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# Investigation of Functional Movement Assessment Scores of Athletes in Different Branches According to Their Biological Maturation Status

Döndü UĞURLU[1 A-E], Hakan Yapıcı[1 A-E], Mehmet Gülü[1 A-E]
[1] *Faculty of Sport Sciences, Kirikkale University, Kirikkale, Turkey,*

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**ABSTRACT**

This study investigates the effect of athletes' biological maturation levels on their Functional Movement Screen (FMS) scores. FMS tests were administered to 243 male athletes from different sports branches in Kırıkkale, Türkiye, based on their maturity status. Data collection included age, height, sitting height, body weight, BMI, and FMS test scores. FMS tests were scored on a scale from 0 to 3. Statistical analyses were performed using IBM SPSS 28.0. According to the findings, early-maturing athletes had significantly higher values in height (161.4±7.2 cm), sitting height (82.6±4.1 cm), body weight (56.7±12.1 kg), and body mass index (21.6±2.4 kg/m²) compared to on-time (155.9±8.7 cm; 77.6±3.9 cm; 48.2±9.1 kg; 19.7±3.1 kg/m²) and late-maturing athletes (150.5±6.3 cm; 75.1±3.2 cm; 46.2±10.1 kg; 20.0±2.4 kg/m²) ($p<0.001$). In terms of total FMS scores, early- and on-time-maturing athletes demonstrated significantly better performance than late-maturing athletes ($p < 0.05$). In conclusion, early-maturing athletes obtained higher FMS scores. Early biological maturation is associated with better muscular control, advanced motor skills, and reduced risk of injury. The study reveals that the biological maturation level directly affects athletes' movement quality and performance. This study emphasizes the importance of customizing training programs based on biological maturation levels in terms of athlete health and performance.

**Keywords:** Young athletes, biological maturation, functional movement assessment (FMS)

## Farklı Branşlarda Yer Alan Sporcuların Biyolojik Olgunlaşma Durumlarına Göre Fonksiyonel Hareket Değerlendirme Skorlarının İncelenmesi

**ÖZET**

Bu çalışma, sporcuların biyolojik olgunlaşma düzeylerinin fonksiyonel hareket değerlendirme (FMS) skorları üzerindeki etkisini araştırmaktadır. Kırıkkale ilinde farklı spor branşlarında yer alan 243 erkek sporcuya biyolojik olgunlaşma düzeylerine göre FMS testleri uygulanmıştır. Verilerin toplanmasında yaş, boy uzunluğu, oturma yüksekliği, vücut ağırlığı, BMI ve FMS testine ait veriler kullanılmıştır. FMS testlerinde 0-3 arasında puanlama yapılmıştır. İstatistiksel veriler IBM SPSS 28.0'de analiz edilmiştir. Elde edilen bulgulara göre; erken olgunlaşan sporcuların boy uzunluğu (161.4±7.2 cm), oturma yüksekliği (82.6±4.1 cm), vücut ağırlığı (56.7±12.1 kg) ve vücut kitle indeksi (21.6±2.4 kg/m²) değerleri; zamanında (boy: 155.9±8.7 cm, oturma yüksekliği: 77.6±3.9 cm, ağırlık: 48.2±9.1 kg, BMI: 19.7±3.1 kg/m²) ve geç olgunlaşan (boy: 150.5±6.3 cm, oturma yüksekliği: 75.1±3.2 cm, ağırlık: 46.2±10.1 kg, BMI: 20.0±2.4 kg/m²) sporculara kıyasla anlamlı düzeyde daha yüksektir ($p<0.001$). FMS toplam skorlarına göre ise erken ve zamanında olgunlaşan sporcuların, geç olgunlaşanlara kıyasla daha yüksek performans sergilediği tespit edilmiştir ($p<0.05$). Sonuç olarak, erken olgunlaşan sporcuların daha yüksek FMS skorları elde ettiği görülmüştür. Erken biyolojik olgunlaşma, daha iyi kas kontrolü, gelişmiş motor beceriler ve düşük sakatlanma riskiyle ilişkilidir. Araştırma, biyolojik gelişim düzeyinin sporcuların hareket kalitesini ve performansını doğrudan etkilediğini ortaya koymaktadır. Bu çalışma, biyolojik olgunlaşma düzeyine göre antrenman programlarının özelleştirilmesinin sporcu sağlığı ve performansı açısından önemli olduğunu vurgulamaktadır.

**Anahtar Kelimeler:** Genç sporcular, biyolojik olgunlaşma, fonksiyonel hareket değerlendirme (FMS)

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## Introduction

Among the many factors affecting sports performance, the developmental characteristics and movement quality of the individual stand out as the main elements that directly affect the overall performance of athletes (Chang et al., 2020; Ericsson & Harwell, 2019). Especially for growth and developmental athletes, various parameters such as biological maturation level, physical fitness, motor skills, and injury risk play a decisive role in the success of training processes and athlete health (Yapıcı et al., 2022; Kaya et al., 2024). Therefore, evaluating athletes not only according to their chronological age but also according to their biological developmental processes enables individualization of training loads and performance expectations in a healthier and more efficient way (Sweeney et al., 2023; Arede et al., 2022).

