composition (Toselli et al., 2021). Therefore, individual differences in relative age effect and biological maturation, directly and indirectly, influence player selection and deselection.

The current study examined the RAE and the effects of maturation on anthropometrics and physical performance in young Turkey adolescent male soccer players aged from U-12 to U-15 years old. It was hypothesized that players born in the first half of the year (Q1, Q2) and advanced in biological maturity status (early maturity) would have better anthropometric and physical performance compared to the second half of the year (Q3, Q4) and less matured (late maturity) players.

Methods

Participants

A total of 100 Turkish youth male soccer players aged 12–15 in Istanbul, Turkey, were recruited in a cross-sectional experimental research study. Before enrollment, the participants and their parents were informed about the experimental procedures and the study's risks. Healthy, active children involved in a soccer training program without any injury or disease were recruited for the study. Goalkeepers and players who dropped out of the program were excluded. Additionally, without a complete data set, the participant's data were excluded from the data analysis. The participants were free to withdraw at any time. Written informed consent and assent were obtained from the participants and their parents, respectively. The ethical committee of Istanbul Gedik University approved the study protocol.

Experimental design

Data were collected at the Istanbul Gedik University laboratory. All the anthropometric data were collected on the first testing day. On the second testing day, the test battery was performed following a 10-minute cardiovascular warm-up in the second testing session. The warm-up and performance testing duration was approximately 45 minutes per player.

Anthropometric Measurements

Height and sitting height were measured to the nearest 0.1 cm using a stadiometer (Seca 213 Portable Stadiometer, Seca, Germany), and leg length was derived by subtracting sitting height from standing height. Players removed their shoes and socks to measure their standing height, with their heels, buttocks, shoulders, and head in contact with the stadiometer. For sitting height, players sat on a 40 cm chair with their hips, shoulders, and head as close as possible to the stadiometer. Body weight was measured to the nearest 0.1 kg (wearing light indoor clothing, without shoes) using a calibrated analog scale (0.1 kg, Seca©, Hamburg, Germany). Anthropometric assessments were undertaken following the International Society for the Advancement of Kinanthropometry (ISAK) standards. Anthropometric variables included the sum of eight skinfolds -∑8SF (Biceps, Triceps, Subscapular, Suprailiac, Supraspinal, Abdominal, Front thigh, and Medial calf), five girths (upper arm relaxed, upper arm flexed and tensed, waist, gluteal and maximum calf), and two breadths (Humerus bi-epicondylar and Femur bi-epicondylar. Skinfolds were taken using the Slim-guide skinfold calliper (CH, Plymouth Mich, USA) to the nearest 0.5 mm (Ackland et al., 2009), and the girths were performed with a flexible metallic tape measure (Lupkin W606PM, Mexico), with a precision of 1 mm completed by a single certified investigator (ISAK Level 1). Skinfolds were taken two times, and the mean value was recorded for further analysis. Somatotype was determined according to the Heath and Carter somatotyping method (Carter, & Heath, 1990). The technical error of measurement (TEM) was always lower than 7.5% for each skinfold region and lower than 1.5% for the remaining measurements, which were acceptable (Perini et al., 2005). A third measurement was taken if two measurements at any site were greater than the technical error of measurement (TEM). Given the importance of accurate anthropometric measures, the test-retest reliability for a sample of 20 soccer players (12–15 years) separated by 7-days was established (body height: intraclass correlation coefficient [ICC] = 1.00 [1.00–1.00], typical error [TE] = 0.6 cm [0.5 cm– 0.7 cm]; sitting height: ICC = 0.97 [0.95–0.98]; TE = 0.9 cm [0.8 cm to 1.1 cm]; body-mass: ICC = 1.00 [1.00–1.00]; TE = 0.3 kg [0.3 kg– 0.4 kg].

Maturity Status

An estimation of the years from peak height velocity (PHV), an indicator of the adolescent growth spurt, was determined using the equation for boys by Mirwald et al. (2002), where *Maturity Offset = −9.236 + 0.0002708*Leg Length and Sitting Height interaction −0.001663*Age and Leg Length interaction + 0.007216*Age and Sitting Height interaction + 0.02292*Weight by Height ratio* (Mirwald et al., 2002). Based on the prediction equation used, the approximation of the age at PHV (APHV) is often lower in younger children who are not yet in their adolescent growth spurt and higher in older participants who already passed their adolescent growth spurt. Age-specific z-scores were used in the present study to classify players according to their maturity status to counter this potential age-dependent over and underestimation of APHV. The predicted APHV was used to calculate z-scores within each specific age category (U12-U15; N = 82). Based on these age specific-scores of the predicted APHV, players were then classified as 'earlier' ($z < -1$), "on time" ($-1 \le z \le 1$), or "later" ($z > 1$) maturing (Hill, Scott, Malina, McGee, & Cumming, 2020).

Classification of Relative Age

Relative age was established from the birth date of each player and the cut-off date for the respective year group (1st January). As such, January was selected as the first month of the selection year, and December was the last. The birth month of each player was compiled to define the birth quarter (Q), and four birth quartiles were designated: (Q1; 1st January to 31st March), (Q2; 1st April to 30th June), (Q3; 1st July to 30th September), and (Q4; 1st October to 31st December) (Jakobsson et al., 2021).

Physical Performance Battery Test

The players performed a battery of fitness tests at the beginning of the competitive season, before the pre-season training period, and as part of their respective training programs. One minute of rest was allowed between two attempts, and the mean of two trials was used for further analysis. Flexibility was assessed using a custom sit and reach box (32.4 cm high and 53.3 cm long) to assess the flexibility of the lower back and hamstring muscles with no shoes. Hand grip dynamometry (Takei Scientific Instruments Co., Ltd., Tokyo, Japan) was used to assess the maximal isometric strength of the forearm and hand muscles on both sides. The maximal strength of the lower body muscle was assessed using leg dynamometry (Takei Scientific Instruments Co., Ltd., Tokyo, Japan). Explosive strength power was determined through countermovement jump testing with arm swing using photoelectric cells (Microgate, Bolzano, Italy).

All the measurements were performed twice, and the mean of the two measurements was recorded. If the measurements varied more than 0.05, a third measure was taken, and the median score was recorded. All data collection was completed within an indoor environment at İstanbul Gedik University exercise physiology laboratory. Participants were encouraged to refrain from vigorous activity for 24-48 h prior to testing.

