

# The examination of some anthropometric and motoric characteristics of students aged eight years according to their maturation level

**Authors' Contribution:** Erdal Ari<sup>1 ABCD</sup>, Gökhan Deliceoglu<sup>2 ABCD</sup>

**A** Study Design  
**B** Data Collection  
**C** Statistical Analysis  
**D** Data Interpretation  
**E** Manuscript Preparation  
**F** Literature Search  
**G** Funds Collection

<sup>1</sup> Ordu University Physical Education and Sports School, Turkey

<sup>2</sup> Kırıkkale University Faculty of Sports Sciences, Kırıkkale, Turkey

## abstract

- Background:** Maturation is an important factor for exercise. The maturation effect on some anthropometric and motoric characteristics of students aged eight years was examined in this study.
- Material and methods:** 535 primary education students voluntarily participated in this study. Anthropometric measurements (weight, height, sitting height, stroke length, stroke rate, leg length and body mass index), flexibility, handgrip strength, vertical jump (squat and countermovement jump), tapping (skipping) test parameters (step frequency, flight times and contact times to ground of right and left foot, step/speed ratio), postural sway (anterior-posterior, medial lateral and total postural sway), visual reaction and reaction time, 20 meters sprint time, agility values were measured. The test parameters were compared in terms of gender and maturation level (early, normal and delayed maturation) by parametric (independent samples T-test, one way ANOVA) and non-parametric (Mann Whitney-U and Kruskal Wallis-H) tests.
- Results:** A significant difference was indicated between boy and girl students in most of the test parameters ( $p < 0.05$ ). The analysis results indicated that students at early maturation level had better test values ( $p < 0.05$ ).
- Conclusions:** The maturation factor positively affected some anthropometric and motoric parameters of students aged eight years.
- Key words:** maturation, maturation offset, anthropometric measurements, students, children.

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- Corresponding author:** Erdal ARI, Ordu University Physical Education and Sports School Ordu, TURKEY, ariedal@hotmail.com.
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## INTRODUCTION

Maturation is a consequence of physical growth, and it can be defined as a functional development of limbs. The development of tissues, organs and systems in the body is known as biological maturation [1]. The development of endocrin and nervous system in growth and maturation period is effective on skeletal and physical maturation [2]. Malina and Kozielec [3] indicated that biological maturation could be examined with chronological age and maturation timing factors. The chronological age is a indicator of human growth and it can be equal to the real maturation level. The biological maturation level of children in same chronological age may widely differ [4, 5]. Sometimes, children's real maturation levels can be higher than the maturation level of chronological age. The body systems, physical and psychological features of individuals in periods of pre-puberty and puberty may have different development rates [6]. The physical growth of children at an early maturation level is greater than of children at a delayed maturation level, and this situation can provide advantage in physical activities. The maturation level can be effective on physical activity performance [7]. The bone age and puberty phase are mentioned as biological maturation indicators in athletic performance studies [8]. The main requirements of physical activity are basic performance characteristics, such as strength, speed, endurance, power, agility. These performance parameters are affected by body composition. Therefore, the maturation level is a important factor for body composition and physical performance. The muscle mass of body is a important factor at strength and power sports, and muscle mass increase is triggered by maturation. Also, the determination of biological maturation role on musculoskeletal development is important in terms of healthy development of adolescent individuals [9]. Deprez et al. [10] indicated that early maturation could increase the selection possibility during identification of young soccer players. Many sport disciplines requires spesific physical performance parameters at different levels. The talent selection process involves selection of children at an optimal physical fitness level in different sports disciplines. The determination of maturation level of children can assist sports sciences professionals in the talent selection process. The determination of performance parameters differences among early, normal and delayed maturation levels is also important in many sport disciplines for the effective talent selection process. In this context, the aim of the study was to examine some physical fitness parameters of students aged eight years according to their maturation level and gender.

## MATERIAL AND METHODS

### PARTICIPANTS

The research group consisted of 535 primary education students (age:  $8.19 \pm 2.25$  years, weight:  $31.34 \pm 11.84$  kg, height:  $131.02 \pm 13.66$  cm), 300 of them being boys (age:  $8.25 \pm 2.32$  years, weight:  $32.41 \pm 12.82$  kg, height:  $131.69 \pm 3.59$  cm) and 235 girls (age:  $8.12 \pm 2.16$  years, weight:  $29.98 \pm 10.33$  kg, height:  $130.16 \pm 13.31$  cm). All students and their parents were informed about measurement tests. The informed voluntary consent form was filled by students' parents, and all students participated in the study voluntarily. The study was performed in consistence with the Helsinki Declaration.

## EXPERIMENTAL DESIGN

### *Anthropometric Measurements*

The weight, height, sitting height, stroke length, stroke rate, leg length and body mass index parameters as anthropometric measurement parameters were measured. The height values of students were measured with a stadiometer (Holtain Ltd., Crymych, Dyfed, UK). The weight values were measured with 0.1 kg precision with an electronic weight scale calibrated manually (SECA 709, Hamburg, Germany). The sitting height values of students were measured with a Harpenden sitting height device (Holtain Ltd., Crymych, Dyfed, UK). The hips, backs and occiputs of students were placed to device on the vertical plane [11]. The position of heads was adjusted according to the Frankfurt plane of anatomy [11]. The sitting height was recorded with 0.1 cm precision. The stroke length was measured by a sliding caliper with the arms opened to the side on the horizontal axis and leaning against the wall in a standing position (Holtain Ltd., Crymych, Dyfed, UK). The distance between the middle fingers of both hands was measured as the stroke length with 0.01 cm precision. The stroke rate value was determined as difference between stroke length and height values. The length between tibial condyle and medial malleolus was measured as leg length [12–14] with 0.1 cm precision used a sliding caliper (Holtain Ltd., Crymych, Dyfed, UK). The body mass index was determined by dividing the body weight value expressed in kg by the square of height value expressed in m [15, 16].

### *Flexibility Test*

The flexibility values of students were measured with a sit-and-reach test. The sit-and-reach test was carried out using a sit-and-reach-apparatus (Lafayette 01285A, Lafayette Instruments, USA). A scale on it indicates the reach distance of students during the sit-and-reach test. The calibration of test bench was done manually before the test. The students performed the test barefoot. The students sat on the floor and leaned soles of their feet against to test bench. Then students pushed the apparatus of the sit-and-reach bench with their hands, and the reach distance was recorded with 0.1 cm precision.

