GROWTH AND MATURITY STATUS OF MEDAL-WINNING YOUNG TABLE TENNIS PLAYERS

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ABSTRACT

GROWTH AND MATURITY STATUS OF MEDAL-WINNING YOUNG TABLE TENNIS PLAYERS

…, …

M.S., The Department of Physical Education and Sports

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The purpose of the study was to determine the growth and maturity status of young medal-winning table tennis players and to compare them with their non-medal-winning counterparts. A sample of 117 (57 males aged 12.87 ± 1.35 years, and 60 females aged 12.99 ± 1.24 years) competitive players was assessed for standing height, sitting height, and body mass. Body mass index (BMI) was calculated by dividing weight (kg) by the squared height (m), and growth status was determined using a reference database. Utilizing age at peak height velocity (APHV) and maturity offset, somatic maturity status was estimated. The difference between the APHV and chronological age was computed to determine the value of maturity offset. Results showed that mean height, body mass, and BMI percentiles for both genders were above the 37th percentile compared to normative references. Boys were significantly taller with higher height z-scores, while girls were more advanced in maturation and reached peak height velocity earlier. There were no significant differences between medal-winning and non-medal-winning players in both genders in terms of growth and maturation. Coaches should monitor the growth and maturity status of the players and adapt training strategies by taking into account the physical characteristics of the

players. The findings may contribute to a better understanding of talent identification, physical development, and their relationships to performance in youth table tennis.

Keywords: racket sports, talent identification, youth athletes, biological maturation, physical growth

ÖZ

MADALYA KAZANAN GENÇ MASA TENİSİ OYUNCULARININ BÜYÜME VE OLGUNLUK DÜZEYLERİ

…, …
Yüksek Lisans, Beden Eğitimi ve Spor Bölümü
Tez Yöneticisi: Doç. Dr. Mustafa SÖĞÜT

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Çalışmanın amacı, madalya kazanan genç masa tenisi oyuncularının büyüme ve olgunluk durumlarını belirlemek ve madalya kazanan ve kazanmayan oyuncuları karşılaştırmaktı. Araştırmaya katılan 117 (57 erkek 12,87 ± 1,35 yıl ve 60 kadın 12,99 ± 1,24 yıl) müsabık oyuncudan oluşan örneklemin boy uzunluğu, oturma yüksekliği ve vücut ağırlığı ölçüldü. Vücut kitle indeksi (VKİ) vücut ağırlığının (kg), boy uzunluğunun karesine (m) bölünmesiyle hesaplandı. Büyüme durumu normatif referans veri tabanı kullanılarak belirlendi. Oyuncuların somatik olgunluk durumları, zirve boy hızı yaşı ve zirve boy hızı zamanına kalan süre hesaplanarak belirlendi. Zirve boy hızı yaşı ile kronolojik yaş arasındaki fark, zirve boy hızı zamanına kalan süreyi belirlemek için hesaplandı. Sonuçlar, her iki cinsiyet için ortalama boy uzunluğu, vücut ağırlığı ve VKİ yüzdelik dilimlerinin, normatif referanslara kıyasla 37. yüzdelik dilimin üzerinde olduğunu gösterdi. Erkeklerin, daha yüksek boy uzunluğu z-skorları ile istatistiksel olarak anlamlı biçimde kızlardan daha uzun olduğu, kızların ise olgunlaşmada erkeklerden daha ileri düzeyde olduğu ve zirve boy hızı yaşına daha erken ulaştığı gözlenmiştir. Bununla birlikte, iki cinsiyette de madalya kazanan ve kazanmayan oyuncular arasında büyüme ve olgunluk düzeyleri açısından anlamlı bir fark bulunamamıştır. Antrenörler, fiziksel özelliklere ek olarak oyuncuların büyüme

ve olgunlaşma durumlarını izlemeli ve antrenman stratejilerini buna göre uyarlamalıdır. Bulgular, masa tenisinde yetenek belirlemenin, fiziksel gelişimin ve bunların performansla ilişkilerinin daha iyi anlaşılmasına katkıda bulunabilir.

Anahtar Kelimeler: raket sporları, yetenek belirleme, genç sporcular, biyolojik olgunlaşma, fiziksel büyüme

To my family

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LIST OF ABBREVIATIONS

APHV	Age at Peak Height Velocity
BMI	Body Mass Index
CDC	Centers for Disease Control and Prevention
ISAK	International Society for the Advancement of Kinanthropometry
PAH	Predicted Adult Height
PHV	Peak Height Velocity
SES	Socioeconomic Status
WHO	World Health Organization

CHAPTER 1

INTRODUCTION

Millions of people have been playing major racket sports such as tennis, table tennis, badminton, and squash for over a century (Lees, 2003; Robertson, Pion, Mostaert, Wazir, Kramer, Faber, Vansteenkiste & Lenoir, 2018). Research has demonstrated that practicing racket sports can enhance the coordination between the brain and hands, eyes, and feet, and lead to improvements in speed, coordination, reflexes, endurance, flexibility, agility, general physical quality, and working memory (Jaworski, Lech, Ambroży & Żak, 2020; Schaefer & Scornaienchi, 2019). Racket sports require a well-organized combination of both aerobic and anaerobic fitness, high perceptual skills, technical proficiency, awareness, and control, in addition to speed, power, agility, flexibility, and strength (Lees, 2003; Mori, Ohtani, & Imanaka, 2002).