Statistical analyses

Descriptive statistics were calculated and reported as mean ± standard deviation (SD) for continuous variables, while the frequency of appearance (percentage, %) was determined for qualitative variables (RAE and maturity status). The variables' distribution was checked via scatter plots and box plots and verified using the Shapiro-Wilk test. The Chi-square test was used to compare the expected distribution (reference population) and observed distribution (soccer players) of birth quartiles. Multivariate analysis of variance (MANOVA) was used to examine the effects of RAE and maturity on anthropometric and physical performance. The anthropometrical variables and the physical performance test were used as dependent variables. Bonferroni post hoc was conducted following multivariate analysis to examine univariate effects between each dependent variable. Effect sizes using partial eta squared (η^2) were calculated and interpreted using the benchmarks provided by Cohen (0.01 = small, 0.06 = medium, and 0.14 = large) (Cohen, 1988). The significance level adopted for all analyses was $p \leq 0.05$. Statistical analyses were carried out using SPSS 25.0.

Results

Data from 4 goalkeepers and 8 participants were excluded from the statistical analysis due to incomplete anthropometric or physical performance testing data, with data from 82 participants used in the final analysis. The distribution for chronological age, anthropometric, somatotype, and maturity timing appears in Table and Figure 1. The presence of late and early maturation was observed in U-12 (late: 78.6%), U-13 (late: 47.1), U-14 (early: 9.1%), and U-15 (early: 65.5%) year groups (Table 2). The late mature soccer players just have seen in the U-12 and U-13 years groups. When analyzing the variation of soccer players for chronological age, significant differences were observed in the U-15 group compared to the U-14, U-13, and U-12 groups for anthropometric and physical performance tests (Wilks A = 0.139, F (48, 188) = 3.70, p<0.001, η^2 = 0.483, observed power 1; Table 4).

Table 1. Descriptive statistics of participants per age group

Variables (N = 82)	U-12 (n = 14)	U-13 (n = 17)	U-14 (n= 22)	U-15 (n = 29)
	Men ± SD			
CA (years	11.8 ± 0.4	12.7 ± 0.2	13.3 ± 0.6	14.7 ± 0.2

Age at PHV (years)	13.6 ± 0.6	13.6 ± 0.6	13.8 ± 0.6	13.7 ± 0.6
Weight (kg)	44.7 ± 10.4	45.2 ± 7.1	53.0 ± 9.1	58.4 ± 6.9
Height (cm)	151 ± 9.4	154.6 ± 6.9	163.7 ± 8.4	170.3 ± 5.8
Sitting height (cm)	78 ± 4.4	80.5 ± 4.2	85.9 ± 4.6	88.6 ± 3.5
Endomorphy	4.1 ± 1.8	2.7 ± 1.2	2.5 ± 1.1	2.5 ± 0.8
Mesomorphy	4.4 ± 1.3	4.1 ± 0.9	4.0 ± 0.9	3.7 ± 1
Ectomorphy	2.8 ± 1.5	3.4 ± 0.9	3.4 ± 0.8	3.6 ± 0.8
X	-1.3 ± 3	0.6 ± 1.9	0.8 ± 1.7	1 ± 1.4
Y	1.8 ± 3.1	2 ± 2.1	2 ± 1.9	1.2 ± 2.6
%Adult height	83.9 ± 1.7	86.2 ± 2.2	91.5 ± 3.2	95.1 ± 2.2
∑8SF (mm)	119.7 ± 53.9	80.9 ± 38.2	77.3 ± 33.8	81.1 ± 26.2
% Fat Skinfold	12.4 ± 4.6	9.2 ± 3.1	8.9 ± 2.8	9.3 ± 2.2
Sit and Reach (cm)	20.2 ± 4.2	22.6 ± 6	25.2 ± 6.7	24.3 ± 5.7
Hand Grip R (kg)	16.1 ± 3.8	19.2 ± 3.9	26.3 ± 7	28.3 ± 5
Hand Grip L (kg)	15.8 ± 3.9	20.1 ± 3.8	25.5 ± 6.2	28.4 ± 5.5
Leg Strength (kg)	43.6 ± 8.9	60.4 ± 13	64.9 ± 17.7	80.3 ± 17.6
CMJ (CM)	25.2 ± 3.5	35.4 ± 6.2	38.5 ± 7	35.9 ± 6.1

Note; CA: Chronological age; PHV: Peak height velocity; ∑8SF: Sum of eight skinfolds; R: Right; L: Left; CMJ: Countermovement jump

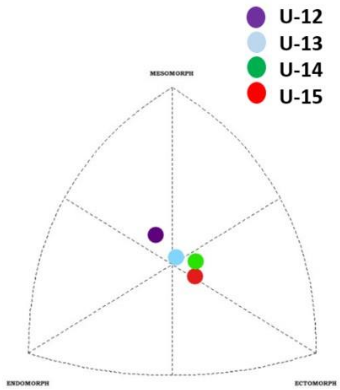

Figure 1. Distribution of Somatotype values of each age category (somatocharts)

Table 2. Descriptive data of soccer players from different biological age category

Age	Maturity	Frequency	Percent (%)
U-12	Late	11	78.6
	Normal	3	21.4
U-13	Late	8	47.1
	Normal	9	52.9

U-14	Late	1	4.5
	Normal	19	86.4
	Early	2	9.1
U-15	Normal	10	34.5
	Early	19	65.5
Total	Late	20	24.4
	Normal	41	50.0
	Early	21	25.6

Table 3. Descriptive data of soccer players from birth date distribution

Age		**RAE**			
		Q1	**Q2**	**Q3**	**Q4**
U-12	**n**	4	2	5	3
	%	28.6	14.3	35.7	21.4
U-13	**n**	2	2	9	4
	%	11.8	11.8	52.9	23.5
U-14	**n**	7	9	1	5
	%	31.8	41	4.5	22.7
U-15	**n**	6	7	6	10
	%	20.7	24.1	20.7	34.5
Total	**n**	19	20	21	22
	%	23.3	24.4	25.6	26.8

Table 4. Descriptive statistics of anthropometric and physical performance characteristics of soccer players based on chronological age and MANOVA results comparing age groups.