### *Handgrip Strength Test*

The handgrip strength of students was determined with a handgrip dynamometer (Takei Scientific Instruments, Tokyo, Japan). The right and left handgrip strength was tested. The handgrip strength measurement was carried out at 45° of shoulder flexion. The students gripped the dynamometer with the maximum effort for three seconds. The test was carried out as two repetitions for both hands. The highest value of three repetitions was recorded in kg as the test score.

### *Vertical Jump Tests*

Students' vertical jump ability was determined with squat jump and countermovement jump tests. The tests were carried out on different days. The Optojump measurement system consisting of two bars attached to a computer was used for vertical jump tests (Optojump, Microgate, Bolzano, Italy). The students did vertical jumps between two bars of measurement system. The two bars of the measurement system were connected to computer and the vertical jump values were calculated by system software. The squat jump test was used to determine explosive strength of leg muscles. The test was carried out at 90° knee flexion with both hands at the waist. The students tried to jump with maximum effort. The countermovement jump was a test measuring

elastic strength of leg muscles as well as the explosive strength. The students stood in the position of full knee extension with both hands at the waist. After taking position at 90° knee flexion, students carried out vertical jump with maximum effort. Both of the vertical jump tests were carried out as three repetitions, and the best value was recorded in cm as the vertical jump value.

#### *Tapping (Skipping) Test*

The tapping (skipping) test was carried out to determine the step frequency during a running exercise. During the tapping (skipping) test, the step frequency, flight times and contact times to the ground by the right and left foot, step/speed ratio parameters were measured by Optojump measurement system (Optojump, Microgate, Bolzano, Italy). The Optojump measurement system has two bars. One of these bars has a transmitter system and other one has a receiver system. The bars of system are paralelly set and the system measures flight times, contact times, step frequency and step/speed ratio parameters in 1 ms precision with these bars. The receiver bar of the system includes electronic diodes emitting light. When the jump exercise is carried out between the transmitter and receiver bars, the receiver bar interrupts light and the system's timer measures the contact time as the total time of contact to ground and the flight time as the total time among contacts to ground. The tapping (skipping) test lasted 15 seconds, and students tried to step with maximum effort during 15 seconds test duration [17]. The test parameters were determined by software of the Optojump system connected to a computer.

#### *Postural Sway Test*

The postural sway test was carried out to evaluate mobility and the stationary position at the center of gravity over a support leg. The postural sway test was carried out on a portable force plate (Kistler 9807, Kistler Instrumente AG, Winterthur, Switzerland). The force plate measures total, anterior-posterior (throughout Y axis) and medial-lateral (throughout X axis) postural sway values in millimeters (mm) with 50 Hz frequency. The students stood on a force plate in a double leg stance position with opened eyes without losing balance for 10 seconds [18]. The anterior-posterior and medial lateral postural sway values were automatically determined with the device software on a computer connected to the plate. It is stated that lower postural sway values indicate a higher balance ability.

#### *Visual Reaction Test*

Students' visual reaction time was determined by an electronic reaction measurement system (Witty Sem, Microgate, Bolzano, Italy). The system consisted of six visual reaction lamps which include blue, green and red light stimulants. The visual reaction lamps were attached to tripods and placed in the half circle with 1.8 meter radius of the basketball pitch free throw line on the parquet floor of an indoor sports hall. When the test began, students tried to touch lamps giving blue light alerts randomly. The test was finished when sixty light alerts were completed. The mean visual reaction time values during test were determined by software of reaction measurement system with 0.01 sec. precision.

#### *Reaction Test*

The reaction time was determined by an electronic reaction time measurement system (Smart Speed, Fusion Sport, Brisbane, Australia). The system consisted of a light stimulant, a photocell gate, a reaction mat and a computer. The 5 m sprint run was carried out for the reaction test. The photocell gate of the system was set at the finish line of 5 m sprint run. The students carried out warming exercises before test. The reaction mat of system was set at the start

line of test. The students stepped to the reaction mat with the dominant foot and waited for the light stimulant positioned in finish photocell at start position. The light stimulant of system was given and the students sprinted to the finish photocell. The students completed the 5 m distance with maximum effort. The test was carried out as three repetitions and the best reaction time value was accepted as the test score. The students' reaction time was calculated with an accuracy of 0.01 seconds as the difference between the time of emitting the light stimulus and the time of leaving the mat.

#### *Sprint Test*

The 20 m sprint time was carried out to determine students' sprint ability. The 20 m test track was set on a parquet floor of an indoor sport hall. The wireless photocell system was used to determine the sprint times (Witty, Microgate, Bolzano, Italy). The photocells were placed at the start and the finish line of 20 m test track. The warming exercises were carried out before the test. The time started automatically when the start photocell was passed. The 20 meters test time was determined automatically with 0.01 seconds precision when the student passed the 20 meters photocell and stopped the time. The students' test time was recorded by an electronic tracking device of a wireless photocell. The test was carried out in three repetitions with rest intervals, and the best sprint time was recorded as the 20 meters sprint time.

#### *Agility Test*

The Pro-agility test was carried out to determine students' ability to change direction quickly. The test times were determined by a wireless electronic photocell system (Witty, Microgate, Bolzano, Italy). The test track is demonstrated in Figure 1 [19]. The Pro-agility test consists of total 9.14 meters distances as 4.57 meters to the right and the left of the start line. The gate of a wireless photocell was put in the start line of the test. After warming exercises, the students carried out the test. The students started test time when passing the start line. The test consists of runs to 4.57 meters to the right, 9.14 meters to the left and back to the start line, respectively (Figure 1). The test time was automatically recorded by an electronic photocell system. The students carried out the Pro-agility test in three repetitions with rest intervals, and the shortest test time was determined as the agility test value.