Racket sports share many similarities in terms of task requirements, match performances, and individual talent determinants, and involve bursts of high-intensity exercise (Faber, Bustin, Oosterveld, Elferink-Gemser & Nijhuis-Van Der Sanden, 2016; Pluim, 2004). However, despite their apparent similarities, they have major differences, such as swinging patterns, pitch size, and speed of the ball (Ak & Koçak, 2010; Akpınar, Devrilmez & Kirazcı, 2012). As an example, tennis players have a greater advantage in anticipating the placement of the ball and reacting accordingly to the speed and spin of the shots compared to players in other racket sports, whereas table tennis players are at a disadvantage in terms of responding to the speed and spin of the shots as they have less time to react (Ak & Koçak, 2010).

Adult tennis games typically have an average ball speed of around 100 km/hr (27 m/s), which is even slower in games involving younger players (Ferrauti & Bastiaens, 2007; Iino & Kojima, 2009). With a distance of 25 meters between the baselines in tennis,

players have less than one second to react to the ball. In contrast, the average speed of a badminton shuttlecock is approximately 125 km/hr (35 m/s) (Chen, Pan, & Chen, 2009; Tsai, Huang, & Jih, 1997), with the distance between players being 13.4 meters, giving players nearly 0.5 seconds to react. The average speed of a table tennis ball, however, is much slower at about 36 km/hr (10 m/s) (Durey & Seydel, 1994), yet the distance between players in table tennis is only about 3 meters, giving players less than 0.5 seconds to react. Table tennis demands faster reactions in smaller areas compared to other racket sports, with players focusing more on reaction time rather than preparing for the perfect shot and positioning (Ak & Koçak, 2010). As a result, table tennis is considered to be one of the fastest sports at the highest level. It is widely recognized as a challenging task since it requires executing complex motor tasks under time constraints and frequently changing conditions (Gentile, 2000; Schmidt & Lee, 2011; Mori, Ohtani, & Imanaka, 2002).

A world-level table tennis competition typically spans over a week, during which a highly ranked player has to compete in multiple games and sometimes play numerous matches in a day. The competition can be grueling due to various factors, such as a tight schedule, strong opponents, changes in diets and sleep patterns, a different environment, and dealing with time zone differences (Yan, 1992). Therefore, it is crucial for a table tennis player to maintain excellent physical fitness and mental well-being (Kondrič, Zagatto & Sekulic, 2013). The physical characteristics of the athletes play an important role in determining the level of table tennis performance since speed and explosive power have developed into determinant factors in table tennis performance (Robertson et al., 2018). Moreover, a high degree of technical ability, high speed in footwork, anticipation, and reaction time are vital to elite-level performance in table tennis (Ak & Koçak, 2010; Akpınar et al., 2012; Sève, Saury, Theureau & Durand, 2002). Technical skills are essential to having successful performance and development in table tennis (Faber, Koopmann, Busch & Schorer, 2021); however, other factors such as growth and maturity status, training history and structure, match experience, and physical characteristics of the players are also vital elements in determining the level of table tennis performance (Coelho-e-Silva, Konarski, Krzykała, Galas, Pluta, Żurek, Faria, Tavares, Oliveira, Rodrigues, Martinho, Valente-Dos-Santos & Malina, 2021).

In a recent study, Coelho-E-Silva et al. (2021) examined the growth and skeletal maturation of 99 male youth table tennis players. The results showed that the majority of male youth table tennis players were early maturing based on skeletal age and average maturing based on somatic indicators. Their heights and body masses were above the reference medians from 10 to 13 years, and their skeletal ages were generally advanced relative to chronological age. The study suggested that table tennis tends to retain taller and heavier participants who are somewhat advanced in skeletal maturity, and that age- and maturity-associated variations should be considered in youth table tennis competitions. In another study, Doherty, Martinent, Martindale, and Faber (2018) investigated if the multidimensional profiling model could predict table tennis players' current and future performance. The results indicated significant correlations between actual performance rating and age at peak height velocity (APHV), sprint test, years of practice, positive refocusing, self-regulation in learning, and evaluation. Moreover, positive refocusing, self-monitoring, and years of practice were correlated with performance ratings one year later. The study also showed that age from PHV, sprint test, years of practice, self-monitoring, and evaluation were significantly correlated with progression scores.

