An evaluation of biomotor characteristics according to biological maturation level in 11-12 age soccer players

Avaliação das características biomotoras de acordo com o nível de maturação biológica em jogadores de futebol de 11 a 12 anos

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Abstract

The aim of this study was to evaluate the biomotor characteristics of 11–12-year-old soccer players according to their biological maturation level. The participants in the study were divided into 3 groups according to their peak height (PHV) values which determine their biological maturation levels. The mean age, height and body mass of the participants were 11.22±0.42 years, 163.56±9.30 cm, 54.37±10.05 kg for the PHV1 group, 11.46±0.55 years, 152.45±5.22 cm, 41.32±4.84 kg for the PHV2 group, 11.10±0.31 years, 148.60±4.42 cm, 39.21±4.59 kg for the PHV3 group. The participants were competitive athletes with at least 2 years of continuous training and competition experience. The maturation level of the participants, was determined by Mirwald equation. Biomotor characteristics of the participants were determined by hand grip strength and back leg strength, standing long jump, flexibility, yo-yo intermittent recovery tests. Data were analyzed using IBM SPSS 26 package program. One-way analysis of variance (ANOVA) was used for comparison between groups and Tukey HSD test was used for Post Hoc comparisons of significant relationships. As a result of the evaluation made according to the biological maturation levels of the participants, numerically positive effects on biomotor characteristics were found as the biological maturation level increased. A statistically significant difference between the data constituting the positive effects was observed only in the hand grip strength data. According to the Tukey...
multiple comparison analysis, it was determined that this significant difference occurred as the biological maturation level increased. As a result of the data obtained as a result of our research, it was concluded that the biomotor characteristics of 11-12 age group soccer players developed positively according to the level of biological maturation. In line with these results, it can be stated that biological maturation has a positive effect on biomotor characteristics.

**Keywords:** Biological Maturation. Biomotor Characteristics. Soccer Players.

**Resumo**

O objetivo deste estudo foi avaliar as características biomotoras de jogadores de futebol de 11 a 12 anos de idade de acordo com seu nível de maturação biológica. Os participantes do estudo foram divididos em três grupos de acordo com seus valores de altura máxima (PHV), que determinam seus níveis de maturação biológica. A média de idade, altura e massa corporal dos participantes foi de 11,22±0,42 anos, 163,56±9,30 cm, 54,37±10,05 kg para o grupo PHV1, 11,46±0,55 anos, 152,45±5,22 cm, 41,32±4,84 kg para o grupo PHV2, 11,10±0,31 anos, 148,60±4,42 cm, 39,21±4,59 kg para o grupo PHV3. Os participantes eram atletas de competição com pelo menos dois anos de treinamento contínuo e experiência em competições. O nível de maturação dos participantes foi determinado pela equação de Mirwald. As características biomotoras dos participantes foram determinadas pela força de preensão manual e força da perna de trás, salto em distância em pé, flexibilidade e testes de recuperação intermitente com ioió. Os dados foram analisados com o programa IBM SPSS 26. A análise de variância (ANOVA) de uma via foi usada para comparação entre os grupos e o teste Tukey HSD foi usado para comparações post hoc de relações significativas. Como resultado da avaliação feita de acordo com os níveis de maturação biológica dos participantes, foram encontrados efeitos numericamente positivos nas características biomotoras à medida que o nível de maturação biológica aumentava. Uma diferença estatisticamente significativa entre os dados que constituem os efeitos positivos foi observada somente nos dados de força de preensão manual. De acordo com a análise de comparação múltipla de Tukey, foi determinado que essa diferença significativa ocorreu à medida que o nível de maturação biológica aumentou. Como resultado dos dados obtidos em nossa pesquisa, concluiu-se que as características biomotoras dos jogadores de futebol da faixa etária de 11 a 12 anos se desenvolveram positivamente de acordo com o nível de maturação biológica. De acordo com esses resultados, pode-se afirmar que a maturação biológica tem um efeito positivo sobre as características biomotoras.


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Introduction

Evaluating developmental factors allows us to understand the dynamic interaction between maturation and exercise by exploring physical activity levels, motor skill acquisition and overall health in children (Kaya et al., 2018). It is said that regular physical activity in adolescents contributes positively to anthropometric and physiological development and a healthy physical and psycho-social development can be observed (Saç & Çolak, 2019). Maturation has a significant impact on the acquisition of motor skills that are fundamental for engaging in physical activity. Early-maturing children may exhibit different activity patterns than their late-maturing peers, potentially influencing long-term exercise habits (Malina & Koziel, 2014).