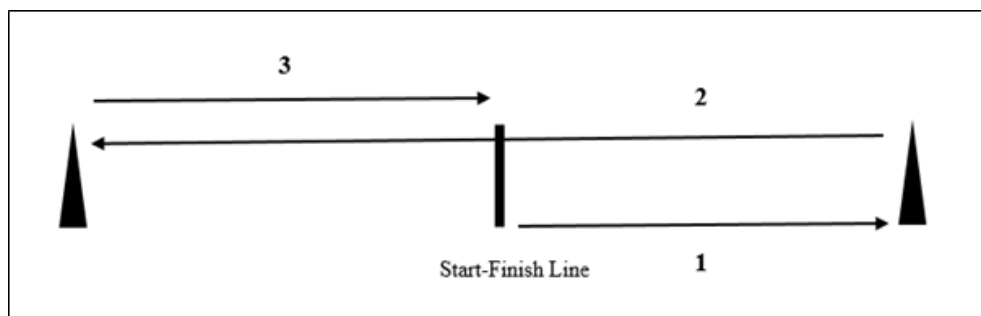


Fig. 1. Pro-Agility Test [19]

#### *Determination of the level of maturation*

The maturation offset of students was calculated by the maturation offset formula of Malina et al. [20], separately for boy and girl students. The maturation offset formula of Malina et al. [20] is given below:

$$\text{Boys: maturity offset} = -9.236 + [0.0002708 \times (\text{leg length} \times \text{sitting height})] + [-0.001663 \times (\text{age} \times \text{leg length})] + [0.007216 \times (\text{age} \times \text{sitting height})] + [0.02292 \times (\text{mass} / \text{height ratio} \times 100)].$$

$$\text{Girls: maturity offset} = -9.376 + 0.0001882 (\text{leg length} \times \text{sitting height}) + 0.0022 (\text{age} \times \text{leg length}) + 0.005841 (\text{age} \times \text{sitting height}) - 0.002658 (\text{age} \times \text{weight}) + 0.07693 (\text{mass} / \text{height ratio} \times 100)].$$

A high positive correlation between skeletal age and maturation offsets was reported [21]. The maturation offset values were standardized with z-score (z-score = raw maturation offset - mean of raw maturation offsets / standart deviation of raw maturation offsets). The categorization of maturation levels was determined by z-score values of maturation offsets [20], and it is presented in Table 1.

Table 1. Maturation level categorization according to z-scores of maturation offsets [20]

z-Score of Maturation Offset	Maturation Level
Over +1.0	Early
-1.0 to +1.0	Normal
Below -1.0	Delayed

## STATISTICAL ANALYSIS

The study data was analyzed in SPSS 22.0 statistic package program (SPSS Inc., IBM, Chicago, USA). The data is presented as descriptive statistics (mean ± standard deviation). The normality of data distribution was tested by the Kolmogorov-Smirnov test. The test parameters were compared according to students' gender and maturation level. The parametric study data were compared with independent samples T-test according to gender and with one way ANOVA test according to the maturation level. The variance homogeneity in independent samples of the T-test and one-way ANOVA analysis was determined with Levene's test. The comparison of non-parametric data was done with the Mann Whitney-U test, according to gender, and with the Kruskal Wallis-H test, according to the maturation level. The pairwise comparisons of significant differences between groups in one-way ANOVA test were analyzed with Tukey HSD test and Dunnett C test according to variances homogeneity. The Mann Whitney-U test with Bonferroni correction was used for pairwise comparisons of significant differences between groups in the Kruskal Wallis-H test. The significance level of statistical analysis was set as  $p < 0.05$ .

## RESULTS

The Table 2 is depicting a descriptive statistics of test parameters of boy and girl students.

According to Table 3, there was a significant difference between boy and girl students in terms of sitting height, stroke rate, flexibility, squat jump, reaction, jump and right foot flight time parameters ( $p < 0.05$ ). Also, a better flexibility value of girl students was noted in comparison to boys ( $p < 0.05$ ).



Table 2. Descriptive statistics of test parameters of boy and girl students

		Boys (n = 300)		Girls (n = 235)		Total (n = 535)	
		$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Anthropometric Measurements	Age (year)	8.25	2.32	8.12	2.16	8.19	2.25
	Height (cm)	131.69	13.91	130.16	13.31	131.02	13.66
	Weight (kg)	32.41	12.82	29.98	10.33	31.34	11.84
	Body Mass Index	18.01	3.59	17.20	3.15	17.65	3.42
	Sitting Height (cm)	69.55	7.05	68.49	6.80	69.09	6.95
	Leg Length (cm)	62.13	7.27	61.66	6.92	61.92	7.12
	Stroke Length (cm)	130.11	15.82	127.68	15.99	129.04	15.93
	Stroke Rate	-1.57	3.71	-2.47	3.75	-1.97	3.75
Sit and Reach	Flexibility (cm)	22.72	5.76	24.41	5.95	23.46	5.90
Hand Grip Strength	Right Hand (kg)	13.50	5.77	12.01	4.60	12.85	5.34
	Left Hand (kg)	12.94	5.52	11.39	4.55	12.26	5.17
Vertical Jump	Squat Jump (cm)	14.49	4.70	13.24	4.15	13.94	4.51
	Countermovement Jump (cm)	15.11	4.95	13.87	4.26	14.56	4.70
Postural Sway	Anterior-Posterior Sway (mm)	113.14	58.74	97.36	47.96	106.21	54.78
	Medial-Lateral Sway (mm)	135.45	53.86	124.58	56.49	130.68	55.24
	Total Sway (mm)	198.09	81.74	175.47	74.62	188.16	79.42
Reaction	Visual Reaction Time (sec)	24.26	4.81	25.88	5.35	24.97	5.11
	Reaction Time (sec)	.78	.13	.81	.13	.79	.13
Sprint	20 Meters Sprint (sec)	4.90	.74	5.13	.83	5.00	.79
Agility	Pro-Agility Test Time (sec)	7.10	1.09	7.45	1.14	7.25	1.12
Tapping (Skipping) Test	Right Foot Flight Time (sec)	.29	.08	.31	.08	.30	.08
	Right Foot Contact Time (sec)	.23	.07	.22	.06	.23	.07
	Right Foot Frequency (cycle/sec)	2.31	.51	2.20	.56	2.26	.54
	Left Foot Flight Time (sec)	.28	.08	.32	.08	.30	.08
	Left Foot Contact Time (sec)	.23	.08	.22	.06	.23	.07
	Left Foot Frequency (cycle/sec)	2.34	.54	2.15	.49	2.26	.53
	Step/Speed Rate	.51	.10	.49	.10	.50	.10

Table 3. Independent samples t-test analysis table of the parametric test values according to gender