The biological maturity of a 12-year-old child can vary widely, between that of a 9- and 15-year-old (Borms, 1986); therefore, relying solely on chronological age for classification may not be appropriate and other factors such as growth and maturation should be taken into account. Understanding growth and maturation in youth sports is essential for identifying potential talent, optimizing coaching strategies and training programs, addressing factors affecting performance, and informing policies for youth athlete development (Malina, Bouchard & Bar-Or, 2004). Although table tennis is a popular sport played by millions of people regularly and competitively, and the studies devoted to table tennis are increasing, the extent of literature on the growth and maturity status of young table tennis players is not extensive (Coelho-e-Silva et al., 2021).

1.1. Purpose of the Study

The purposes of this study were to determine the growth and maturity status of young medal-winning table tennis players and to compare them with their non-medal-winning counterparts.

1.2. Research Questions

In this study, whether growth and maturity status differ between medal-winning and non-medal-winning young competitive table tennis players was investigated.

1.3. Significance of the Study

The literature in racket sports regarding growth and maturation showed that the studies were mostly conducted in tennis, and there were only two studies in table tennis. One of them was conducted with only male players without reporting any medal-winning status or ranking, whereas the other one focused on the influence of a multidimensional approach on young table tennis players again without the medal-winning or ranking information. In summary, the studies in youth table tennis have not ordinarily focused on the relationship between the growth and maturity status and medal-winning status of young competitive table tennis players. The study is original in the sense that it investigates how growth and maturity status affect the medal-winning status of young competitive table tennis players at consecutive ages. Integrating this research into policy-making can provide valuable insights for talent identification, development programs, and long-term athlete development plans in table tennis.

1.4. Definition of Terms

Biological maturity: Progressing towards the mature biologic state.
Physical growth: The measurable changes that occur in the body of an organism over time, such as changes in height, weight, and body composition.
Age at peak height velocity: The age at the maximum rate of growth occurring during the adolescent growth spurt.

Maturity offset: The difference in years from the age at peak height velocity.

Chronological age: The difference between the birth and measurement date.

CHAPTER 2

LITERATURE REVIEW

Designing effective training programs for young athletes requires an understanding of how growth and maturity affect child development (Balyi & Hamilton, 2004; Balyi, Way & Higgs, 2013; Ford, De Ste Croix, Lloyd, Meyers, Moosavi, Oliver, Till & Williams, 2011). In order to ensure that young athletes receive training that supports their overall development, it is crucial to have a thorough understanding of these two biological processes because they are essential parts of a child's development and have substantial effects on their physical, mental, and emotional well-being (Beunen & Malina, 2008). The factors influencing growth and maturation in children will be examined in the literature review, together with the assessments of growth and maturation. Additionally, it will examine how growth and maturation impact youth sports, with a particular focus on table tennis.

2.1.Growth and Maturation in Children

Although they are commonly used as synonymous with each other and often thought of as referring to the same things, both the terms growth and maturation completely represent two different biological processes (Cameron, 2022a; Malina, Bouchard, & Bar-Or, 2004). While maturation is the progression of the body's skeletal, sexual, and somatic systems toward the adult state, growth can be defined as changes in size and body composition that happen as people age (Baxter-Jones, 1995; Baxter-Jones, Eisenmann & Sherar, 2005; Cameron, 2022b; Malina et al., 2004).

Although there can be substantial individual fluctuations in the timing and rate of these processes, growth and maturation typically appear to exhibit predictable patterns (Baxter-Jones et al., 2002). For instance, the adolescent growth spurt usually causes a rapid increase in both height and weight, with boys often going through this spurt later

than girls. The timing and length of the growth spurt might range significantly across individuals, which can affect training and athletic performance.

For young athletes to benefit from effective training programs, it is crucial to comprehend the patterns and elements that affect the growth and maturation of children (Gabbett, Johns, & Riemann, 2008; Lloyd, Oliver, Faigenbaum, Myer, & De Ste Croix, 2014). Optimizing training programs to take these processes into consideration can help young athletes realize their full potential because physical development is vital to sports success. Besides this, identifying the differences from the norm in growth and maturation can be crucial for children since they may be signs of underlying medical issues or developmental delays that influence their overall health and well-being (Hebestreit & Bar-Or, 2008).

2.2.Factors Influencing Growth and Maturation

Growth and maturation are complex and interrelated processes that occur throughout childhood and adolescence (Malina et al., 2004). Children go through major growth- and maturity-related physical changes throughout this time, including adjustments to their height, weight, body composition, and hormone levels. Genetics, nutrition, environmental factors, and physical activity are some of the variables that have an impact on these changes (Cameron & Bogin, 2012; Rogol, Roemmich & Clark, 2002).