In the evaluation of biological maturation level, skeletal age assessment is the method that is a clinical assessment and allows us to obtain the best maturation assessment index (İzgi and Hatice, 2020). However, this methodology is not well suited to field studies due to its cost and the need for specialized equipment. There are models based on mathematical equations to predict the levels of biological maturation in children. The biological maturation level refers to the difference between a child's chronological age (actual age) and the skeletal age, which represents the maturation level of the skeletal system. Positive values indicate that the individual is more mature in terms of skeletal development than his/her actual age, while negative values indicate that the individual is less mature. The methods commonly used in these mathematical equations in children and adolescents are Mirwald method, Khamis-Roche method, Fels method, Tanner-Whitehouse method, Bayley-Pinneau method. In the classifications to be made according to chronological age in soccer players, it is possible that there may be differences in height, weight, strength, speed and endurance of children in Peak Height Volecity (PHV) among the athletes who play in the same team and whose birth years are the same. PHV is often used in longitudinal studies that help us analyze changes in the level of biological maturation over time. In this case, the change in height and weight means that there will be a differentiation in physical capacity among athletes (Pfirrmann etal., 2016). The range of variability in somatic and biological growth between individuals of the same chronological age is described as wide, especially in the majority of adolescent growth spurts (Mirwald et al., 2002). Organizing training and competitions by classifying according to the biological maturation parameter remains very limited (Saç and Çolak, 2019). It is an important assessment that participants with the same biological maturation level will benefit from equal
competition environment and training efficiency. In this way, it is expected to achieve the highest potential benefit target for the athlete.

In our study, it was aimed to evaluate the extent of differentiation between bio motor characteristics of 11-13 year-old soccer players whose PHV levels were calculated using Mirwald method according to their biological maturation level.

**Methodology**

2.1 Research Model

This study was carried out with the approval of the Tekirdağ Namık Kemal University, Non-Invasive Clinical Research Ethics Committee (2023.147.07.12 numbered article). The study is observational in terms of the data collection technique, descriptive according to the causality relationship, and cross-sectional considering the timing relationship. Experimental research from quantitative research methods was used in the study.

2.2 Research Group

This study was carried out with voluntary participation of 2 Football team’s 28 licensed players of Tekirdağ City. Participants were required to be regular players with a minimum of two years of consistent training and competition experience. The average sports experience was 2.1 years. All participants had provided written informed consent. PARQ and ACSM risk factor analysis was performed on the participants' families prior to the study and only participants who were not found to have any health risks were included in the study. The participants in the study were divided into 3 groups according to their peak height (PHV) with the Mirwald equation determining their biological maturation levels. The mean age, height and body mass of the participants were 11.22±0.42 years, 163.56±9.30 cm, 54.37±10.05 kg for the PHV1 group, 11.46±0.55 years, 152.45±5.22 cm, 41.32±4.84 kg for the PHV2 group, 11.10±0.31 years, 148.60±4.42 cm, 39.21±4.59 kg for the PHV3 group. Height, body weight, strength, flexibility and sprint test measurements of the participants were taken. For the standardization of the measurements, the measurements of both groups were performed on the same ground. To ensure familiarization with the tests, the test procedures were introduced before participants were made to apply them.
In this study, the Mirwald Equation (MD), known as the Mirwald Method (Mirwald formula), a mathematical model used to predict maturity balance in children and adolescents, was used. The Mirwald equation estimates the maturity balance by measuring the difference between chronological age and skeletal age based on a quadratic formula.

\[
MD \text{ (Male)} = -9.236 + 0.0002708 \times (\text{leg length} \times \text{sitting height}) - 0.001663 \times (\text{age} \times \text{leg length}) + 0.007216 \times (\text{age} \times \text{sitting height}) + 0.02292 \times \left(\frac{\text{Body weight}}{\text{height}}\right)
\]

R = 0.94, R² = 0.891 (Mirwald et al., 2002)

2.3 Data Collection Tools

2.3.1 Hand Grip Strength Test

TKK 5401 Digital Hand Dynamometer was used. The participants were asked to squeeze the dynamometer with their dominant hand while standing, without any support from anywhere. Two measurements were repeated, and the best degree was recorded.

2.3.2 Back Leg Strength Test

TKK 5402 Digital Back Leg Dynamometer was used for the measurement. The participant stands on the dynamometer stand with knees bent. With the torso slightly tilted forward and the arms stretched, and the knees bent, the participant pulls the dynamometer bar grasped with his/her hands up vertically at the maximum rate using his/her legs (Tekin et al., 2018).

2.3.3 Standing Long Jump Test

A forward leap was made with both feet. The distance between the heel and the starting point was recorded at the point of fall and the best of the two trials was taken (Bozdoğan & Kızılet, 2017).

2.3.4 Speed Tests

20-meter sprint measurements were performed. Before all measurements, a 10-min warm-up protocol including repeated short sprints was applied to the participants. Participants
were given full rest in each measurement. Participants were asked to perform each test 2 times and the best grade was recorded.