	Gender	n	$\bar{x}$	SD	t	p
Sitting Height (cm)	Boys	300	69.55	7.05	1.752	.080
	Girls	235	68.49	6.80		
Stroke rate	Boys	300	-1.57	3.71	2.759	.006*
	Girls	235	-2.47	3.75		
Flexibility (cm)	Boys	300	22.72	5.76	-3.320	.001*
	Girls	235	24.41	5.95		
Squat Jump (cm)	Boys	300	14.49	4.70	3.224	.001*
	Girls	235	13.24	4.15		
Reaction Time (sec)	Boys	300	.78	.13	-3.234	.001*
	Girls	235	.81	.13		
Right Foot Flight Time (sec)	Boys	300	.29	.08	-2.746	.006*
	Girls	235	.31	.08		

\* p < 0.05

According to Table 4, a significant difference was determined between boy and girl students with regard to all non-parametric test values without leg length, stroke length, left foot contact time and step/speed ratio parameters ( $p < 0.05$ ). As regards the postural sway values, girl students' balance ability was better than boys'.

Table 4. The Mann Whitney-U test analysis table of the non-parametric test values according to gender

	Gender	n	$\bar{x}$	SD	Median	U	p
Body Mass Index	Boys	300	18.01	3.59	16.88	30506.00	.008*
	Girls	235	17.20	3.15	16.34		
Leg Length (cm)	Boys	300	62.13	7.27	62.05	33960.00	.467
	Girls	235	61.66	6.92	61.00		
Stroke Length (cm)	Boys	300	130.11	15.82	130.45	31766.50	.050
	Girls	235	127.68	15.99	126.00		
Right Hand Strength (kg)	Boys	300	13.50	5.77	12.75	29079.50	.001*
	Girls	235	12.01	4.60	11.40		
Left Hand Strength (kg)	Boys	300	12.94	5.52	12.05	28371.50	.000*
	Girls	235	11.39	4.55	10.70		
Countermovement Jump (cm)	Boys	300	15.11	4.95	14.80	29773.50	.003*
	Girls	235	13.87	4.26	13.30		
Anterior-Posterior Sway (mm)	Boys	300	113.14	58.74	98.26	28713.00	.000*
	Girls	235	97.36	47.96	89.09		
Medial-Lateral Sway (mm)	Boys	300	135.45	53.86	121.90	29791.00	.002*
	Girls	235	124.58	56.49	113.90		
Total Sway (mm)	Boys	300	198.09	81.74	179.85	28671.50	.000*
	Girls	235	175.47	74.62	161.60		
Visual Reaction (sec)	Boys	300	24.26	4.81	23.55	28310.50	.000*
	Girls	235	25.88	5.35	24.61		
20 Meters Sprint (sec)	Boys	300	4.90	.74	4.82	30338.00	.006*
	Girls	235	5.13	.83	4.92		
Pro-Agility Test Time (sec)	Boys	300	7.10	1.09	6.82	27799.50	.000*
	Girls	235	7.45	1.14	7.20		
Right Foot Contact Time (sec)	Boys	300	.23	.07	.21	31384.00	.029*
	Girls	235	.22	.06	.21		
Right Foot Frequency (cycle/sec)	Boys	300	2.31	.51	2.26	29792.00	.002*
	Girls	235	2.20	.56	2.11		
Left Foot Flight Time (sec)	Boys	300	.28	.08	.27	25368.00	.000*
	Girls	235	.32	.08	.31		
Left Foot Contact Time (sec)	Boys	300	.23	.08	.22	32271.50	.093
	Girls	235	.22	.06	.21		
Left Foot Frequency (cycle/sec)	Boys	300	2.34	.54	2.33	26681.50	.000*
	Girls	235	2.15	.49	2.09		
Step/Speed Ratio	Boys	300	.51	.10	.50	32682.50	.148
	Girls	235	.49	.10	.50		

\*  $p < 0.05$



Table 5. Descriptive statistics of test parameters of boy students according to their maturation level

		Early (n=49)		Normal (n=209)		Delayed (n=42)	
		$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Anthropometric Measurements	Age (year)	8.40	2.41	8.30	2.28	7.78	2.45
	Height (cm)	141.03	14.77	131.33	12.57	122.60	12.88
	Weight (kg)	43.40	16.70	31.50	11.01	24.12	6.13
	Body Mass Index	21.03	4.20	17.73	3.26	15.83	1.87
	Sitting Height (cm)	74.74	6.86	69.41	6.38	64.24	6.27
	Leg Length (cm)	66.28	8.37	61.92	6.56	58.36	7.08
	Stroke Length (cm)	139.44	16.62	129.85	14.69	120.53	14.45
	Stroke Rate	-1.58	4.75	-1.47	3.60	-2.07	2.78
Sit and Reach	Flexibility (cm)	24.69	5.76	22.45	5.85	21.75	4.81
Hand Grip Strength	Right Hand (kg)	15.99	5.77	13.54	5.79	10.41	4.13
	Left Hand (kg)	15.53	5.51	12.92	5.53	10.06	3.84
Vertical Jump	Squat Jump (cm)	13.68	3.60	14.90	4.86	13.43	4.85
	Countermovement Jump (cm)	14.58	3.68	15.41	5.13	14.25	5.25
Postural Sway	Anterior-Posterior Sway (mm)	91.84	29.39	115.72	61.86	125.15	63.38
	Medial-Lateral Sway (mm)	120.54	39.87	137.11	58.22	144.60	41.62
	Total Sway (mm)	171.78	52.42	201.03	87.47	214.21	74.54
Reaction	Visual Reaction Time (sec)	23.64	3.86	24.15	4.81	25.52	5.60
	Reaction Time (sec)	.80	.12	.78	.13	.73	.12
Sprint	20 Meters Sprint (sec)	4.92	.72	4.84	.68	5.21	.93
Agility	Pro-Agility Test Time (sec)	7.16	1.10	7.03	1.04	7.37	1.27
Tapping (Skipping) Test	Right Foot Flight Time (sec)	.30	.09	.29	.08	.30	.10
	Right Foot Contact Time (sec)	.25	.08	.23	.07	.23	.08
	Right Foot Frequency (cycle/sec)	2.28	.66	2.30	.46	2.38	.57
	Left Foot Flight Time (sec)	.29	.09	.28	.07	.30	.10
	Left Foot Contact Time (sec)	.24	.09	.23	.07	.23	.08
	Left Foot Frequency (cycle/sec)	2.26	.65	2.36	.51	2.33	.55
	Step/Speed Rate	.50	.12	.51	.09	.49	.09

The sitting height, leg and stroke length, flexibility, right and left hand strength, total postural sway parameters were significantly differentiated among boy students at an early, normal and delayed maturation level, according to analysis results ( $p < 0.05$ ). Boy students at an early maturation level had higher test values than boy students at other maturation levels, except for the total postural sway parameter, when the pairwise comparison results between the groups were examined. It was determined that boy students at an early maturation level had lower total postural sway values than boy students at other maturation levels. This finding indicated that the balance ability of boy students at early maturation level was better than the balance ability of boy students at a normal and delayed maturation level.