2.2.1. Genetics

Growth and maturation are significantly influenced by genetics. For instance, genetics significantly affects height (Sovio, Bennett, Millwood, Molitor, O'Reilly, Timpson, Kaakinen, Laitinen, Haukka, Pillas, Tzoulaki, Molitor, Hoggart, Coin, Whittaker, Pouta, Hartikainen, Freimer, Widen, Peltonen, Elliott, McCarthy & Järvelin, 2009). According to studies, genetics account for around 80% of the variance in height, with environmental variables accounting for the remaining 20% (Silventoinen, Sammalisto, Perola, Boomsma, Cornes, Davis, Dunkel, De Lange, Harris, Hjelmborg, Luciano, Martin, Mortensen, Nisticò, Pedersen, Skytthe, Spector, Stazi, Willemsen & Kaprio, 2003).

Beyond height, genetics can have significant effects on body composition (Loos, 2012). Due to variances in gene expression or polymorphisms in specific genes that alter metabolic processes, some individuals may have more body fat or muscle mass. In addition, despite similar levels of nutrition and physical activity, genetic variances in insulin-like growth factor secretion can influence disparities in muscle mass (Schiaffino, Dyar, Ciciliot, Blaauw & Sandri, 2013).

Growth and maturation can be affected by genetic disorders. For instance, a genetic condition known as Turner syndrome, which affects females, is characterized by short stature, delayed puberty, and infertility. According to Bondy (2009), an incomplete or missing X chromosome is the underlying cause of this disorder.Overall, while examining growth and maturation, genetics is an essential factor that must be taken into consideration. Researchers can better promote children's healthy growth by knowing how genetics affect growth.

2.2.2. Nutrition

Nutrition is another significant component that influences growth and maturation in children. Adequate nutrition is essential for children and adolescents to grow and develop healthily (Lifshitz, 2009). An adequate diet assures that children receive the nutrients, vitamins, and minerals they require for healthy physical and cognitive development.

For the formation of muscles, bones, and other tissues, as well as for its support, protein is vital. The World Health Organization (WHO) states that a protein deficit can result in impaired immunological function, stunted growth, and poor muscle and bone development (WHO, 2007). As protein consumption can directly affect performance and recovery, it is particularly vital for young athletes who participate in regular physical development and training (Thomas, Erdman & Burke, 2016). As a source of energy for everyday tasks and physical activity, carbohydrates are essential for growth and development. Carbohydrates should constitute about 45% to 65% of an individual's total calorie intake if they are one year or older, according to a 2002 report by the American Dietetic Association (Trumbo, Schlicker, Yates & Poos, 2002).

Because they provide energy and help in the absorption of vitamins and minerals, fats are essential for growth and development. To promote healthy growth and development, the American Heart Association (Gidding et al., 2005) advises children to follow a diet high in unsaturated fats, such as those found in nuts, seeds, and vegetable oils (Gidding et al., 2005). Micronutrients, such as vitamins and minerals, support a number of bodily functions and are critical for growth and development. For instance, iron promotes the formation of red blood cells and cognitive development, whereas calcium and vitamin D are crucial for bone health (CDC, 2022).

In general, children's healthy growth and development depend on adequate nutrition. A wide range of nutrient-dense foods included in a balanced diet can support optimal mental and physical development.

2.2.3. Environmental Factors

External factors such as air pollution, chemical exposure, and socioeconomic status (SES) can influence growth and maturation. According to The Lancet Commission (Landrigan, Fuller, Acosta, Adeyi, Arnold, Basu, Baldé, Bertollini, Bose-O'Reilly, Boufford, Breysse, Chiles, Mahidol, Coll-Seck, Cropper, Fobil, Fuster, Greenstone, Haines, Hanrahan, Hunter, Khare, Krupnick, Lanphear, Lohani, Martin, Mathiasen, McTeer, Murray, Ndahimananjara, Perera, Potočnik, Preker, Ramesh, Rockström, Aguilar-Salinas, Samson, Sandilya, Sly, Smith, Steiner, Stewart, Suk, Van Schayck, Yadama, Yumkella & Zhong, 2018), exposure to air pollution has been related to impaired lung function and an increased risk of respiratory illnesses, both of which can have a detrimental effect on growth and development. Toxins such as lead and mercury can affect cognitive function and neurological development, affecting growth and maturation (Grandjean & Landrigan, 2014).

SES is another environmental factor impacting growth and maturation (De Waal, 1993). Children from lower SES backgrounds may have limited access to nutritious food, healthcare, and safe living environments, which can contribute to poor growth outcomes (Kramer, 1987). Additionally, stressors associated with low SES, such as

family conflict and financial insecurity, can also impact growth and development through physiological mechanisms (Evans & Kim, 2013).