Variables	**Age**	**M ± SE**	**95% CI**		**Age**		**M ± SE**	**Sig. b**	**95% CI**	
Weight (kg)	U-15	58.4 ± 1.5	55.42	61.51	U-15	U-14	5.3 ± 2.3	0.14	-0.9	11.7
						U-13	13.1 ± 2.5	0.001*	6.4	20.0
	U-14	53 ± 1.7	49.60	56.59		U-12	13.7 ± 2.7	0.001*	6.5	21.0
					U-14	U-13	7.8 ± 2.7	0.026*	0.6	15.0
	U-13	45.2 ± 2	41.32	49.27		U-12	8.3 ± 2.8	0.023*	0.8	16.0
	U-12	44.7 ± 2.2	40.33	49.10	U-13	U-12	0.5 ± 3	1.00	-7.5	8.6
Height (cm)	U-15	170.3 ± 1.3	167.64	173.14	U-15	U-14	6.6 ± 2.1	0.01	0.9	12.3
						U-13	15.7 ± 2.3	0.001*	9.6	21.9
	U-14	163.7 ± 1.5	160.61	166.93		U-12	19.3 ± 2.4	0.001*	12.8	25.9
					U-14	U-13	9.1 ± 2.4	0.001*	2.6	15.6
	U-13	154.6 ± 1.8	151.07	158.26		U-12	12.7 ± 2.5	0.001*	5.8	19.6

	U-12	151 ± 1.9	147.07	155.00	U-13	U-12	3.6 ± 2.7	1.00	-3.6	10.9
Sitting height (cm)	U-15	88.6 ± 0.7	87.17	90.21	U-15	U-14	2.7 ± 1.2	0.11	-0.4	5.9
						U-13	8.1 ± 1.3	0.001*	4.8	11.6
	U-14	85.9 ± 0.8	84.15	87.65		U-12	10.6 ± 1.3	0.001*	7.0	14.2
					U-14	U-13	5.3 ± 1.3	0.001*	1.8	9.0
	U-13	80.5 ± 1	78.56	82.53		U-12	7.8 ± 1.4	0.001*	4.0	11.6
	U-12	78 ± 1.1	75.89	80.27	U-13	U-12	2.4 ± 1.5	0.61	-1.6	6.5
Endomorphy	U-15	2.5 ± 0.2	2.16	3.03	U-15	U-14	0 ± 0.3	1.00	-0.9	0.9
						U-13	-0.1 ± 0.4	1.00	-1.2	0.8
	U-14	2.5 ± 0.2	2.09	3.10		U-12	-1.5 ± 0.4	0.001*	-2.6	-0.5
					U-14	U-13	-0.1 ± 0.4	1.00	-1.2	0.8
	U-13	2.7 ± 0.2	2.21	3.36		U-12	-1.5 ± 0.4	0.001*	-2.7	-0.5
	U-12	4.1 ± 0.3	3.54	4.80	U-13	U-12	-1.3 ± 0.4	0.01*	-2.5	-0.2
Mesomorphy	U-15	3.7 ± 0.1	3.41	4.15	U-15	U-14	-0.2 ± 0.3	1.00	-1.0	0.5
						U-13	-0.3 ± 0.3	1.00	-1.2	0.5
	U-14	4 ± 0.2	3.63	4.49		U-12	-0.7 ± 0.3	0.27	-1.6	0.2
					U-14	U-13	-0.1 ± 0.3	1.00	-0.9	0.8
	U-13	4.1 ± 0.2	3.64	4.61		U-12	-0.4 ± 0.3	1.00	-1.3	0.5
	U-12	4.4 ± 0.2	3.92	4.98	U-13	U-12	-0.3 ± 0.3	1.00	-1.3	0.7
Ectomorphy	U-15	3.6 ± 0.1	3.32	4.04	U-15	U-14	0.1 ± 0.3	1.00	-0.6	0.9
						U-13	0.2 ± 0.3	1.00	-0.6	1.1
	U-14	3.4 ± 0.2	3.08	3.91		U-12	0.8 ± 0.3	0.08	-0.1	1.7
					U-14	U-13	0 ± 0.3	1.00	-0.8	0.9
	U-13	3.4 ± 0.2	2.96	3.91		U-12	0.6 ± 0.3	0.40	-0.3	1.5
	U-12	2.8 ± 0.2	2.35	3.39	U-13	U-12	0.5 ± 0.4	0.70	-0.4	1.5
∑8SF (mm)	U-15	81.1 ± 6.7	67.58	94.63	U-15	U-14	3.7 ± 10.3	1.00	-24.2	31.8
						U-13	0.1 ± 11.2	1.00	-30.1	30.4
	U-14	77.3 ± 7.8	61.81	92.87		U-12	-38.6 ± 11.9	0.01*	-70.9	-6.5
					U-14	U-13	-3.6 ± 11.8	1.00	-35.6	28.4
	U-13	80.9 ± 8.8	63.31	98.64		U-12	-42.4 ± 12.5	0.001*	-76.3	-8.6
	U-12	119.7 ± 9.7	100.32	139.25	U-13	U-12	-38.8 ± 13.2	0.025*	-74.6	-3.1
% Fat Skinfold	U-15	9.3 ± 0.5	8.24	10.51	U-15	U-14	0.3 ± 0.9	1.00	-1.9	2.7
						U-13	0 ± 0.9	1.00	-2.4	2.6