Table 6. One-way ANOVA analysis table of the parametric test values of boy students according to their maturation level

	Maturation Level	n	$\bar{x}$	SD	F	p	Significant Difference
Sitting Height (cm)	Early	49	74.74	6.86	30.197	.000*	Early-Normal Early-Delayed Normal-Delayed
	Normal	209	69.41	6.38			
	Delayed	42	64.24	6.27			
Leg Length (cm)	Early	49	66.28	8.37	14.954	.000*	Early-Normal Early-Delayed Normal-Delayed
	Normal	209	61.92	6.56			
	Delayed	42	58.36	7.08			
Stroke Length (cm)	Early	49	139.44	16.62	18.094	.000*	Early-Normal Early-Delayed Normal-Delayed
	Normal	209	129.85	14.69			
	Delayed	42	120.53	14.45			
Stroke Rate	Early	49	-1.58	4.75	.445	.641	
	Normal	209	-1.47	3.60			
	Delayed	42	-2.07	2.78			
Flexibility (cm)	Early	49	24.69	5.76	3.761	.024*	Early-Normal Early-Delayed
	Normal	209	22.45	5.85			
	Delayed	42	21.75	4.81			
Right Hand Strength (kg)	Early	49	15.99	5.77	11.027	.000*	Early-Normal Early-Delayed Normal-Delayed
	Normal	209	13.54	5.79			
	Delayed	42	10.41	4.13			
Left Hand Strength (kg)	Early	49	15.53	5.51	11.663	.000*	Early-Normal Early-Delayed Normal-Delayed
	Normal	209	12.92	5.53			
	Delayed	42	10.06	3.84			
Squat Jump (cm)	Early	49	13.68	3.60	2.607	.075	
	Normal	209	14.90	4.86			
	Delayed	42	13.43	4.85			
Countermovement Jump (cm)	Early	49	14.58	3.68	1.289	.277	
	Normal	209	15.41	5.13			
	Delayed	42	14.25	5.25			
Total Sway (mm)	Early	49	171.78	52.42	3.549	.030*	Early-Delayed
	Normal	209	201.03	87.47			
	Delayed	42	214.21	74.54			
Reaction Time (sec)	Early	49	.80	.12	2.898	.057	
	Normal	209	.78	.13			
	Delayed	42	.73	.12			
Right Foot Frequency (cycle/sec)	Early	49	2.28	.66	.508	.602	
	Normal	209	2.30	.46			
	Delayed	42	2.38	.57			
Left Foot Frequency (cycle/sec)	Early	49	2.26	.65	.777	.461	
	Normal	209	2.36	.51			
	Delayed	42	2.33	.55			

\* p < 0.05

The analysis results of non-parametric test parameters indicated that the anterior-posterior and medial-lateral sway value of boy students at an early maturation level was the lowest among the three groups. Accordingly, the balance ability with regard to the anterior-posterior sway parameter of boy students at early maturation level was better than in the other groups. On the other hand, a significant difference was found between early and delayed maturation groups

in terms of medial-lateral sway value ( $p < 0.05$ ). This finding indicated that the balance ability in terms of the medial-lateral sway parameter was at a better level in the early maturation group as compared to the delayed maturation group.

Table 7. The Kruskal Wallis-H analysis table of the non-parametric test values of boy students according to their maturation level

	Maturation Level	n	$\bar{x}$	SD	Median	Chi-square	p	Significant Difference
Body Mass Index	Early	49	21.03	4.20	20.24	46.516	.000*	Early-Normal Early-Delayed Normal-Delayed
	Normal	209	17.73	3.26	16.82			
	Delayed	42	15.83	1.87	15.76			
Anterior-Posterior Sway (mm)	Early	49	91.84	29.39	85.59	10.141	.006*	Early-Normal Early-Delayed
	Normal	209	115.72	61.86	99.75			
	Delayed	42	125.15	63.38	117.56			
Medial-Lateral Sway (mm)	Early	49	120.54	39.87	116.41	8.321	.016*	Early-Delayed
	Normal	209	137.11	58.22	119.90			
	Delayed	42	144.60	41.62	141.65			
Visual Reaction Time (sec)	Early	49	23.64	3.86	22.80	2.029	.363	
	Normal	209	24.15	4.81	23.57			
	Delayed	42	25.52	5.60	23.90			
20 Meters Sprint (sec)	Early	49	4.92	.72	4.82	4.588	.101	
	Normal	209	4.84	.68	4.82			
	Delayed	42	5.21	.93	5.20			
Pro-Agility Test Time (sec)	Early	49	7.16	1.10	6.87	2.145	.342	
	Normal	209	7.03	1.04	6.81			
	Delayed	42	7.37	1.27	7.11			
Right Foot Flight Time (sec)	Early	49	.30	.09	.29	.587	.745	
	Normal	209	.29	.08	.28			
	Delayed	42	.30	.10	.28			
Right Foot Contact Time (sec)	Early	49	.25	.08	.22	1.196	.550	
	Normal	209	.23	.07	.21			
	Delayed	42	.23	.08	.21			
Left Foot Flight Time (sec)	Early	49	.29	.09	.28	2.268	.322	
	Normal	209	.28	.07	.27			
	Delayed	42	.30	.10	.28			
Left Foot Contact Time (sec)	Early	49	.24	.09	.22	.766	.682	
	Normal	209	.23	.07	.22			
	Delayed	42	.23	.08	.21			
Step/Speed Rate	Early	49	.50	.12	.51	2.221	.329	
	Normal	209	.51	.09	.50			
	Delayed	42	.49	.09	.48			

\* $p < 0.05$

Analysis results in Table 9 a indicated significant difference among groups in terms of the body mass index, sitting height, leg length, stroke length, flexibility, left hand strength and right foot flight time parameters ( $p < 0.05$ ). Girl students at a delayed maturation level had the lowest test values except the right foot flight time values, according to analysis results of a pairwise comparison. On the other hand, the pairwise comparison results among groups indicated that the test values of girl students at an early maturation level were higher than the test values of other groups except for the right foot flight time parameters.