Biological maturation is a multidimensional process that represents the physical development process of an individual and takes place in interaction with genetic, hormonal, and environmental factors (Dorn et al., 2019; Worthman et al., 2019). Biological developmental differences between athletes in the same age group can create significant variability in many areas, such as training adaptations, physical performance levels, injury tendencies, and psychological resilience (Steidl-Müller et al., 2020; Wik, 2022). This is an important factor that should be taken into account in choosing a sport branch, organizing training load and developing strategies suitable for developmental needs, especially in individuals participating in sports at a developmentally critical stage such as adolescence (Gryko, 2021; Marzouki et al., 2023).

Functional movement quality is an evaluation process that reveals how effectively, efficiently, and balanced the athlete can perform basic movement skills (Zemková & Zapletalová, 2022; Stapleton et al., 2021). The Functional Movement Screen (FMS) stands out as a valid and reliable method used to measure movement quality and analyze the developmental level of the athlete. FMS is a widely used tool to detect inadequacies and asymmetries in movement patterns, to identify potential injury risks in advance, and to obtain more comprehensive information about the athlete's health status (Asgari et al., 2021; Moore et al., 2019). In addition to providing important information about the athlete's movement efficiency, this assessment also provides indirect indicators of the level of biological maturation (Davis et al., 2020; Sawczyn, 2020). However, there is a limited number of studies directly examining the relationship between Functional Movement Screen (FMS) scores and biological maturation levels in adolescent athletes. This study aims to fill this gap by providing comparative data across different sports disciplines, thereby offering an original contribution to the literature.

In this context, examining the biological maturation levels and functional movement quality of young athletes in different sports branches is of great importance in terms of both supporting performance development and minimizing injury risks. The correlation between biological maturation and movement quality offers crucial guidance for athletes' healthy development processes, thereby lowering their injury risk. In this study, it is aimed to compare the functional movement assessment (FMS) scores of young athletes from different branches according to their biological maturation levels. In this way, it is aimed that training programs can be structured on a more scientific basis and athlete development can be monitored in a healthier way. Accordingly, the main research question of this study is: “Is there a significant difference between the biological maturation levels and functional movement scores of young athletes?” The hypothesis of the study is

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stated as follows: "There are significant differences in the functional movement scores of young athletes with different levels of biological maturation."

## Method

### Research Group

This study included a total of 243 male athletes with a mean age of 11.93 years who were engaged in various sports branches in Kırıkkale province.The distribution of the participants according to their branches [volleyball: n = 64, basketball: n = 73, football: n = 106] is as follows. The parents of the athletes were given detailed information about the study and their written informed consent was obtained. All participants and their parents were informed about the measurement protocol and the purpose of the study. No participant was excluded during the study. All of the participants regularly train at least 2 hours a week in their own branches. In addition, all participants are licensed athletes competing at the school team or local club level, and regularly participate in amateur competitions appropriate for their age group, which ensures a relatively homogeneous sample in terms of training exposure and competitive experience. The study was conducted at Kırıkkale University Faculty of Sport Sciences in accordance with the principles of the Declaration of Helsinki. Ethics committee approval was granted by Kırıkkale University Non-Interventional Research Ethics Committee (Date: January 12, 2022, Decision No: 2021-12-14).

### Data Collection

During the research process, each participant was visited in the laboratory before the tests were applied. During the first laboratory visit, participants were informed about the purpose of the study and the tests to be applied. In the second laboratory visit, the necessary tests were applied by experts. After this process, the biological maturation status of the athletes was calculated.

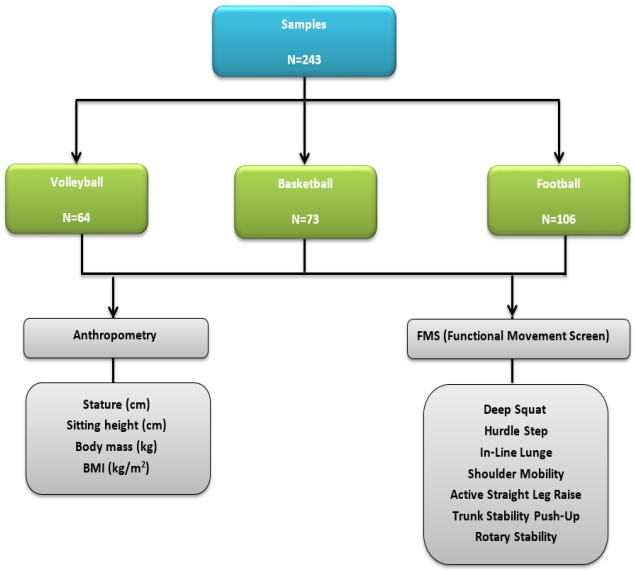


**Figure 1.** Flowchart showing the distribution of participants (N=243) by sports branch (Volleyball, Basketball, and Football) and the assessment methods used**.**