	U-14	8.9 ± 0.6	7.67	10.27		U-12	-3.1 ± 1	0.015*	-5.8	-0.4
					U-14	U-13	-0.3 ± 1	1.00	-3.0	2.4
	U-13	9.2 ± 0.7	7.80	10.76		U-12	-3.5 ± 1	0.01	-6.3	-0.7
	U-12	12.4 ± 0.8	10.86	14.12	U-13	U-12	-3.2 ± 1.1	0.029*	-6.2	-0.2
Sit and Reach (cm)	U-15	24.3 ± 1	22.15	26.48	U-15	U-14	-0.9 ± 1.1	1.00	-5.5	3.5
						U-13	1.6 ± 1.8	1.00	-3.2	6.5
	U-14	25.2 ± 1.2	22.80	27.77		U-12	4 ± 1.9	0.21	-1.1	9.2
					U-14	U-13	2.6 ± 1.9	1.00	-2.5	7.8
	U-13	22.6 ± 1.4	19.82	25.48		U-12	5 ± 2	0.08	-0.4	10.5
	U-12	20.2 ± 1.5	17.11	23.35	U-13	U-12	2.4 ± 2.1	1.00	-3.3	8.1
Hand Grip R (kg)	U-15	28.3 ± 0.9	26.37	30.25	U-15	U-14	1.9 ± 1.5	1.00	-2.1	6.0
						U-13	9 ± 1.6	0.001*	4.7	13.4
	U-14	26.3 ± 1.1	24.14	28.60		U-12	12.2 ± 1.7	0.001*	7.6	16.8
					U-14	U-13	7.1 ± 1.7	0.001*	2.6	11.7
	U-13	19.2 ± 1.2	16.68	21.76		U-12	10.2 ± 1.8	0.001*	5.4	15.1
	U-12	16.1 ± 1.4	13.31	18.90	U-13	U-12	3.1 ± 1.9	0.63	-2.0	8.3
Hand Grip L (kg)	U-15	28.4 ± 0.9	26.55	30.36	U-15	U-14	2.8 ± 1.5	0.31	-1.1	6.8
						U-13	8.2 ± 1.6	0.001*	4.0	12.6
	U-14	25.5 ± 1.1	23.38	27.76		U-12	12.6 ± 1.7	0.001*	8.1	17.2
					U-14	U-13	5.3 ± 1.7	0.01	0.9	9.9
	U-13	20.1 ± 1.2	17.68	22.66		U-12	9.7 ± 1.8	0.001*	5.0	14.5
	U-12	15.8 ± 1.3	13.08	18.57	U-13	U-12	4.3 ± 1.9	0.13	-0.7	9.4
Leg Strength (kg)	U-15	80.3 ± 2.9	74.61	86.15	U-15	U-14	15.4 ± 4.4	0.001*	3.5	27.3
						U-13	19.9 ± 4.8	0.001*	7.0	32.8
	U-14	64.9 ± 3.3	58.35	71.60		U-12	36.7 ± 5.1	0.001*	23.0	50.5
					U-14	U-13	4.5 ± 5	1.00	-9.1	18.1
	U-13	60.4 ± 3.7	52.94	68.01		U-12	21.3 ± 5.3	0.001*	6.9	35.8
	U-12	43.6 ± 4.1	35.36	51.96	U-13	U-12	16.8 ± 5.6	0.022*	1.6	32.1
CMJ (CM)	U-15	35.9 ± 1.1	33.73	38.20	U-15	U-14	-2.6 ± 1.7	0.77	-7.2	2.0
						U-13	0.5 ± 1.8	1.00	-4.4	5.6
	U-14	38.5 ± 1.2	36.03	41.16		U-12	10.7 ± 2	0.001*	5.4	16.0
					U-14	U-13	3.1 ± 1.9	0.64	-2.1	8.5
	U-13	35.4 ± 1.4	32.49	38.32		U-12	13.3 ± 2.1	0.001*	7.7	18.9

	U-12	25.2 ± 1.6	22.05	28.48	U-13	U-12	10.1 ± 2.2	0.001*	4.2	16.0

Note; CA: Chronological age; PHV: Peak height velocity; ∑8SF: Sum of eight skinfolds; R: Right; L: Left; CMJ: Countermovement jump

Birth Date Distribution

The birthdate distribution by quarter for each subgroup is shown in Table 2.

Maturity on Anthropometrics and physical performance tests

The MANOVA revealed a significant effect of maturity on the dependent variables (Wilks A = 0.150, F (30, 130) = 6.862, P < 0.001, η^2 = 0.613, observed power = 1; Table 5. Following the Bonferroni adjustment, ANOVA, tested at 0.05 alpha level, revealed a significant effect of maturity on weight [F (2, 79) = 51.317, P < 0.001, η^2 = 0.565, Large effect, observed power = 1], height [F (2, 79) = 99.31, P < 0.001, η^2 = 0.715, Large effect, observed power = 1], sitting height [F (2, 79) = 119.10, P < 0.001, η^2 = 0.751, Large effect, observed power = 1], hand grip rigth [F (2, 79) = 38.34, P < 0.001, η^2 = 0.493, Large effect, observed power = 1], hand grip left [F (2, 79) = 52.74, P < 0.001, η^2 = 0.572, Large effect, observed power = 1], leg strength [F (2, 79) = 33.96, P < 0.001, η^2 = 0.462, Large effect, observed power = 1], and countermovement jump [F (2, 79) = 7.36, P < 0.001, η^2 = 0.157, minimum effect observed power = 0.93]. Therefore, the evidence shows that the dependent variables differ between maturity types. The effect size was large, with an observed power of 1.00, indicating a 100% chance that the results could have been significant.

Table 5. Anthropometric and physical performance characteristics of soccer players based on maturity and MANOVA results comparing age groups.

Variables (N=82)	Maturity	M ± SD	Maturity		MD ± SE	Sig.	95% CI	
APHV	Early	14.7 ± 0.5	Early	-	-	-	-	-
	Normal	13.4 ± 0.8		Late	-.5 ± 0.1	0.001 ***	-0.845	-0.233
	Late	12.2 ± 0.6		Normal	-0.236	0.077	-0.499	0.026
Weight (Kg)	Early	62 ± 5.7	Early	-	-	-	-	-
	Normal	52 ± 6.7		Late	21 ± 2	0.001***	16.914	25.188
	Late	41 ± 7.2		Normal	9.9 ± 1.7	0.001***	6.438	13.544
Height (cm)	Early	173.5 ± 3.9	Early	-	-	-	-	-
	Normal	162.7 ± 6.3		Late	25 ± 1.7	0.001***	21.490	28.585
	Late	148.5 ± 5.7		Normal	10.7 ± 1.5	0.001***	7.745	13.838
Sitting height (cm)	Early	90.7 ± 1.9	Early	-	-	-	-	-
	Normal	84.9 ± 3.3		Late	14 ± 0.9	0.001***	12.221	15.860
	Late	76.7 ± 2.9		Normal	5.8 ± 0.7	0.001***	4.286	7.412
Endomorphy	Early	2.5 ± 0.6	Early	-	-	-	-	-
	Normal	2.9 ± 1.3		Late	-0.6 ± 0.4	0.126	-1.432	0.180
	Late	3.1 ± 1.5		Normal	-0.4 ± 0.3	0.177	-1.166	0.218
Mesomorphy	Early	3.8 ± 1.1	Early	-	-	-	-	-
	Normal	4 ± 0.9		Late	-0.3 ± 0.3	0.234	-1.012	0.251
	Late	4.2 ± 1		Normal	-0.1 ± 0.2	0.574	-0.696	0.389
Ectomorphy	Early	3.6 ± 0.8	Early	-	-	-	-	-
	Normal	3.4 ± 0.8		Late	0.4 ± 0.3	0.119	-0.130	1.113
	Late	3.1 ± 1.2		Normal	0.2 ± 0.2	0.354	-0.284	0.783
∑8SF (mm)	Early	82.3 ± 24.1	Early	-	-	-	-	-