Table 8. Descriptive statistics of test parameters of girl students according to maturation levels

		Early (n=36)		Normal (n=174)		Delayed (n=25)	
		$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Anthropometric Measurements	Age (year)	8.16	2.13	8.12	2.11	8.08	2.59
	Height (cm)	137.05	13.34	129.87	12.66	122.26	13.27
	Weight (kg)	40.93	11.69	28.53	8.77	24.32	7.67
	Body Mass Index	21.36	3.26	16.54	2.54	15.82	1.83
	Sitting Height (cm)	72.51	6.62	68.31	6.46	64.02	6.42
	Leg Length (cm)	64.53	7.04	61.56	6.66	58.24	7.13
	Stroke Length (cm)	135.26	15.48	127.34	15.52	119.17	15.69
	Stroke Rate	-1.78	3.10	-2.53	3.87	-3.09	3.71
Sit and Reach	Flexibility (cm)	25.98	6.86	24.50	5.87	21.52	4.05
Hand Grip Strength	Right Hand (kg)	14.22	4.94	11.85	4.42	9.93	4.22
	Left Hand (kg)	13.46	4.28	11.21	4.59	9.71	3.66
Vertical Jump	Squat Jump (cm)	11.86	4.03	13.56	4.16	12.99	4.02
	Countermovement Jump (cm)	12.55	3.92	14.27	4.26	12.95	4.43
Postural Sway	Anterior-Posterior Sway (mm)	88.31	49.28	100.20	49.42	90.66	32.34
	Medial-Lateral Sway (mm)	118.41	51.13	125.33	57.54	128.25	57.99
	Total Sway (mm)	163.10	74.81	177.96	75.05	176.00	72.50
Reaction	Visual Reaction Time (sec)	25.63	4.67	25.83	5.60	26.62	4.57
	Reaction Time (sec)	.81	.10	.82	.14	.78	.13
Sprint	20 Meters Sprint (sec)	5.12	.68	5.09	.81	5.44	1.11
Agility	Pro-Agility Test Time (sec)	7.53	.99	7.37	1.09	7.88	1.57
Tapping (Skipping) Test	Right Foot Flight Time (sec)	.32	.08	.31	.08	.35	.06
	Right Foot Contact Time (sec)	.24	.09	.21	.05	.22	.06
	Right Foot Frequency (cycle/sec)	2.23	.65	2.24	.55	1.89	.34
	Left Foot Flight Time (sec)	.29	.07	.32	.09	.32	.07
	Left Foot Contact Time (sec)	.24	.06	.22	.06	.22	.05
	Left Foot Frequency (cycle/sec)	2.21	.49	2.15	.50	2.04	.44
	Step/Speed Rate	.51	.09	.48	.10	.54	.08

Table 9. One-way ANOVA analysis table of the parametric test values of girl students according to their maturation level

	Maturation Level	n	$\bar{x}$	SD	F	p	Significant Difference
Body Mass Index	Early	36	21.36	3.26	55.001	.000*	Early-Normal Early-Delayed
	Normal	174	16.54	2.54			
	Delayed	25	15.82	1.83			
Sitting Height (cm)	Early	36	72.51	6.62	12.914	.000*	Early-Normal Early-Delayed Normal-Delayed
	Normal	174	68.31	6.46			
	Delayed	25	64.02	6.42			
Leg Length (cm)	Early	36	64.53	7.04	6.450	.002*	Early-Normal Early-Delayed
	Normal	174	61.56	6.66			
	Delayed	25	58.24	7.13			
Stroke Length (cm)	Early	36	135.26	15.48	8.089	.000*	Early-Normal Early-Delayed Normal-Delayed
	Normal	174	127.34	15.52			
	Delayed	25	119.17	15.69			

Table 9. continuation

	Maturation Level	n	$\bar{x}$	SD	F	p	Significant Difference
Stroke Rate	Early	36	-1.78	3.10	.978	.378	
	Normal	174	-2.53	3.87			
	Delayed	25	-3.09	3.71			
Flexibility (cm)	Early	36	25.98	6.86	4.330	.014*	Early-Delayed Normal-Delayed
	Normal	174	24.50	5.87			
	Delayed	25	21.52	4.05			
Left Hand Strength (kg)	Early	36	13.46	4.28	5.795	.004*	Early-Normal Early-Delayed
	Normal	174	11.21	4.59			
	Delayed	25	9.71	3.66			
Squat Jump (cm)	Early	36	11.86	4.03	2.581	.078	
	Normal	174	13.56	4.16			
	Delayed	25	12.99	4.02			
Countermovement Jump (cm)	Early	36	12.55	3.92	3.116	.046*	
	Normal	174	14.27	4.26			
	Delayed	25	12.95	4.43			
Visual Reaction (sec)	Early	36	25.63	4.67	.288	.750	
	Normal	174	25.83	5.60			
	Delayed	25	26.62	4.57			
Reaction Time (sec)	Early	36	.81	.10	.806	.448	
	Normal	174	.82	.14			
	Delayed	25	.78	.13			
Right Foot Flight Time (sec)	Early	36	.32	.08	3.612	.029*	Normal-Delayed
	Normal	174	.31	.08			
	Delayed	25	.35	.06			
Left Foot Flight Time (sec)	Early	36	.29	.07	1.205	.302	
	Normal	174	.32	.09			
	Delayed	25	.32	.07			

\*p < 0.05

According to the analysis results of non-parametric test values, there was a significant difference among groups with regard to test values of the right hand strength, anterior-posterior sway, right foot frequency and step/speed rate parameters ( $p < 0.05$ ). Girl students at an early maturation level had the highest right hand strength test values, and anterior-posterior sway values of the girl students at a normal maturation level were worse than test values of the girl students at an early and a delayed maturation level. Also, it was seen that the right foot frequency value of the girl students at an early and a normal maturation level was similar, and there was a significant difference between the right foot frequency values of normal and delayed maturation groups ( $p < 0.05$ ). Although there was a significant difference among groups in terms of step/speed rate parameter ( $p < 0.05$ ), no significant difference among groups was determined according to the pairwise comparison of analysis results.