2.3.5 **Sit and Reach Flexibility Test**

The participant was asked to take a position with one foot resting on the measuring table, the sole of the other foot on the floor and the leg bent at the knee. The participant was asked to stretch forward in a slow and controlled manner by placing his/her hands on top of each other. The participant was asked to stretch twice, and the best degree was recorded.

2.3.6 **Trunk (Trunk Lift) Test**

Trunk (trunk lift) flexibility test was performed to evaluate trunk extensor strength and flexibility. The measurement was performed with 2 repetitions by measuring the height in cm from the shoulder biacromion end point and the highest value was recorded as a score in cm.

2.3.7 **Yo-Yo Intermittent Recovery Level 1 Child Test (YYIR1C)**

The test was reduced from the original $2 \times 20 \text{ m} (2 \times 5 \text{ m})$ to $2 \times 16 \text{ m} (2 \times 4 \text{ m})$ to make it more suitable for longer endurance of young athletes (Ahler et al., 2012; Bendiksen et al. 2013). This test version uses the same audio recording as the Yo-Yo Intermittent Recovery Test Level 1 test. The test taker must cover a distance of 16 m in the audio recording until the start and return signals. He/she performs a rest run within a 4 m area until the start of the second cyan. The test consists of gradually increasing running speeds and continues until the participant is exhausted or receives 2 warnings.

2.4 **Data Analysis**

In the study, descriptive statistical analysis was performed and arithmetic averages, standard deviations, maximum and minimum values for the measurement results of each variable were calculated separately and normality distribution (Shapiro-Wilk) evaluations were made. Anova analyze was used to test whether there was a significant difference between the averages of the independent groups and the significance level was taken as $p<0.05$. 

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Revista Gestão e Secretariado (GeSec), São Paulo, SP, v. 14, n. 10, 2023, p. 19139-19149.
Results

<table>
<thead>
<tr>
<th>Variable</th>
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<th>n</th>
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<th>±</th>
<th>Sum of</th>
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<td>±</td>
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<tr>
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<td>±</td>
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<td>±</td>
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<tr>
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<td>PHV 2</td>
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<td>±</td>
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<td>±</td>
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<td>±</td>
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<td>PHV 3</td>
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<td>39.21</td>
<td>±</td>
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</table>

Table 1: Descriptive statistics of the participants
Source: Author

Descriptive statistics of the participants were given for three groups in Table 1. According to the descriptive statistics data presented in Table 1, age, height and body mass means of the participants were for PHV1 group; 11.22±0.42 years, 163.56±9.30 cm., 54.37±10.05 kg., for PHV2 group; 11.46±0.55 years, 152.45±5.22 cm., 41.32±4.84 kg., for PHV3 group; 11.10±0.31 years, 148.60±4.42 cm., 39.21±4.59 kg.

<table>
<thead>
<tr>
<th>Variable</th>
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<th>±</th>
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<td>±</td>
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<tr>
<td>(PHV) (cm)</td>
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<td>±</td>
<td>0.0937</td>
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<td></td>
<td>PHV 3</td>
<td>10</td>
<td>-2.7200</td>
<td>±</td>
<td>0.1943</td>
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</table>

Table 2: Peak Height Velocity (PHV) data of the participants
Source: Author

The test scores of Peak Height Velocity (PHV) data of the three groups are given in Table 2. According to Table 2, the test scores of the groups were determined as follows: PHV1 group; -1.6882±0.3148 cm, PHV2 group; -2.3160±0.0937 cm, PHV3 group; -2.7200±0.1943 cm.
An Evaluation of Biomotor Characteristics According to Biological Maturation Level in 11-12 Age Soccer Players

PHV 1  8 29.87  5.11  22  39
PHV 2  10 27.20  ±  2.00  24  30
PHV 3  10 26.90  ±  2.28  24  31

PHV 1  8 3.71  0.25  3.33  4.01
PHV 2  10 3.63  ±  0.21  3.35  3.98
PHV 3  10 3.66  ±  0.10  3.53  3.87

PHV 1  8 920  296  544  1504
PHV 2  10 1088  ±  360  384  1504
PHV 3  10 995  ±  332  384  1472

### Table 3: Biomotor data of the participants
Source: Author

The test scores of biomotor data of the three groups are given in Table 3. According to the evaluations made; PHV 2 group participants had the best trunk strength values with 20.60 ± 9.57 and 18.10 ± 12.03 repetitions in Sit-up and Push-up tests, respectively. In the hand grip strength test, PHV 2 and PHV 3 groups had similar scores with 19.58 ± 3.32 kg and 19.61 ± 4.39 kg, respectively, while PHV 1 group participants had a better score compared to the other groups with 26.30 ± 5.89 kg. PHV 1, PHV 2 and PHV 3 groups had similar scores with 146.62 ± 17.84 cm, 146.10 ± 11.31 cm and 145.70 ± 16.05 cm, respectively.