	Normal	87.8 ± 41.2		Late	-6.5 ± 12.3	0.598	-31.013	17.979
	Late	88.8 ± 47.4		Normal	-5.4 ± 10.5	0.605	-26.535	15.543
% Fat Skinfold	Early	9.4 ± 1.9	Early	-	-	-	-	-
	Normal	9.8 ± 3.4		Late	-0.4 ± 1	0.643	-2.523	1.568
	Late	9.9 ± 4		Normal	-0.4 ± 0.8	0.645	-2.166	1.348
Sit and Reach (cm)	Early	24.9 ± 5.7	Early	-	-	-	-	-
	Normal	24 ± 6.6		Late	4 ± 1.8	0.032*	0.342	7.668
	Late	20.9 ± 3.9		Normal	0.8 ± 1.5	0.579	-2.265	4.026
Hand Grip R (kg)	Early	30.1 ± 4.3	Early	-	-	-	-	-
	Normal	24.2 ± 6.1		Late	13.9 ± 1.5	0.001***	10.753	17.117
	Late	16.2 ± 3.1		Normal	5.8 ± 1.3	0.001***	3.127	8.592
Hand Grip L (kg)	Early	30.6 ± 4.5	Early	-	-	-	-	-
	Normal	24.1 ± 5.1		Late	14.6 ± 1.4	0.001***	11.844	17.554
	Late	15.9 ± 2.9		Normal	6.4 ± 1.2	0.001***	4.019	8.923
Leg Strength (Kg)	Early	85.3 ± 17	Early	-	.	-	-	-
	Normal	64.9 ± 15		Late	38.2 ± 4.6	0.001***	28.980	47.484
	Late	47.1 ± 11.7		Normal	20.3 ± 3.9	0.001***	12.417	28.310
CMJ (cm)	Early	36.9 ± 6.3	Early	-	-	-	-	-
	Normal	36 ± 7.3		Late	7.3 ± 2.1	0.001***	3.064	11.662
	Late	29.6 ± 6.6		Normal	0.8 ± 1.8	0.629	-2.792	4.592

Note; Early (n=21), Normal (n=41), Late (n=20); M ± SD: Mean ± Standard Deviation; MD ± SE: Mean Difference ± Std. Error; APHV: Age at peak high velocity (years); R: Right; L: Left

RAE on Anthropometrics and physical performance tests

The MANOVA identified no statistically significant effect of RAE on the anthropometric and physical performance variables (Wilks Λ = 0.494, $F(45, 190) = 1.138$, $P = 0.272$, $\eta^2 = 0.210$, observed power = 0.963; Table 6).

Table 6. Anthropometric and physical performance characteristics of soccer players based on birthdate distribution and MANOVA results comparing age groups.

Variables (N= 82)	RAE	M ± SD	RAE		M ± SE	Sig.	95% CI	
APHV	Q1	13.6 ± 0.4	Q1	-	-	-	-	-
	Q2	13.7 ± 0.5		Q2	-0 ± 0.1	1	-0.5	0.3
	Q3	13.8 ± 0.5		Q3	-0.1 ± 0.1	1	-0.6	0.3
	Q4	13.7 ± 0.6		Q4	-0 ± 0.1	1	-0.3	0.5
Weight (kg)	Q1	53.3 ± 9.7	Q1	-	-	-	-	-
	Q2	52.5 ± 8.5		Q1	0.7 ± 3.1	0.81	-5.59	7.11
	Q3	48.7 ± 11.9		Q2	4.6 ± 3.1	0.15	-1.67	10.89
	Q4	53.2 ± 9.1		Q3	0 ± 3.1	0.99	-6.16	6.26
Height (cm)	Q1	163.7 ± 11.6	Q1	-	-	-	-	-
	Q2	164.8 ± 9.6		Q2	-1.1 ± 3.3	0.73	-7.84	5.51
	Q3	158.3 ± 10.9		Q3	5.3 ± 3.3	0.11	-1.23	11.95