### Implementation Process of the Tests

The tests were performed in Kırıkkale University, Faculty of Sports Sciences, Exercise Physiology Laboratory and indoor gymnasium on one day for each branch group. In the first session, anthropometric measurements were taken before breakfast. Then, a 15-minute standard warm-up protocol consisting of 5 minutes of low-paced jogging, 2 minutes of free stretching and 8 minutes of upper and lower extremity movements was performed. In the FMS test scoring, the athlete is given 3 points if the movement is performed painlessly and flawlessly. If the movement was performed painlessly with some correction or support, 2 points were given, and if the movement could not be performed despite the support, 1 point was given. If pain or soreness

was felt during the movement, the athlete was given 0 points and referred to further evaluation methods. In the FMS test, each movement was performed 3 times and the best score was recorded. Participants were asked to wear shorts and t-shirts on the test day and to avoid intense physical activity 24 hours before the test. All measurements were performed by the same expert team in accordance with standardized procedures. The following tests were performed with maximum effort: height, sitting height, body weight and FMS tests were completed indoors.

### *Measurements*

### *Anthropometric Measurements*

Height and sitting height were measured with a portable measuring device (Seca 213, Germany) with an accuracy of 0.1 cm. Body weight was determined by Tanita BC-418 (Japan). Biological maturity level was assessed based on the %PAS value according to predicted adult height (PAS) and classified as early ($z > 0.5$), timely ($z \pm 0.5$) and late ($z < 0.5$) maturation according to z-scores.

### *Sitting Height Measurement*

Participants were seated on a straight chair; standardized position was ensured by adjustable leg height. After deep breathing, sitting height was measured with a Holtain stadiometer with a precision of 0.1 mm. Peak height velocity was estimated using the following formula: $-9.236 + 0.0002708$ (Leg length × Sitting height) $- 0.001663$ (Age × Leg length) $+ 0.007216$ (Age × Sitting height) $+ 0.02292$ (Body weight / Height × 100)

### *Somatic Maturity*

The PAS value was calculated using the Khamis-Roche method based on age, height and parental height. Parental height data were obtained via self-reported information from parents during the pre-assessment phase. Although the Khamis-Roche method is widely used due to its non-invasive nature and ease of application in field settings, it may have limitations related to the accuracy of self-reported data and its applicability across different populations. The maturity level was evaluated based on %PAS and grouped according to the sample median.

### *FMS (Functional Movement Analysis)*

FMS consists of seven basic tests that evaluate the movement abilities of athletes. Each test measures body stabilization, range of motion, balance, strength, flexibility, and neuromuscular coordination.

***Deep Squat:*** Lower body mobility and core stabilization were assessed taking into account the sitting height and somatotype of the participants.

***Hurdle Step:*** Hip, knee and ankle mobility and single leg balance control were tested according to the somatic maturity level of the participants.

***In-Line Lunge:*** Changing direction, balance and flexibility abilities were tested according to sitting height and somatic structure.

***Shoulder Mobility:*** Shoulder flexibility and range of motion were assessed according to the somatotype and sitting position of the participants.

***Active Straight Leg Raise:*** Hip flexion, hamstring flexibility and core stability were observed according to somatic development and sitting height.

***Trunk Stability Push-Up:*** Core stabilization was tested according to the physical structure and somatic maturity of the participants.

***Rotary Stability:*** Upper and lower body integration, stabilization and mobilization coordination were assessed depending on sitting height and somatotype.

The FMS quickly and effectively assessed factors such as asymmetry, body stabilization, flexibility, and strength by scoring for each movement (Cook et al., 2003; Hall, 2014).

***Data Analysis***

Based on the initially provided table data, the normality of the variables was assessed using the Kolmogorov-Smirnov test. Parametric tests were applied for variables showing a normal distribution. Descriptive statistics are presented as mean ± standard deviation. One-Way Analysis of Variance (ANOVA) was used for comparisons between groups, and Tukey HSD post-hoc test was conducted for variables with significant differences. The relationships between variables were examined using Pearson correlation analysis. The level of significance was set at $p < 0.01$. All statistical analyses were performed using IBM SPSS version 28.0 (New York, USA).