Overall, environmental factors can have significant impacts on physical growth and biological maturation in children. Understanding and addressing these factors is essential for promoting optimal growth and development in children.

2.2.4. Physical Activity

Regular physical activity is an essential component of a healthy lifestyle for children. The WHO recommends that children aged 5-17 years engage in at least one hour of moderate to vigorous physical activity per day to improve their physical health and reduce the risk of developing chronic diseases later in life (WHO, 2019). According to the U.S. Department of Health and Human Services (2020), regular physical activity can help children maintain healthy body weight, develop strong bones and muscles, improve cardiovascular health, and support overall physical and mental well-being. Children who engage in physical activity are more likely to have better academic performance, cognitive function, and social skills than their sedentary peers (Bailey, 2017; Bidzan-Bluma & Lipowski, 2018; Trost & Van Der Mars, 2009).

The American Academy of Pediatrics emphasizes the importance of incorporating physical activity into children's daily routines, including at school and home (McCambridge, Bernhardt, Brenner, Congeni, Gomez, Gregory, Gregory, Griesemer, Reed, Rice, Small, Stricker, LeBlanc, Raynor, Lindros, Frankowski, Gereige, Grant, Hyman, Magalnick, Mears, Monteverdi, Murray, Pattishall, Roland, Young, LaCursia, Vernon-Smiley, Mazyck, Wallace & Li, 2006). They recommend that children engage in various activities that promote muscular strength, endurance, flexibility, and bone health. Such activities can include running, jumping, climbing, sports, and physical exertion games.

In summary, regular physical activity is crucial for a child's growth and development, supporting healthy body weight, strong bones and muscles, and overall physical and mental well-being. However, research shows that early-maturing girls between 10 and

12 may display lower physical activity levels than average or late-maturing girls (Drenowatz, Eisenmann, Pfeiffer, Wickel, Gentile & Walsh, 2010). Encouraging children to engage in physical activity is important, and parents, caregivers, schools, and communities all play a vital role in creating environments that support physical activity, especially for those who may be at risk of lower physical activity levels.

2.3.Assessments of Growth and Maturation in Children

Assessments of growth and maturation in children typically involve a combination of anthropometric measurements and evaluations of biological maturation (Malina et al., 2004). Anthropometry involves measuring various body dimensions, including height, weight, and body composition, and comparing these measurements to growth charts based on age and gender (Fryar, Gu & Ogden, 2008). These measurements can provide valuable information on a child's overall growth and development and can help identify potential problems such as stunted growth or obesity (Cameron, 1993). In addition to anthropometry, assessments of biological maturation are also crucial in evaluating growth and development. Skeletal maturity assessments, which involve evaluating the development of bones in the hand and wrist, can help predict the timing of the pubertal growth spurt and estimate adult height (Tanner & Tanner, 1962). Sexual maturity assessments, which involve evaluating secondary sexual characteristics such as breast development or pubic hair growth, can provide additional information on a child's overall maturation (Marshall & Tanner, 1969). Somatic maturity assessments, which include measures such as APHV and predicted adult height (PAH), can also be used to evaluate growth and development in children (Mirwald, Baxter-Jones, Bailey & Beunen, 2002). By using a combination of these assessments, healthcare providers can gain a more complete understanding of a child's growth and development and provide appropriate care and management.

2.3.1. Assessments of Growth

Growth assessment involves evaluating and monitoring physical development changes over time (Lohman, Roche & Martorell, 1988; Malina et al., 2004). The process typically involves measuring and keeping track of changes in body mass, stature,

sitting height, as well as other physical characteristics like skinfold thickness, limb circumference, and skeletal breadths (Eston & Reilly, 2009). The main goal of growth assessment is to keep track of the physical development of an individual and compare it to established growth patterns (Lohman et al., 1988; Malina et al., 2004). This is necessary to identify any potential health issues or developmental delays and ensure that the person is growing and developing at a healthy rate.

The standard approach for measuring height is the stretch stature technique, which involves the individual standing barefoot with their feet together and their heels, buttocks, and back touching the measuring scale while positioning the head in the Frankfort plane (Eston & Reilly, 2009). To measure sitting height, the individual is seated, and the length of the torso from the seat of the chair to the top of the head is measured. This measurement is useful in estimating leg length when combined with stature measurement (Malina et al., 2004). Measuring body mass involves standing barefoot on a weighing scale without support and distributing body mass evenly between both legs (Eston & Reilly, 2009).