	Q4	161.6 ± 9.6		Q4	2 ± 3.2	0.53	-4.43	8.61
Sitting height (cm)	Q1	86.2 ± 6.2	Q1	-	-	-	-	-
	Q2	86.0 ± 5.1		Q2	0.1 ± 1.8	0.92	-3.39	3.78
	Q3	81.8 ± 6		Q3	4.3 ± 1.7	0.06	0.79	7.87
	Q4	83.8 ± 4.9		Q4	2.3 ± 1.7	0.19	-1.16	5.85
Endomorphy	Q1	2.6 ± 1	Q1	-	-	-	-	-
	Q2	2.5 ± 0.7		Q2	0 ± 0.4	0.82	-0.73	0.91
	Q3	2.8 ± 1.3		Q3	-0.2 ± 0.4	0.61	-1.02	0.60
	Q4	3.4 ± 1.7		Q4	-0.7 ± 0.4	0.07	-1.55	0.05
Mesomorphy	Q1	4.1 ± 1	Q1	-	-	-	-	-
	Q2	3.7 ± 0.9		Q2	0.3 ± 0.3	0.25	-0.27	1.01
	Q3	3.8 ± 0.8		Q3	0.2 ± 0.3	0.39	-0.36	0.91
	Q4	4.3 ± 1.2		Q4	-0.1 ± 0.3	0.58	-0.80	0.45
Ectomorphy	Q1	3.3 ± 1.1	Q1	-	-	-	-	-
	Q2	3.7 ± 0.9		Q2	-0.3 ± 0.3	0.27	-0.98	0.28
	Q3	3.5 ± 0.9		Q3	-0.2 ± 0.3	0.50	-0.83	0.41
	Q4	3.0 ± 0.9		Q4	0.3 ± 0.3	0.33	-0.31	0.92
∑8SF (mm)	Q1	80.2 ± 29.1	Q1	-	-	-	-	-
	Q2	77.6 ± 27.3		Q2	2.6 ± 12.3	0.83	-22.03	27.25
	Q3	86.4 ± 40.8		Q3	-6.1 ± 12.2	0.62	-30.52	18.19
	Q4	100.6 ± 50.4		Q4	-20.3±12.1	0.10	-44.46	3.72
% Fat Skinfold	Q1	9.2 ± 2.3	Q1	-	-	-	-	-
	Q2	9 ± 2.2		Q2	0.1 ± 1	0.88	-1.90	2.21
	Q3	9.7 ± 3.4		Q3	-0.5 ± 1	0.57	-2.62	1.44
	Q4	10.9 ± 4.2		Q4	-1.7 ± 1	0.09	-3.73	0.30
Sit and Reach (cm)	Q1	24.2 ± 5.6	Q1	-	-	-	-	-
	Q2	23.2 ± 8		Q2	1 ± 1.9	0.60	-2.85	4.94
	Q3	23.5 ± 5.2		Q3	0.7 ± 1.9	0.71	-3.12	4.59
	Q4	23.2 ± 5.1		Q4	1 ± 1.9	0.59	-2.77	4.85
Hand Grip R (kg)	Q1	25.4 ± 8	Q1	-	-	-	-	-
	Q2	26.5 ± 6.5		Q2	-1 ± 2.2	0.64	-5.40	3.34
	Q3	20.7 ± 7.8		Q3	4.7 ± 2.1	0.06	0.39	9.02
	Q4	22.8 ± 4.6		Q4	2.6 ± 2.1	0.22	-1.61	6.93
Hand Grip L (kg)	Q1	25.6 ± 6.9	Q1	-	-	-	-	-
	Q2	25.8 ± 6.5		Q2	-0.2 ± 2.1	0.90	-4.56	4.04
	Q3	20.9 ± 7.4		Q3	4.7 ± 2.1	0.06	0.46	8.97
	Q4	23 ± 5.9		Q4	2.5 ± 2.1	0.23	-1.65	6.77
Leg Strength (kg)	Q1	67.6 ± 22.1	Q1	-	-	-	-	-
	Q2	67.2 ± 20.1		Q2	0.3 ± 6.4	0.95	-12.50	13.27
	Q3	60.9 ± 17.5		Q3	6.7 ± 6.4	0.30	-6.03	19.44

	Q4	67.7 ± 20.8		Q4	-0.1 ± 6.3	0.99	-12.70	12.49
CMJ (CM)	Q1	33.7 ± 7.3	Q1	-	-	-	-	-
	Q2	38.1 ± 7.2		Q2	-4.3 ± 2.3	0.06	-9.04	0.26
	Q3	32.8 ± 7.8		Q3	0.9 ± 2.3	0.69	-3.67	5.52
	Q4	34.2 ± 6.7		Q4	-0.4 ± 2.2	0.85	-4.97	4.12

Note; Q1 (n=19), Q2 (n=20), Q3 (n=21), Q4 (n=22); M ± SD: Mean ± Standard Deviation; MD ± SE: Mean Difference ± Std. Error; APHV: Age at peak high velocity (years)

Discussion

This research examined the presence of biological maturation and relative age-associated selection biases and the relationships between maturation, relative age, anthropometry and physical fitness characteristics. In particular, we focused on how these relationships varied across age categories. A statistically significant maturation difference was found with large effect sizes across all included players. The distribution of normal, early and late-maturing soccer players significantly differed from the expected normal distribution in all groups, while the birth quartile was not a discriminating factor for better anthropometric and physical performance. We also assessed whether anthropometric or performance advantages were conferred to relatively older players and by what likely mechanisms, via null-hypothesis significance testing, with a statistical model that recognized the confounding influence of chronological age group and maturation upon the dependent variables (i.e., anthropometric and fitness characteristics). Without considering the biological status in all anthropometric traits and physical performance tests, older soccer players (U-15) achieved higher values and better results. Considering only the chronological age of soccer players, the results in individual age categories were parallel to other studies (Fragoso et al., 2015; Lovell et al., 2015), emphasizing the importance of anthropometric (i.e., body height, body weight, sitting height) and performance (i.e., sit and reach, hand grip left and right, leg strength, and countermovement jump) characteristics of young soccer players. In a recent systematic review (2021), youth soccer players with an advanced maturation profile had better anthropometric and physical performance (Albaladejo-Saura et al., 2021). According to the authors, children born in the first quartile had a maturation advantage and better physical performance.

The current study demonstrated no skewness or presence of RAE. Additionally, the post hoc analysis did not reveal any effect of relative age on anthropometric and physical performance characteristics. The current study's results align with Hirose (2009), who found no difference in anthropometric traits between birth's first and fourth quarters (Hirose, 2009). Helsen et al. found that coaches are looking to select children born in the first and second quarters because of physical performance advantages. However, they found no RAE effect or relationship with physical performance (Helsen et al., 2000). Children are routinely grouped by chronological age irrespective of biological maturity, with their biological maturity often misclassified. Differences in stage and rate of maturation disqualify chronological age as an accurate index of physical potential. It is currently accepted that maturity and birth age play an important role in young soccer players' body size and performance level (Toselli et al., 2022). In the present study, the biological maturation showed a statistically significant relationship with the anthropometric and physical performance tests. When a comparison between different maturation groups (early – normal – late) was performed, a tendency to obtain better results was observed when the maturation process was more advanced (early mature) compared to other groups. When analyzing the overall differences between maturation groups, significant differences were found in weight, height, sitting height, and hand grip right, hand grip left, leg strength, and countermovement jump, confirming our hypothesis of the impact of maturational status on anthropometric and physical performance.

Biological maturity and physical fitness measures were statistically has a positive significant relationship between stage of maturity and physical fitness performance (Jones et al., 2000), which is supported by the results of the current studies. Finally, it was hypothesized that the effect would stronger in the early mature compare to the others. On the other hand, the data revealed no skewed relative age effect in Turkey soccer players. The overall RAE for all included soccer players showed no difference in players born at the first of the year compared to the end of the year. This result does not align with the RAE of male players reported in several elite soccer leagues worldwide (Lovell et al., 2015; Pedersen et al., 2022; Vaeyens et al., 2005). It has been shown that various factors, such as physical, psychological, and cognitive, can influence RAE. Furthermore, the physical component are more nominate in team sports such as soccer and there is a skewed birth distribution of soccer players and a result could have effect on selection the athlete into the elite team (Hoppe et al., 2020). Possible explanations include the depth of competition, the interaction of maturation and biological difference, and the low number of participants, with previous studies showing that the RAE decreases after adolescence. When the advantages of early physical maturity fade away and the best players all have similar physical, technical-tactical skills and cognitive abilities could make the difference to produce successful outcomes (McCarthy & Collins, 2014).