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## Results

**Table 1.** Descriptive Statistics of Chronological Age and Anthropometric Profiles of Athletes in Different Branches (Minimum, Maximum, Mean Values)

| Variables | Volleyball (n = 64) | | | Football (n = 106) | | | Basketball (n = 73) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Min | Max | Mean | Min | Max | Mean | Min | Max | Mean |
| Chronological age (years) | 11,30 | 12,45 | 11,85 | 11,40 | 12,60 | 12,00 | 11,35 | 12,50 | 11,92 |
| Percentage of PAS (%) | 70,20 | 90,80 | 80,75 | 68,50 | 82,70 | 82,90 | 71,50 | 91,20 | 81,40 |
| Stature (cm) | 120,00 | 170,00 | 152,40 | 125,00 | 157,00 | 157,20 | 122,00 | 176,00 | 154,37 |
| Sitting height (cm) | 65,50 | 87,30 | 75,70 | 66,00 | 75,20 | 74,90 | 65,80 | 87,50 | 76,10 |
| Body mass (kg) | 39,00 | 85,00 | 48,50 | 37,00 | 50,10 | 50,60 | 29,50 | 87,00 | 48,90 |
| BMI (kg/m$^2$) | 13,50 | 34,20 | 19,95 | 14,10 | 20,33 | 20,33 | 13,80 | 33,70 | 20,10 |

%PAS: Represents the percentage of predicted adult stature attained, calculated as the ratio of current height to predicted adult stature based on the Khamis-Roche method.

In Table 1, descriptive statistics of chronological age and anthropometric characteristics of athletes in different sports branches are presented. The minimum, maximum and mean values of age, height, sitting height, body weight, body mass index (BMI), body mass index (BMI) and percent predicted adult height (PAS) of the athletes in volleyball, football and basketball are presented comparatively.

**Table 2.** Comparison of Chronological Age and Anthropometric Characteristics According to Maturity Status of Athletes

| Dependent variables | Maturity groups (n=243) | | | ANOVA | | |
|---|---|---|---|---|---|---|
| | Early (n = 65) | On-time (n = 145) | Late (n = 33) | F | p-value | Post-hoc comparisons |
| Chronological age (y) | 12.1±0.5 | 11.7±0.4 | 11.9±0.7 | 9.441 | 0.614 | - |
| **Anthropometry** | | | | | | |
| Stature (cm) | 161.4±7.2 | 155.9±8.7 | 150.5±6.3 | 30.126 | 0.001* | Early > On-time > Late |
| Sitting height (cm) | 82.6±4.1 | 77.6±3.9 | 75.1±3.2 | 70.128 | 0.001* | Early > On-time > Late |
| Body mass (kg) | 56.7±12.1 | 48.2±9.1 | 46.2±10.1 | 46.820 | 0.001* | Early > On-time > Late |
| BMI (kg/m$^2$) | 21.6±2.4 | 19.7±3.1 | 20.0±2.4 | 23.375 | 0.001* | Early > On-time & Late |

BMI; Body mass index, *p<0.001

Table 2 presents the results of ANOVA comparing the chronological age and anthropometric characteristics of athletes in different maturity states. In terms of the chronological age variable, no significant differences were found between the groups, but significant differences were observed in terms of anthropometric measures such as height, sitting height, body weight and body mass index. It was determined that the athletes in the early maturing group had higher height, sitting height, body weight, and body mass index compared to the other two groups ($p < 0.001$).

**Table 3.** ANOVA Test Comparisons of Anthropometric Data of Maturity Status of Athletes According

to Their Branches

| Dependent variables | Maturity groups (n=243) | | | | | |
|---|---|---|---|---|---|---|
| **Volleyball** | **Early ( n=18)** | **On-time ( n=35)** | **Late (n= 11)** | **F** | **p-value** | **Post-hoc comparisons** |
| Stature (cm) | 162.3 ± 6.8 | 156.2 ± 7.9 | 151.7 ± 6.5 | 28.512 | 0.001* | Early > On-time > Late |
| Sitting height (cm) | 83.1 ± 4.3 | 78.0 ± 4.0 | 75.5 ± 3.4 | 66.247 | 0.001* | Early > On-time > Late |
| Body mass (kg) | 58.2 ± 11.3 | 49.1 ± 8.6 | 45.9 ± 9.4 | 42.735 | 0.001* | Early > On-time > Late |
| BMI (kg/m$^2$) | 22.1 ± 2.5 | 19.9 ± 2.9 | 20.2 ± 2.1 | 21.618 | 0.001* | Early > On-time & Late |
| **Football** | **Early (n=23)** | **On time (n=71)** | **Late (n=12)** | **F** | **p-value** | **Post-hoc comparisons** |
| Stature (cm) | 160.7 ± 7.5 | 154.8 ± 8.4 | 150.2 ± 6.1 | 27.934 | 0.001* | Early > On-time > Late |
| Sitting height (cm) | 82.2 ± 4.0 | 77.3 ± 3.8 | 74.9 ± 3.3 | 64.510 | 0.001* | Early > On-time > Late |
| Body mass (kg) | 57.3 ± 11.5 | 47.8 ± 8.9 | 46.0 ± 10.3 | 44.221 | 0.001* | Early > On-time > Late |
| BMI (kg/m$^2$) | 21.4 ± 2.3 | 19.5 ± 3.0 | 19.8 ± 2.6 | 22.754 | 0.001* | Early > On-time & Late |
| **Basketball** | **Early (n=24)** | **On-time (n=39)** | **Late (n=10)** | **F** | **p-value** | **Post-hoc comparisons** |
| Stature (cm) | 163.1 ± 6.9 | 157.4 ± 8.2 | 151.3 ± 6.7 | 29.410 | 0.001* | Early > On-time > Late |
| Sitting height (cm) | 83.4 ± 4.2 | 78.5 ± 4.1 | 75.2 ± 3.5 | 68.923 | 0.001* | Early > On-time > Late |
| Body mass (kg) | 59.0 ± 12.2 | 49.6 ± 9.4 | 47.0 ± 9.8 | 45.607 | 0.001* | Early > On-time > Late |
| BMI (kg/m$^2$) | 22.3 ± 2.6 | 20.1 ± 3.2 | 20.5 ± 2.3 | 24.103 | 0.001* | Early > On-time & Late |