According to the evaluations made to determine the back-hip muscles and upper body flexibility levels of the participants; PHV 2 and PHV 3 group participants had scores of 11.20 ± 6.39 cm and 11 ± 5.65 cm, respectively, while PHV 1 participants had a lower back-hip muscles flexibility of 5.87 ± 2.03 compared to the two groups. In the trunk flexibility assessment, PHV 1, PHV 2 and PHV 3 groups had similar scores of 29.87 ± 5.11 cm, 27.20 ± 2.20 cm and 26.90 ± 2.28 cm, respectively.

<table>
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<th>Source of Variance</th>
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<th>df</th>
<th>Mean Square</th>
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<tbody>
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<td>Sit-up (rep)</td>
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<td>8</td>
<td>Between groups</td>
<td>115.682</td>
<td>2</td>
<td>57.841</td>
<td>0.764</td>
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<td></td>
<td>PHV 2</td>
<td>10</td>
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<td>1892.175</td>
<td>25</td>
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<td></td>
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<td>Total</td>
<td>2007.857</td>
<td>27</td>
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<td>Push-up (rep)</td>
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<td>8</td>
<td>Between groups</td>
<td>140.539</td>
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<td></td>
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<td></td>
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<tr>
<td>Hand Grip Strength (kg)</td>
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<td>Between groups</td>
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<td>128.451</td>
<td>6.211</td>
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<td></td>
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<td></td>
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<td>Forward jump (cm)</td>
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<td>Sit and Reach Test (cm)</td>
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<td>2.106</td>
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<td></td>
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<td>96133.3</td>
<td>2</td>
<td>48066.667</td>
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As a result of the analysis of variance performed to determine the difference between the mean biomotor characteristics scores of the participants at different peak height velocities (PHV), a statistically significant difference was found in the hand grip test values ($F_{0.05; 2-25} = 6.211, p<0.05$). As a result of the Tukey multiple comparison test performed to determine which groups the difference originated from, it was determined that the difference originated from PHV1 group ($X=256.902$) and PHV2 group ($X=517.065$), PHV1 and PHV3 group ($X=773.967$) and PHV2 and PHV3 groups. According to these results, as the peak height velocity increases, the hand grip scores increase significantly.

**Discussion & Conclusion**

There was no significant difference between the groups in parameters such as trunk strength, paw strength, explosive strength, speed and cardiorespiratory endurance between the peak height growth rate periods. It is defined that the highest rate of development in biomotor parameters in adolescents who enter the PHV period early is observed due to the increase in physical development (Philippaerts et al., 2006). The effect of the peak height growth rate period is observed in the changes that occur in the longitudinal process (Philippaerts et al., 2006). In adolescent males, maximum strength and power gains are defined to occur closer to the peak height growth rate and maximum weight gain rate (Malina et al., 2004). In our measurements on the biomotor characteristics of adolescent soccer players, it was observed that the participant group in the PHV period had 34.1% and 34.3% better values in peak height growth rate compared to the distance level. However, such a percentage value difference was not observed on other measurement parameters. It is likely that there is an increase in muscle mass (Malina et al., 2004) shortly after the peak height growth rate in adolescence. We can define the main reason for the lack of change in other parameters except hand grip strength in the PHV 1 group as the fact that both groups were far from this period of increase.

Strength gains overlap with the period of peak height growth rate (Philippaerts et al., 2006). In trunk strength assessments such as push-ups and sit-ups, it was observed that the group that was farther away from the peak height growth period had better scores than the...
group that was closer to the peak height growth period. Although there are evaluations that proximity to the peak height growth period has a higher effect on strength development, according to these data, the possibility of an increase in trunk strength in male adolescent soccer players at an earlier period should be evaluated. In different longitudinally designed studies on adolescent soccer players, it has been evaluated that there are variations on trunk strength with the period of peak height growth rate (Beunen et al., 1988, Yague ve De LaFuente, 1998). It is thought that earlier developments in trunk strength may enable the design of functional strength exercises that will not have a negative effect on the range of motion (ROM) that can provide an effect on trunk strength in the early stages of peak height growth rate (Lepley & Butterfield, 2007). It should not be ignored that the improvements in trunk strength may be related to the training status of the participants.

At the end of the peak height growth rate, strength and power parameters increase with the increase in muscle development (Malina et al., 2004, Philippaerts et al., 2006). With this increase in strength and power, a positive increase in biomotor parameters is likely to be observed. It is thought that the participants included in our study have just entered or are entering the period of peak height growth rate, so it is thought that there is no significant difference in biomotor parameters. It is thought that continuing the longitudinal evaluation of the participants included in the study and following the changes in biomotor parameters will help us to have more descriptive evaluations.

References


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