In summary, assessing maturity status is fundamental in explaining anthropometric and body composition. In older soccer players (U-15), maturity timing influences anthropometric and physical performance during tests. Therefore, maturity has a significant impact with a big effect size on anthropometric and physical performance. In contrast, the result of the current study did not support the underdog hypothesis. Our results demonstrate that RAEs did not exist in this adolescent soccer study. Nevertheless, the results of the current study highlight the importance of early mature players within academy systems and challenging players who are advanced in maturation.

References

Ackland, T.R., Elliott, B., & Bloomfield, J. (2009). Applied anatomy and biomechanics in sport. *Human Kinetics.*

Albaladejo-Saura, M., Vaquero-Cristóbal, R., González-Gálvez, N., & Esparza-Ros, F. (2021). Relationship between biological maturation, physical fitness, and kinanthropometric variables of young athletes: A systematic review and meta-analysis. *International Journal of Environmental Research and Public Health*, 18(1): 328. https://doi.org/10.3390/ijerph18010328

Boucher, J.L., & Mutimer, B.T. (1994). The relative age phenomenon in sport: A replication and extension with ice-hockey players. *Research Quarterly for Exercise and Sport*, 65(4): 377-381. https://doi.org/10.1080/02701367.1994.10607644

Carter, J.L., Carter, J.L., & Heath, B.H. (1990). Somatotyping: development and applications. *Cambridge university press.*

Cobley, S., Baker, J., Wattie, N., & McKenna, J. (2009). Annual age-grouping and athlete development. *Sports Medicine*, 39(3): 235-256. https://doi.org/10.2165/00007256-200939030-00005

Cohen, J. (1988). The effect size. Statistical power analysis for the behavioral sciences, 77-83.

D'Hondt, v., Deforche, B., Vaeyens, R., Vandorpe, B., Vandendriessche, J., Pion, J., Renaat P., Ilse de B., Lenoir, M. (2011). Gross motor coordination in relation to weight status and age in 5-to 12-year-old boys and girls: a cross-sectional study. *International Journal of Pediatric Obesity*, 6(sup3): e556-564. https://doi.org/10.3109/17477166.2010.500388

Helsen F.W., Hodges, N. J., Winckel, J. v., & Starkes, J. L. (2000). The roles of talent, physical precocity and practice in the development of soccer expertise. *Journal of Sports Sciences*, 18(9): 727-736. https://doi.org/10.1080/02640410050120104

Fragoso, I., Massuca, L., & Ferreira, J. (2015). Effect of birth month on physical fitness of soccer players (Under-15) according to biological maturity. *International Journal of Sports Medicine*, 36(01): 16-21. https://doi.org/10.1055/s-0034-1384548

Gil, S. M., Badiola, A., Bidaurrazaga-Letona, I., Zabala-Lili, J., Gravina, L., Santos-Concejero, J., Jose A.L., Granados, C. (2014). Relationship between the relative age effect and anthropometry, maturity and performance in young soccer players. *Journal of Sports Sciences*, 32(5), 479-486. https://doi.org/10.1080/02640414.2013.832355

Götze, M., & Hoppe, M.W. (2021). Relative age effect in elite german soccer: influence of gender and competition level. *Frontiers in Psychology*, 11, 587023. https://doi.org/10.3389/fpsyg.2020.587023

Heilmann, F., Memmert, D., Weinberg, H., & Lautenbach, F. (2022). The relationship between executive functions and sports experience, relative age effect, as well as physical maturity in youth soccer players of different ages. *International journal of sport and exercise psychology*, 21(2): 1-19. https://doi.org/10.1080/1612197X.2021.2025141

Hill, M., Scott, S., Malina, R. M., McGee, D., & Cumming, S. P. (2020). Relative age and maturation selection biases in academy football. *Journal of Sports Sciences,* 38(11-12): 1359-1367. https://doi.org/10.1080/02640414.2019.1649524

Hirose, N. (2009). Relationships among birth-month distribution, skeletal age and anthropometric characteristics in adolescent elite soccer players. *Journal of Sports Sciences*, 27(11), 1159-1166. https://doi.org/10.1080/02640410903225145

Hoppe, M.W., Barnics, V., Freiwald, J., & Baumgart, C. (2020). Contrary to endurance, power associated capacities differ between different aged and starting-nonstarting elite junior soccer players. *PloS One,* 15(4): e0232118. https://doi.org/10.1371/journal.pone.0232118

Jakobsson, J., Julin, A.L., Persson, G., & Malm, C. (2021). Darwinian Selection Discriminates Young Athletes: the Relative Age Effect in Relation to Sporting Performance. *Sports Medicine-Open*, 7(1): 1-18. https://doi.org/10.1186/s40798-021-00300-2

Johnson, D., Bradley, B., Williams, S., Whiteside, E., & Cumming, S. (2022). The effect of bio-banding on between-player variance in size and speed in male academy soccer players. *Sport Performance and Science Reports*, 157.

Jones, M., Hitchen, P., & Stratton, G. (2000). The importance of considering biological maturity when assessing physical fitness measures in girls and boys aged 10 to 16 years. *Annals of Human Biology*, 27(1): 57-65. https://doi.org/10.1080/030144600282389

Kelly, A.L., Wilson, M.R., Gough, L.A., Knapman, H., Morgan, P., Cole, M., Daniel T.J., Williams, C.A. (2020). A longitudinal investigation into the relative age effect in an English professional football club: Exploring the 'underdog hypothesis'. *Science and Medicine in Football*, 4(2): 111-118. https://doi.org/10.1080/24733938.2019.1694169

Lovell, R., Towlson, C., Parkin, G., Portas, M., Vaeyens, R., & Cobley, S. (2015). Soccer player characteristics in English lower-league development programmes: The relationships between relative age, maturation, anthropometry and physical fitness. *PloS One*, 10(9): e0137238. https://doi.org/10.1371/journal.pone.0137238