BMI; Body mass index, *p<0.001

Table 3 presents the comparison of the anthropometric characteristics of the maturity status of the athletes according to their branches by ANOVA test. The variables such as height, sitting height, body weight and body mass index of the athletes in volleyball, football and basketball were analyzed. Significant differences were found in height, sitting height, body weight and BMI values between maturity groups in all three branches ($p < 0.001$). Early maturing athletes had higher height, sitting height, body weight, and BMI values than the other groups in each branch. In particular, early maturing athletes were found to be significantly superior to on-time and late maturing groups in these measures.

**Table 4.** Descriptive Statistics (Mean ± Standard Deviation) of FMS (Functional Movement Screening) Scores of Athletes in Different Branches

| Variables | Volleyball (n =64) | Football (n =106) | Basketball (n =73) |
|---|---|---|---|
| Deep Squat | 2,60 ± 0,60 | 2,30 ± 0,70 | 2,70 ± 0,50 |
| Hurdle Step | 2,30 ± 0,60 | 2,60 ± 0,50 | 2,50 ± 0,60 |
| İn Line Lunge | 2,90 ± 0,35 | 2,15 ± 0,75 | 2,80 ± 0,40 |
| Shoulder Mobility | 2,20 ± 0,70 | 2,10 ± 0,80 | 2,40 ± 0,70 |
| Active Straight Leg Raise | 2,40 ± 0,85 | 2,55 ± 0,65 | 2,70 ± 0,60 |
| Trunk Stationary Push-Up | 2,80 ± 0,45 | 2,40 ± 0,90 | 2,90 ± 0,30 |
| Rotary Stability | 2,40 ± 0,80 | 2,10 ± 0,50 | 2,30 ± 0,50 |
| FMS Total | 17,60 ± 2,00 | 16,40 ± 2,50 | 17,70 ± 1,80 |

In Table 4, descriptive statistics of the Functional Movement Screening (FMS) scores of athletes in different branches are presented. The mean and standard deviation values for the seven basic movement abilities of volleyball, football and basketball athletes were compared. FMS total scores showed that

basketball players had the highest mean score of 17.70 ± 1.80 points, while football players had the lowest mean score of 16.40 ± 2.50 points. In each movement test, although significant differences were observed between the branches, the highest averages were obtained by basketball players in the fixed trunk push-up and volleyball players in the single line lunge tests.

**Table 5.** ANOVA Test Results and Post-Hoc Comparisons of FMS Scores According to Maturity Status of Athletes

| Dependent variables | Maturity groups (n=243) | | | ANOVA | | |
|---|---|---|---|---|---|---|
| | Early (n = 65) | On-time (n = 145) | Late (n = 33) | F | p-value | Post-hoc comparisons |
| Deep Squat | 2.61 ± 0.70 | 2.47 ± 0.65 | 2.32 ± 0.68 | 30.271 | 0.001* | Early > On-time > Late |
| Hurdle Step | 2.51 ± 0.60 | 2.48 ± 0.71 | 2.12 ± 0.65 | 70.252 | 0.001* | Early & On-time > Late |
| İn Line Lunge | 2.85 ± 0.36 | 2.83 ± 0.40 | 2.56 ± 0.42 | 45.170 | 0.001* | Early & On-time > Late |
| Shoulder Mobility | 2.47 ± 0.54 | 2.42 ± 0.67 | 2.11 ± 0.72 | 22.386 | 0.001* | Early &On-time > Late |
| Active Straight Leg Raise | 2.25 ± 0.77 | 2.11 ± 0.61 | 2.09 ± 0.83 | 12.815 | 0.001* | Early > On-time & Late |
| Trunk Stationary Push-Up | 2.89 ± 0.50 | 2.72 ± 0.31 | 2.59 ± 0.52 | 14.690 | 0.001* | Early > On-time > Late |
| Rotary Stability | 2.21 ± 0.75 | 2.19 ± 0.60 | 2.05 ± 0.90 | 8.118 | 0.001* | Early & On-time > Late |
| FMS Total | 17.70 ± 2.01 | 17.18 ± 1.25 | 16.54 ± 1.75 | 51.134 | 0.001* | Early & On-time > Late |