Reducing mistakes and determining the level of accuracy in assessing growth is crucial (Ulijaszek & Kerr, 1999). It is necessary to frequently calibrate equipment and compare readings with known weights (Malina et al., 2004). To determine the precision and reliability of the measurements, the intra-observer and inter-observer reliability should be considered, which refers to the variation in measurements made by the same observer and different observers, respectively, when measuring the same individual repeatedly (Ulijaszek & Kerr, 1999).
Height and weight assessments are commonly compared to age and gender-specific growth charts to evaluate the individual's growth status, and growth charts offer valuable data on the average height and weight of individuals at different ages, as well as expected growth rates for each age group (WHO, 2009). Deviation from the expected range of height or weight could be an indication of potential health issues requiring further medical examination (CDC, 2002).

Overall, assessing growth is essential for monitoring physical development and ensuring that individuals are growing and developing at a healthy rate. It requires

standardized techniques, trained assessors, and steps to reduce error and measure imprecision.

2.3.2. Assessments of Maturation

Assessing a child's biological maturation is an important aspect of pediatric medicine, as it can provide valuable insights into the child's overall health and development. However, chronological age is not always a reliable indicator of biological maturity, given the variations in puberty onset and the rate of development among individuals (Baxter-Jones, Helms, Maffulli, Baines-Preece & Preece, 1995; Kemper & Verschuur, 1981). The pubertal growth spurt begins earlier in girls (at around 10 years) compared to boys (at around 12 years), and both boys and girls experience PHV about two years after the onset of the spurt, with growth terminating at around 17.5 years in girls and 19.2 years in boys (Taranger & Hägg, 1980). That's why objective measures are necessary to assess a child's biological maturation, which refers to the physical changes that occur as a child progresses through different stages of development (Lloyd et al., 2014). There are various methods used to assess biological maturation in children, including measures of skeletal, sexual, and somatic maturity.

2.3.2.1.Skeletal Maturity

Skeletal maturity assessment is a process used to determine the biological age of an individual's skeletal system, which is often different from their chronological age. This assessment is used in a variety of fields, including orthodontics, orthopedics, and sports medicine (De Sanctis, Di Maio, Soliman, Raiola, Elalaily & Millimaggi, 2014; Engebretsen, Steffen, Bahr, Broderick, Dvorak, Janarv, Johnson, Leglise, Mamisch, McKay, Micheli, Schamasch, Singh, Stafford & Steen, 2010; Haiter-Neto, Kurita, De Menezes & Casanova, 2006; Martin, Wit, Hochberg, Sävendahl, Van Rijn, Fricke, Cameron, Caliebe, Hertel, Kiepe, Albertsson-Wikland, Thodberg, Binder & Ranke, 2011). There are several methods for assessing skeletal maturity, including the Fels, Greulich-Pyle, and Tanner-Whitehouse methods (Malina, 2011). Each method uses different techniques to evaluate the development of bones in the body.

The Fels method is a radiographic technique that uses X-rays of the left hand and wrist to assess skeletal maturity (Roche, 1992). The reason for choosing the left hand for sampling was because, during the time of sampling, it was observed that the left hand was less likely to be impaired, likely due to the prevalence of factory work among boys, which posed a greater risk of accidents to the right hand (Cavallo, Mohn, Chiarelli & Giannini, 2021). The bones of the hand and wrist are compared to standard reference images, and the degree of skeletal maturation is estimated based on the stage of bone development. It provides a standard error of measurement that can be useful for tracking young athletes over time (Chumela, Roche & Thissen, 1989; Malina, 2011). However, the method requires trained radiographers to analyze the X-rays, which may limit its utility in applied settings. Additionally, the Fels method can be costly due to the need for specialized equipment and software.

The Greulich-Pyle method is another radiographic technique that uses X-rays of the left hand and wrist to assess skeletal maturity (Greulich & Pyle, 1950). This method also compares the bones of the hand and wrist to standard reference images, but it uses a different set of reference images than the Fels method. The Greulich-Pyle method is a more time-efficient technique for assessing skeletal age than other methods because it does not always require individual assessment of each bone (De Sanctis et al., 2014; Mughal, Hassan & Ahmed, 1969); however, the method requires trained radiographers to analyze the X-rays and may not be as accurate as other methods in accounting for individual rates of bone development (Bull, Edwards, Kemp, Fry & Hughes, 1999). In addition, the Greulich-Pyle method was validated primarily in white children from families with high SES, which may limit its applicability to diverse ethnicities.

The Tanner-Whitehouse method is a more complex and detailed method for assessing skeletal maturity (Tanner, 2001). It involves measuring the size and shape of bones in the hand, wrist, elbow, shoulder, knee, and ankle using both X-ray and physical examination (Tanner, 2001). These measurements are then used to estimate the degree of skeletal maturation. The Tanner-Whitehouse method has the potential to be more ethnically diverse than other assessments of skeletal age (Malina, Dompier, Powell, Barron & Moore, 2007). However, it is a time-consuming and costly method of assessment that requires experienced radiographers to interpret the X-rays.