McCarthy, N., & Collins, D. (2014). Initial identification & selection bias versus the eventual confirmation of talent: evidence for the benefits of a rocky road?. *Journal of Sports Sciences*, 32(17): 1604-1610. https://doi.org/10.1371/journal.pone.0137238

Mirwald, R.L., G. Baxter-Jones, A. D., Bailey, D. A., & Beunen, G. P. (2002). An assessment of maturity from anthropometric measurements. *Medicine and Science in Sports and Exercise*, 34(4): 689-694. https://doi.org/10.1097/00005768-200204000-00020

Pedersen, A.V., Aune, T.K., Dalen, T., & Lorås, H. (2022). Variations in the relative age effect with age and sex, and over time—Elite-level data from international soccer world cups. *PloS One*, 17(4): e0264813. https://doi.org/10.1371/journal.pone.0264813

Pérez-González, B., León-Quismondo, J., Bonal, J., Burillo, P., & Fernández-Luna, Á. (2021). The New Generation of Professional Soccer Talent Is Born under the Bias of the RAE: Relative Age Effect in International Male Youth Soccer Championships. *Children*, 8(12): 1117. https://doi.org/10.3390/children8121117

Perini, T.A., Oliveira, G.L.d., Ornellas, J.d.S., & Oliveira, F.P.d. (2005). Technical error of measurement in anthropometry. *Revista Brasileira de Medicina do Esporte*, 11: 81-85. https://doi.org/10.1590/S1517-86922005000100009

Segueida-Lorca, Á., Barrera, J., Valenzuela-Contreras, L., & Herrera-Valenzuela, T. (2022). Comparing Body Composition in Young Footballers Categorised by Bio-Banding. *Apunts: Educació Física i Esports,* (149): 45-52. https://doi.org/10.5672/apunts.2014-0983.es.(2022/3).149.05

Shahidi, S.H., Kingsley, J.D., Svensson, M., TAŞKIRAN, M.Y., & Hassani, F. (2021). Training Wiser Instead of Training Harder: A Complex Training Program (CPX). *Journal of Health and Sport Sciences*, 4(1): 15-18.

Shahidi, S. H., Kingsley, J. D., & Taskiran, M.Y. (2022). Talent Identification Pathway "Coaches, Family, and Environment Eyes. *Journal of Health and Sport Sciences*, 5(1): 17-20.

Smith, K.L., Weir, P.L., Till, K., Romann, M., & Cobley, S. (2018). Relative age effects across and within female sport contexts: a systematic review and meta-analysis. *Sports Medicine*, 48(6): 1451-1478. https://doi.org/10.1007/s40279-018-0890-8

Toselli, S., Campa, F., Maietta Latessa, P., Greco, G., Loi, A., Grigoletto, A., & Zaccagni, L. (2021). Differences in maturity and anthropometric and morphological characteristics among young male basketball and soccer players and non-players. *International Journal of Environmental Research and Public Health*, 18(8): 3902. https://doi.org/10.3390/ijerph18083902

Toselli, S., Mauro, M., Grigoletto, A., Cataldi, S., Benedetti, L., Nanni, G., Riccardo D.M., Paolo A., Davide G., Fischetti, F., Gianpiero G. (2022). Maturation Selection Biases and Relative Age Effect in Italian Soccer Players of Different Levels. *Biology*, 11(11): 1559. https://doi.org/10.3390/biology11111559

Towlson, C., & Cumming, S.P. (2022). Bio-banding in soccer: Past, present, and future. *Annals of Human Biology,* 49(7-8): 269-273. https://doi.org/10.1080/03014460.2022.2129091

Towlson, C., MacMaster, C., Gonçalves, B., Sampaio, J., Toner, J., MacFarlane, N., Steve B., Ally H., Rory J., Hunter, F., Amy S., Tony M., Grant A. (2022). The effect of bio-banding on technical and tactical indicators of talent identification in academy soccer players. *Science and Medicine in Football*, 6(3): 295-308. https://doi.org/10.1080/24733938.2021.2013522

Towlson, C., Salter, J., Ade, J. D., Enright, K., Harper, L. D., Page, R. M., & Malone, J. J. (2021). Maturity-associated considerations for training load, injury risk, and physical performance in youth soccer: One size does not fit all. *Journal of sport and health science*, 10(4): 403-412. https://doi.org/10.1016/j.jshs.2020.09.003

Trecroci, A., Longo, S., Perri, E., Iaia, F. M., & Alberti, G. (2019). Field-based physical performance of elite and sub-elite middle-adolescent soccer players. *Research in Sports Medicine*, 27(1): 60-71. https://doi.org/10.1080/15438627.2018.1504217

Vaeyens, R., Philippaerts, R.M., & Malina, R.M. (2005). The relative age effect in soccer: A match-related perspective. *Journal of Sports Sciences*, 23(7), 747-756. https://doi.org/10.1080/02640410400022052

Viero, V., Triossi, T., Bianchi, D., Campagna, A., & Melchiorri, G. (2020). Physical and performance variables for talent identification in water polo. *The Journal of Sports Medicine and Physical Fitness*. 60(10): 1309-1316. https://doi.org/10.23736/S0022-4707.20.10712-6

Werneck, F.Z., Coelho, E.F., De Oliveira, H., Júnior, D.R., Almas, S.P., De Lima, J., Matta, M.O., Figueiredo, A.J. (2016). Relative age effect in Olympic basketball athletes. *Science & Sports*, 31(3): 158-161. https://doi.org/10.1016/j.scispo.2015.08.004

Zuber, C., Zibung, M., & Conzelmann, A. (2016). Holistic patterns as an instrument for predicting the performance of promising young soccer players - A3-years longitudinal study. *Frontiers in Psychology*, 7: 1088-1088. https://doi.org/10.3389/fpsyg.2016.01088

Acknowledgments
We would like to thank the athletes, parents, and coaches for their support in this study.

Author Contributions
Conceptualization, S.H.S; Methodology, S.H.S, L.Y; Formal Analysis, S.H.S.; Writing Original Draft Preparation, S.H.S, J.E; Writing Reviewing and Editing; S.H.S, J.E.

Data availability: Full access to data on request (Houtan.shahidi@gedik.edu.tr/Hootan.shahidi@yahoo.com).

Funding
This research received no external funding.

Conflicts of Interest
The Authors have no conflict of interest to declare

Informed Consent Statement
Written informed consent was provided by the parents of all subjects involved in the study.