*p<0.001

Table 5 presents the descriptive statistics and the results of the ANOVA test for the Functional Movement Screening (FMS) scores of athletes in different sports according to their maturity. Early maturing athletes generally had the highest scores in each FMS test, showing a significant superiority compared to late maturing athletes ($p < 0.001$). In tests such as the deep squat, single line lunge, shoulder mobility, active straight leg raise, and stationary trunk push-up, the early and timely maturing groups achieved higher averages than the late maturing group. According to the FMS total scores, it was found that early and timely maturing athletes showed significantly higher performance than late maturing athletes.

**Table 6.** Descriptive Statistics and ANOVA Test Results of FMS Scores Related to Maturity Status of Athletes According to Their Branches

| Dependent variables | Maturity groups (n=243) | | | F | p | Post-hoc comparisons |
|---|---|---|---|---|---|---|
| **Volleyball** | **Early ( 18)** | **On-time( 35)** | **Late( 11)** | | | |
| Deep Squat | 2.58 ± 0.66 | 2.45 ± 0.61 | 2.28 ± 0.63 | 26.872 | 0.001* | Early > On-time > Late |
| Hurdle Step | 2.47 ± 0.58 | 2.42 ± 0.64 | 2.15 ± 0.60 | 62.103 | 0.001* | Early & On-time > Late |
| İn Line Lunge | 2.83 ± 0.34 | 2.79 ± 0.37 | 2.54 ± 0.39 | 38.791 | 0.001* | Early & On-time > Late |
| Shoulder Mobility | 2.40 ± 0.50 | 2.35 ± 0.60 | 2.08 ± 0.66 | 20.143 | 0.001* | Early & On-time > Late |
| Active Straight Leg Raise | 2.22 ± 0.74 | 2.09 ± 0.59 | 2.01 ± 0.77 | 11.502 | 0.001* | Early > On-time & Late |
| Trunk Stationary Push-Up | 2.85 ± 0.47 | 2.70 ± 0.33 | 2.52 ± 0.49 | 13.560 | 0.001* | Early > On-time > Late |
| Rotary Stability | 2.17 ± 0.72 | 2.15 ± 0.58 | 2.01 ± 0.82 | 7.801 | 0.001* | Early & On-time > Late |
| FMS Total | 17.42 ± 1.94 | 16.95 ± 1.32 | 16.31 ± 1.62 | 47.521 | 0.001* | Early & On-time > Late |
| **Football** | **Early (23)** | **On time (71)** | **Late (12)** | | | |
| Deep Squat | 2.56 ± 0.68 | 2.43 ± 0.63 | 2.30 ± 0.61 | 25.120 | 0.001* | Early > On-time > Late |
| Hurdle Step | 2.46 ± 0.59 | 2.39 ± 0.68 | 2.13 ± 0.63 | 60.873 | 0.001* | Early & On-time > Late |
| İn Line Lunge | 2.80 ± 0.35 | 2.76 ± 0.38 | 2.51 ± 0.41 | 37.002 | 0.001* | Early & On-time > Late |
| Shoulder Mobility | 2.39 ± 0.52 | 2.33 ± 0.62 | 2.09 ± 0.64 | 19.427 | 0.001* | Early & On-time > Late |
| Active Straight Leg Raise | 2.19 ± 0.70 | 2.08 ± 0.60 | 2.02 ± 0.78 | 10.742 | 0.001* | Early > On-time & Late |
| Trunk Stationary Push-Up | 2.81 ± 0.46 | 2.69 ± 0.34 | 2.53 ± 0.51 | 12.341 | 0.001* | Early > On-time > Late |
| Rotary Stability | 2.14 ± 0.70 | 2.13 ± 0.59 | 2.00 ± 0.85 | 7.204 | 0.001* | Early & On-time > Late |
| FMS Total | 17.35 ± 1.88 | 16.88 ± 1.28 | 16.22 ± 1.66 | 44.703 | 0.001* | Early & On-time > Late |
| **Basketball** | **Early ( 24)** | **On-time (39)** | **Late ( 10)** | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Deep Squat | 2.60 ± 0.69 | 2.46 ± 0.64 | 2.29 ± 0.66 | 27.041 | 0.001* | Early > On-time > Late |
| Hurdle Step | 2.50 ± 0.61 | 2.45 ± 0.70 | 2.16 ± 0.64 | 64.990 | 0.001* | Early & On-time > Late |
| İn Line Lunge | 2.84 ± 0.35 | 2.80 ± 0.39 | 2.53 ± 0.41 | 41.618 | 0.001* | Early & On-time > Late |
| Shoulder Mobility | 2.42 ± 0.53 | 2.37 ± 0.61 | 2.10 ± 0.70 | 21.509 | 0.001* | Early & On-time > Late |
| Active Straight Leg Raise | 2.23 ± 0.75 | 2.10 ± 0.60 | 2.04 ± 0.80 | 11.926 | 0.001* | Early > On-time & Late |
| Trunk Stationary Push-Up | 2.87 ± 0.48 | 2.71 ± 0.32 | 2.55 ± 0.50 | 13.842 | 0.001* | Early > On-time > Late |
| Rotary Stability | 2.20 ± 0.74 | 2.17 ± 0.59 | 2.03 ± 0.89 | 8.005 | 0.001* | Early & On-time > Late |
| FMS Total | 17.61 ± 1.97 | 17.10 ± 1.30 | 16.45 ± 1.70 | 49.183 | 0.001* | Early & On-time > Late |