2.3.2.2.Sexual Maturity

Sexual maturity assessment, also known as Tanner staging or pubertal staging, is a medical evaluation used to determine the level of sexual development and physical maturity in children and adolescents (Lloyd et al., 2014; Malina et al., 2004). The assessment is based on the Tanner Scale, developed by pediatric endocrinologist James Tanner in the 1960s (Tanner & Tanner, 1962). The Tanner Scale categorizes physical changes during puberty into five stages, with stage one being pre-pubertal and stage five being fully mature (Tanner & Tanner, 1962). The stages are based on the development of secondary sexual characteristics, such as breast development in girls and testicular enlargement in boys, as well as pubic hair growth and changes in body shape (Spear, 2002).

There are several advantages and disadvantages to sexual maturity assessment. One option is for individuals to perform a self-assessment by comparing their own sexual characteristics to the reference system. This method is commonly used, but it is important to note that a qualified and experienced medical doctor is required to perform the assessment in a clinical setting (Malina et al., 2004). Coaches should never perform this assessment with individuals as it can be an invasion of privacy and inappropriate for someone who is not a qualified healthcare professional (Beunen, Malina, Lefevre, Claessens, Renson & Simons, 1997). The assessment is unable to differentiate between individuals within the same stage and does not provide insight into the tempo of maturation (Baxter-Jones, Eisenmann & Sherar, 2005; Malina et al., 2004). Additionally, it is inapplicable to youth who are not experiencing the pubertal growth spurt, limiting its effectiveness for long-term monitoring (Beunen et al., 1997).

2.3.2.3.Somatic Maturity

The assessment of somatic maturity can be performed using various indicators, such as percentages of PAH and APHV. Percentages of PAH provide an estimate of the final adult height based on the child's current height and the average height of their biological parents (Khamis & Roche, 1994; Tanner, Whitehouse, Marshall & Carter, 1975). APHV refers to the age at which a child reaches their maximum growth rate,

typically around 12 in girls and 14 in boys (Baxter-Jones et al., 2005; Malina et al., 2004).

Understanding somatic maturity is important in evaluating a child's physical development, identifying any potential growth and developmental disorders, and determining the appropriate course of treatment or intervention. Somatic maturity assessments are also relatively easy to perform, non-invasive, and can be conducted in various settings (Malina et al., 2007). Additionally, these assessments can be used to track changes in growth and development over time, providing a valuable tool for longitudinal studies and monitoring the effectiveness of medical interventions. This section will explore the various assessments of somatic maturity, including percentages of PAH and APHV, and their importance in understanding physical development in children.

2.3.2.3.1. Percentages of Predicted Adult Height

Percentages of PAH is a method used to estimate a child's final adult height based on their current height and the average height of their biological parents. The prediction takes into account the child's age, gender, and height, and it is based on the assumption that a child's height is genetically determined and that it will follow a growth pattern similar to that of biological parents.

The method involves a mathematical formula that takes into account the child's height, gender, and the height of their biological parents. The formulas introduced by Bayley (1946), Roche, Wainer, and Thissen. (1975), and Tanner et al. (1975) are generally deemed as the most precise and commonly utilized (Eston & Reilly, 2009). To determine biological maturity, each method necessitates the evaluation of skeletal age, which is an expensive procedure and requires exposing the individual to radiation (Sherar, Mirwald, Baxter-Jones & Thomis, 2005). As a result, Beunen et al. (1997) developed a new non-invasive technique to predict adult height and use the percentage of adult height as a maturity indicator without having to evaluate skeletal age. Furthermore, Khamis and Roche (1994) adapted Roche et al.'s (1975) method by removing the need to assess skeletal age and aiming to simplify the process.

Once the PAH is calculated, it is expressed as a percentage of the average height for the child's age and gender, which can be obtained from a growth chart (Hebestreit & Bar-Or, 2008; Malina et al., 2004). The percentage of PAH is an important indicator of a child's growth and development, as it helps healthcare professionals and parents identify potential growth disorders and track a child's progress over time.

Percentages of PAH have several advantages and disadvantages as an assessment method for determining physical development in children. One of its main advantages is that it can be particularly useful in sports where stature predicts performance, such as basketball and tennis (Cui, Liu, Bao, Liu, Zhang & Gómez, 2019; Söğüt, 2018; Vaverka & Cernosek, 2013). It is a simple and non-invasive method that practitioners can perform themselves (Hebestreit & Bar-Or, 2008; Malina et al., 2004). While Percentages of PAH have a comparatively low margin of error in prediction (Bielicki & Welon, 1966), the height measurements of both biological parents may not always be obtainable (Sherar et al., 2005).

Percentages of PAH are particularly useful when longitudinal growth data has not been collected, and youth can be classified as pre-, circa-, or post-PHV (Cumming, Lloyd, Oliver, Eisenmann & Malina, 2017). However, there are some limitations to this method. Using self-reported parental height can introduce some errors, especially as males tend to over-predict height (Bowman & Delucia, 1992). While having parents' height measured by practitioners is preferable, it may not always be feasible in an applied setting.