Table 10. The Kruskal Wallis-H analysis table of the non-parametric test values of girl students according to their maturation level

	Maturation Level	n	$\bar{x}$	SD	Median	Chi-square	p	Significant Difference
Right Hand Strength (kg)	Early	36	14.22	4.94	13.25	13.736	.001*	Early-Normal Early-Delayed
	Normal	174	11.85	4.42	10.80			
	Delayed	25	9.93	4.22	8.20			
Anterior-Posterior Sway (mm)	Early	36	88.31	49.28	77.61	6.781	.034*	Early-Normal
	Normal	174	100.20	49.42	90.79			
	Delayed	25	90.66	32.34	84.70			
Medial-Lateral Sway (mm)	Early	36	118.41	51.13	102.11	1.268	.530	
	Normal	174	125.33	57.54	115.05			
	Delayed	25	128.25	57.99	107.10			
Total Sway (mm)	Early	36	163.10	74.81	144.75	3.700	.157	
	Normal	174	177.96	75.05	163.20			
	Delayed	25	176.00	72.50	156.20			
20 Meters Sprint (sec)	Early	36	5.12	.68	5.00	1.834	.400	
	Normal	174	5.09	.81	4.86			
	Delayed	25	5.44	1.11	4.93			
Pro-Agility Test Time (sec)	Early	36	7.53	.99	7.21	2.276	.320	
	Normal	174	7.37	1.09	7.19			
	Delayed	25	7.88	1.57	7.27			
Right Foot Contact Time (sec)	Early	36	.24	.09	.21	1.502	.472	
	Normal	174	.21	.05	.20			
	Delayed	25	.22	.06	.21			
Right Foot Frequency (cycle/sec)	Early	36	2.23	.65	2.11	9.872	.007*	Normal-Delayed
	Normal	174	2.24	.55	2.15			
	Delayed	25	1.89	.34	1.88			
Left Foot Contact Time (sec)	Early	36	.24	.06	.24	5.953	.051	
	Normal	174	.22	.06	.20			
	Delayed	25	.22	.05	.20			
Left Foot Frequency (cycle/sec)	Early	36	2.21	.49	2.15	2.022	.364	
	Normal	174	2.15	.50	2.11			
	Delayed	25	2.04	.44	1.86			
Step/Speed Rate	Early	36	.51	.09	.51	6.131	.047*	
	Normal	174	.48	.10	.49			
	Delayed	25	.54	.08	.50			

\*p<0.05; the pairwise comparisons were examined by Mann Whitney-U test with Bonferroni correction.

## DISCUSSION

The same performance parameters were compared in this study according to students' gender and maturation level. The significant difference was determined between boys and girls in terms of sitting height, stroke rate, flexibility, squat jump, reaction time, right foot flight time, body mass index, right hand strength, left hand strength, countermovement jump, anterior-posterior, medial-lateral and total sway, visual reaction, 20 meters sprint, pro-agility test time, right foot contact time, right foot frequency, left foot flight time, left foot frequency parameters (p<0.05). It was found that the sitting height, leg and stroke length, flexibility, right and left hand strength, anterior-posterior, medial-lateral and total sway, body mass index parameters of boy

students significantly differed depending on the maturation level ( $p < 0.05$ ). There was a significant difference among girl students of different maturation levels in terms of the body mass index, sitting height, leg and stroke length, flexibility, right and left hand strength, right foot flight time, anterior-posterior sway and right foot frequency parameters ( $p < 0.05$ ). Carvalho et al. [22] found a moderately positive correlation between the maturation offset and the knee extensor and flexor muscles isokinetic strength values of young male basketball players aged 14-16 years in eccentric and concentric exercises. It was revealed that the right and left hand strength values of boy students significantly differed depending on the maturation level in our study. The boy students at an early maturation level had higher hand strength values than boy students at other maturation levels, thus there was a similarity between the two studies.

A study of Wickel et al. [23] indicated that there was a significant difference between early maturation and other maturation groups with regard to leg length and body mass index values of girl students. The results of Wickel et al. [23] were similar to our study results in terms of the mentioned parameters. It may be said that the maturation level has a positive effect on anthropometric and physical performance parameters, and individuals at an early maturation level have an advantage in terms of exercise performance. The neuromuscular systems of individuals at an early maturation level may develop more than of those at a normal and a delayed maturation level, and this functional difference may affect physical performance. Similarly, Wickel and Eisenmann [24] determined a significant difference among early, normal and delayed maturation levels in both boy and girl students aged 13-14 years old in terms of leg length parameter. These authors also found that there was a significant difference among maturation groups in the body mass index values of boy students, and the body mass index values of early maturation group were higher than of other maturation groups. In the light of these findings, it could be said that early maturation was important for physical performance.

A study of Mahon et al. [25] indicated that the maturation offset and resting heart rate values significantly predicted maximal heart rate values. The maximal heart rate values during maximal exercise could be affected by the maturation level. The maximal heart rate values indicate the maximal loading rate of exercise, and individuals at an early maturation level could carry out the exercise efficiently. In our study, the right and left hand strength values of students at an early maturation level were higher than strength values of normal and delayed maturation groups. It could be said that the right and left hand strength values could be affected by the maturation level, such as the heart rate values determined in a study by Mahon et al. [25]. Gil et al. [26] reported that the maturity offset was a predictor of 30 meters velocity value with the total skinfold, fat-free mass, and chronological age. The fast muscle contraction is important for velocity exercises, and the muscle structure and physiology of individuals at an early maturation level may positively affect velocity performance. A significant difference was noted between the right foot frequency values of girl students at normal and delayed maturation levels in our study. The foot frequency values during the skipping test may be an indicator of speed and agility parameters. Although there was no significant difference between the agility test values of both boy and girl students in terms of the maturation level in our study, the difference in the right foot frequency values of girl students at normal and delayed maturation levels may be interpreted with regard to an agility parameter.