*p<0.001

Table 6 presents the descriptive statistics of Functional Movement Screening (FMS) scores of athletes in different sports branches according to their maturity status and the results of the ANOVA test. The FMS total score of the athletes in volleyball, football, and basketball shows that the early- and timely-maturing groups are significantly higher than the late-maturing group. ($p< 0.001$). In tests such as deep squat, obstacle stepping, single-line lunge, shoulder mobility, active straight-leg raise, fixed-trunk push-up, and rotation stability, the early- and timely-maturing groups had significantly higher scores than the late-maturing group.

## Discussion and Conclusion

This study aims to examine the biological maturation levels and functional movement assessment (FMS) scores of young athletes in detail. According to their branches, the mean values of chronological age, height, body weight, body mass index (BMI), body mass index (BMI), and percent predicted adult height (PAS) variables were higher in football players, while the mean values of sitting height variables were higher in basketball players.

Analysis of the athletes' chronological age and anthropometric characteristics based on their maturity status revealed no significant difference between the groups in terms of chronological age; however, early-maturing athletes had higher scores in height, sitting height, body weight, and body mass index compared to timely- and late-maturing athletes. Gülü et al. (2023) also stated in their study that there is a relationship between early maturation and obesity, especially in girls; obesity triggers early maturation and may lead to health problems in the future. Söğüt et al. (2022) stated in their study that early-maturing athletes were taller and had a higher body weight. These consistent findings may stem from the fact that early-maturing individuals undergo hormonal changes, such as increased secretion of growth hormone and insulin-like growth factor 1 (IGF-1), earlier, which accelerates physical development and somatic growth compared to their peers.

Examination of the anthropometric characteristics of athletes according to their maturity status and sports branches indicated that early-maturing athletes in volleyball, football, and basketball had higher scores in height, sitting height, body weight, and body mass index compared to timely- and late-maturing athletes. In volleyball, football and basketball, it was seen that the early maturing athletes had higher scores than the late maturing athletes, and there was no statistical difference in the BMI scores of only the early and late maturing individuals. Almeida-Neto et al. (2021) reported that lean body mass was associated with bone age and peak height velocity in adolescent athletes. Yapıcı et al. (2022) also examined the relationship between the biological development levels of adolescents and muscle strength. When the body length scores of male students were examined, it was seen that the average body length of early and timely maturing adolescents was higher than the average body length of late maturing adolescents. Söğüt et al. (2022) stated in their study that sport-specific skills are not only related to early maturation, but also chronological age, experience, and regular training are effective in sports skill development. Albaladejo-Saura et al. (2022) reported that age and biological maturity have an effect on adolescent volleyball athletes. These findings suggest that maturity status significantly affects athletes' physical development and branch-specific anthropometric profiles. However, it is also important to consider alternative explanations such as differences in nutritional habits, training exposure, and socioeconomic background, which may independently affect anthropometric outcomes alongside biological maturation.

An analysis of the Functional Movement Screening (FMS) scores of athletes in different sports branches showed that

volleyball athletes had higher single-line lunge and rotation stability scores, football athletes had higher obstacle stepping scores, and basketball athletes had higher deep squat, shoulder mobility, active straight leg raise, fixed trunk push-up, and FMS total scores. In each movement test, although significant differences were observed between the branches, the highest averages were obtained by basketball players in the fixed trunk push-up and volleyball players in the single line lunge tests. These findings emphasize the effect of the movement skills required by sports branches on the FMS scores of athletes and that branch-specific physical profiles play an important role. Saç and Çolak (2019) stated in their study that anthropometric and physiological differences in young basketball players may be related to the level of biological maturation as well as regular training. Functional Movement Screening (FMS) scores have been associated with better neuromuscular control, enhanced motor skills, and reduced injury risk (Asgari et al., 2021; Yapıcı et al., 2022). This relationship is supported by evidence showing that FMS reflects the efficiency of neuromuscular coordination, proprioception, and muscle activation patterns (Zemková & Zapletalová, 2022). Moreover, biological maturation influences neuromuscular development by affecting muscle fiber composition, motor unit recruitment, and central nervous system maturation (Usluer et al. 2021; Yapıcı et al., 2022). Therefore, higher FMS scores in early-maturing athletes may partly be explained by their advanced neuromuscular maturity, which enhances movement quality and injury resilience.

Altundağ et al. (2021), in their study on volleyball athletes, stated that corrective exercises should be added to training programs to reduce the risk of injury and improve functional movement patterns of athletes. Öztürk and Sangün (2023) stated in their study that as the total score of functional movement analysis decreased, the 10-30m sprint, repeated sprint and agility performances of football players were negatively affected, which may cause a decrease in performance. Yıldırım and Çar (2024) stated in their study that the application of functional movement training to swimmers as a program had a significant difference in terms of performance and development. In addition to sport-specific demands, variations in coaches' emphasis on movement quality, athletes' prior injury history, and individual differences in motor learning or neuromuscular efficiency may also influence FMS outcomes.

An examination of the Functional Movement Screening (FMS) scores of athletes based on their maturity status revealed that early and timely maturing groups had higher scores in obstacle stepping, single-line lunge, shoulder mobility, rotation stability, and total FMS scores compared to the late-maturing group. Additionally, while the active straight leg raise scores of the early and late maturing groups were similar, early maturing athletes showed higher scores in deep squat and fixed trunk push-up tests. According to the FMS total scores, it was found that early and timely maturing athletes had significantly higher performance than late maturing athletes. These findings suggest that maturity status is an important factor affecting the functional movement capacity of athletes and that early maturation may be associated with higher

performance in movement skills. This may be linked to more advanced neuromuscular coordination and increased relative strength in early maturers, which provides advantages in tasks requiring motor control and stability. In their study, Turgut and Yapıcı (2023) reported that individuals born in the first months of the year and matured early had better sportive performance than those born in the last months of the year and matured late.

An examination of the Functional Movement Screening (FMS) scores of athletes in different sports branches based on their maturity status showed that early-maturing athletes demonstrated the highest performance, while late-maturing athletes had the lowest scores in each FMS test across volleyball, football, and basketball branches. In volleyball, football, and basketball, obstacle stepping, single-line lunge, shoulder mobility, rotation stability, and total FMS scores were high in early- and late-maturing groups and low in late-maturing groups, and active straight leg raising scores were close and low in early- and late-maturing athletes. In the deep squat and fixed trunk test scores, it was observed that the scores of early maturing athletes were higher than those of timely and late maturing athletes, and the scores of timely maturing athletes were higher than those of late maturing athletes. In their study, Altundağ et al. (2019) determined that there was a positive difference in favor of small and star teams in squatting in one move, and there was a positive significance in the scores of athletes in small and mini groups in the high step test. Usluer et al. (2021) reported that corrective exercises contributed to FMS total scores and motor skill development of children in their study on basketball players. Dişçeken and Atik (2024) stated that functional mobility training plays an important role in improving the performance of young tennis players and reducing the risk of injury, and functional movement training should be added to the training of athletes. It should also be noted that psychosocial maturity, coach-athlete interaction quality, and training consistency may play moderating roles in how biological maturation reflects in movement quality across different sports.

As a result, it was concluded that early maturing athletes had higher scores than timely and late maturing athletes in height, sitting height, body weight and body mass index scores according to anthropometric characteristics of athletes according to maturity status and branches. According to the total scores of Functional Movement Screening (FMS) according to sports branches and maturity status, it was determined that early and timely maturing athletes had higher performance than late maturing athletes. This suggests that structured interventions targeting movement quality can help mitigate the disadvantages faced by late-maturing athletes, helping to balance developmental disparities. Biological maturation and motor skills are thought to have an impact on the performance and injury risk of young athletes. Early-maturing athletes generally have better motor skills and lower injury risk, while late-maturing athletes need more attention to their training programs. Therefore, it is necessary to create appropriate training programs for young athletes, to shape them according to their individual biological maturation status, to tailor training programs, and to minimize the risks of overload and injury. In addition, training programs in accordance with the

individual development levels of athletes can help them to reveal their potential more efficiently. Future studies may benefit from including longitudinal designs to observe how functional movement patterns evolve over time in relation to changing maturation status, and how other contextual variables (e.g., sleep, stress, growth spurts) influence these changes. Like any study, this research has some limitations. First, the sample included only male athletes, which limits the generalizability of the findings to female athletes. Second, the cross-sectional design prevents establishing causal relationships between biological maturation and functional movement quality. Third, potential confounding factors such as training content, nutritional status, and socioeconomic background were not controlled, which may have influenced the results. Future research should consider these factors and employ longitudinal designs to provide a more comprehensive understanding.

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***Corresponding Author Information***
***Author Name Surname:****Döndü UĞURLU*
***Institution:*** *Kırıkkale Üniversitesi*
***Address:*** *Kırıkkale Üniversitesi (Spor Bilimleri Fakültesi*
***Orcid Numarası: Orcid Number:*** *0000-0002-9153-8900*