Matthys et al. [27] reported that 20 meters sprint time and handgrip test values differentiated young handball players at early, normal and delayed maturation levels. Handball requires strong handgrip. In our study, higher hand strength values of students at an early maturation level support results of Matthys et al. [27]. Similarly, it was indicated that the maturity offset values of boys aged 11-16 years correlated with speed, step length, step frequency and contact time parameters [28]. The maturation offset is an indirect indicator of individuals' maturation and growth. The findings of Meyers et al. [28] may be presented as evidence to the importance of the maturation level in physical activity and exercise performance. There was a significant difference between right foot frequency values of girl students from normal and delayed maturation groups in our study, which supported the step frequency-maturity offset relationship in findings of Meyers et al. [28].

Gay et al. [29] determined a significant correlation between the maturation offset and the body mass index, sitting height, leg length parameters. The body mass index, sitting height, leg length are important anthropometric parameters for many sport disciplines. The positive effect of the maturation level on anthropometric parameters in a study of Gay et al. [29] was supported by significant a difference among maturation level groups in terms of the sitting height, leg length and body mass index parameters found in our study. Gastin et al. [30] divided young male soccer players (10-18 years old) into five puberty stage groups and examined differences between the groups. The authors found that there was a significant difference between some puberty stage groups in terms of sitting height and 20 meters sprint values. The study results by Gastin et al. [30] also indicated that the puberty stage 4 and puberty stage 5 groups had better sitting height and sprint values than other puberty stage groups. Soccer players in late puberty may have better values of performance parameters because of an advanced level of physical maturation. The sitting height value of boy students at an early maturation level in our study was higher than values of other maturation groups. According to these findings, it may be said that the effect of the maturation level on the sitting height parameter is important. Santos et al. [31] analyzed horizontal jump, time of jump with single foot on 10 meters distance and tennis ball throw velocity values of adolescent individuals aged 11-17 years with and without using the maturation offset as a control variable. Their study indicated a significant difference between boy and girl adolescents in terms of performance parameters, with boys' performance parameters better than the girls. A significant difference was found in most performance parameters according to gender in our study, and these findings supported the study of Santos et al. [31]. Asadi et al. [32] also reported development in the values of vertical jump, peak power output, standing long jump, 20 meters sprint, 20 meters sprint with ball parameters of young male soccer players in the different maturation periods after six weeks' plyometric training period. Asadi et al. [32] reported the most development in 20-meter sprint and vertical jump parameters after six weeks' training in post-peak height velocity (post-maturation) group. There was no significant difference among maturation groups in terms of 20-meter sprint and vertical jump parameters of boy and girl students in our study. The difference between the two studies may arise from the conducting this study on boy and girl students in same age group.

Deliceoğlu [33] determined that there was a significant difference among maturation groups (early, normal, delayed maturation groups) in boys and girls aged 8, 9 and 10 years in terms of foot contact and flight time parameters. In his study, the jumping height values differentiated maturation groups in boys

aged 6, 7, 8, 9 and 10 years and in girls aged 7, 8, 9 and 10 years. In our study, the girl students at a delayed maturation level had higher right foot flight time values than the normal maturation group. In Deliceoğlu's study [33], the foot flight time value of girls at an early maturation level was higher than in the normal and delayed maturation groups. The discrepancy between the findings of the two studies may be arise from individual differences in maturation of the study samples. In a study of Lätt et al. [34], there was a significant difference among maturation groups of boys aged 10-14 years in terms of fat-free mass and body mass index parameters, and it was determined that the values of boys at an early maturation level were higher than of boys at a normal and a delayed maturation level. The body mass index values of boy and girl students at an early maturation level in our study were the highest of all maturation groups, and this finding supported results of the study by Lätt et al. [34]. Segers et al. [35] indicated that the maximal oxygen uptake values at 8, 9.5 and 11 km/h running speeds and thigh length values of male soccer players at an early maturation level were higher than in the delayed maturation group. In terms of differences of leg length values among maturation groups, the findings of our study showed a similarity to the study by Segers et al. [35]. Also, some anthropometric measurement values may affect the maximal oxygen uptake values, and the maturation level of boy and girl children predicting anthropometric parameters may be important in terms of aerobic endurance.

The study of Zago et al. [36] compared the sway values of male soccer players in different categories with regard to maturation levels and conditions of opened and closed eyes during the test. The authors observed a significant effect of the maturation level (categorization according to maturation offset) on the sway area, displacement velocity at center of pressure, anterior-posterior and medial-lateral sway standard deviation parameters. In their study, soccer players with a high maturation offset had a lower postural sway standard deviation, which indicated an effect of the maturation level on postural sway parameters. The postural sway values of boy students at an early maturation level were lower than in other maturation groups in our study, and the anterior-posterior sway values of girl students at an early maturation level were lower than in other maturation groups in our study. Although both studies were conducted on children of different age groups, it could be said that their findings showed a similarity in terms of postural sway parameters. On the other hand, the male athletes aged 11-15 years were divided into three maturation groups (pre-PHV, mid-PHV, post-PHV groups) according to peak height velocity based the maturation offset in a study by Meylan et al. [37]. Their findings showed that the leg length and body mass index values of post-peak height velocity (post-PHV) group with the highest maturation offset were higher than in groups of pre-peak height velocity (pre-PHV) and mid-peak height velocity (mid-PHV). In terms of the body mass index and leg length anthropometric parameters, the findings of our study supported the findings of Meylan et al. [37]. According to findings of these studies, it may be concluded that leg length and body mass index parameters are indicators of the maturation level, and these parameters may provide serious advantages to athletes during physical exercise.

A significant difference was seen between boy and girl students in terms of many measurement parameters in this study. The specific physiological structures of boys and girls may cause these differences of measurement parameters. In our study, there was no significant difference between the maturation groups in terms of some performance parameters. The maturation effect on some performance parameters may be lower than others, and the similarity in the maturation groups may be due to this situation.

## CONCLUSIONS

In conclusion, most anthropometric and motoric parameters of students aged 8 years differed depending on gender, and some parameters of both boy and girl students were affected by the maturation level factor. In the light of these findings, it may be concluded that the maturation level is an important factor in some anthropometric and motoric performance characteristics in boy and girl students aged 8 years, and the early maturation level positively affected these parameters. The maturation offset may be effectively used in exercises for children's athletic improvement. Future studies may be conducted on children and adolescents of different age groups, and the effects of the maturation level on physical fitness may be comprehensively revealed.

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