2.3.2.3.2. Age at Peak Height Velocity

APHV is a somatic maturity indicator and refers to the age at which a child reaches their maximum growth rate, typically around puberty (Hebestreit & Bar-Or, 2008; Malina et al., 2021). APHV is calculated by plotting the child's stature measurements on a growth chart and determining the point at which there is a peak in the velocity of growth (Malina et al., 2004; Malina, Rogol, Cumming, Coelho-E-Silva & Figueiredo, 2015). During periods of rapid growth, such as the first year of life and the adolescent growth spurt, it is recommended to increase the frequency of measurements, with

monthly measurements suggested for the first year of life and measurements every three months for the adolescent growth spurt (Eston & Reilly, 2009).

APHV is a simple and non-invasive assessment that practitioners can easily perform (Eston & Reilly, 2009). APHV also allows practitioners to easily identify those who are early, on-time, or late-maturers with the help of maturity offset equations proposed by Mirwald et al. (2002). However, there is a standard error of approximately 6 months with this measure, which may increase the further individuals are away from their PHV (Malina et al., 2004). Additionally, the method involves collecting more anthropometric measurements than other somatic methods, including body mass, which requires more sensitivity (Mirwald et al., 2002). Furthermore, this calculation is biased toward chronological age at the time of prediction (Malina et al., 2004). Despite these limitations, the APHV remains a valuable tool for assessing physical maturity in children.

2.4.Growth and Maturation in Youth Sports

Human growth and maturation are complex processes that are influenced by a range of genetic and environmental factors. In the context of youth sports, understanding the relationship between growth and maturation, and sports performance is crucial for talent selection and development (Malina et al., 2004). Especially in the last decade, a lot of studies in both team and individual sports, particularly in team sports such as soccer and basketball, have investigated this relationship. This chapter covers the studies regarding growth and maturation in youth sports.

The studies on soccer have focused on the relationship between biological maturation, growth-related factors, and physical performance among young soccer players. They examined how factors such as skeletal maturity, sexual maturity, weight, height, and exposure time affect physical performance, injury risk, self-regulation, and player selection, and also explored the differences in physical development and skill levels between early, on-time, and late-maturing players.

The study by Malina, Eisenmann, Cumming, Ribeiro and Aroso (2004) examined how experience, body size, and maturity status affect the functional capacities of 69 adolescent soccer players aged 13.2-15.1 years from three Portuguese clubs. Sexual maturation was estimated by using the Tanner (1962) staging method. The findings revealed that biological maturity status significantly influences the functional capacity of adolescent football players. Sexual maturity status was found to be the primary contributor to variance in the intermittent shuttle run, while weight and height were the primary contributors to the explained variance in the 30-m dash and vertical jump, respectively.

In another study, Malina, Reyes, Eisenmann, Horta, Rodrigues and Miller (2000) evaluated the height, body mass, and skeletal maturity of 141 elite Portuguese male soccer players aged 11-16 years. Skeletal maturation was estimated by using the Fels method (Roche, 1992). The study found that the players were taller and heavier than the Portuguese population of the same age range. Additionally, the majority of players were advanced in skeletal maturity.

Cumming, Searle, Hemsley, Haswell, Edwards, Scott, Gross, Ryan, Lewis, White, Cain, Mitchell and Malina (2018) analyzed the relationships between biological maturation, relative age, and self-regulation in 171 professional academy soccer players aged between 11 and 14. Somatic maturity was estimated using the PAH percentage (Khamis & Roche, 1995). The study found that late-maturing players are more likely to possess and develop more adaptive self-regulation skills, particularly in self-evaluation and reflection, while there was no significant association between relative age and self-regulation in professional academy soccer players.

Hill, Scott, Malina, McGee and Cumming (2020) investigated how relative age and biological maturity status affect player selection in an English professional soccer academy. Somatic maturity was estimated using the PAH percentage (Roche et al., 1983). They found that players born in the first birth quarter of the year were overrepresented in all age groups, and there was a bias towards selecting players advanced in maturity status for their chronological age. The bias was most apparent in the U12 age group and increased with age.

Parr, Winwood, Hodson-Tole, Deconinck, Hill, Teunissen and Cumming (2020) investigated the relationship between biological maturity, relative age, and physical performance in 84 adolescent male soccer players from a professional soccer academy in the English Premier League. Somatic maturity was estimated using the PAH percentage (Roche, Tyleshevski & Rogers, 1983). They found that physical performance was related to biological maturity but not relative age, with early-maturing players performing better in most physical performance tests.

Johnson, Farooq, and Whiteley (2017) investigated whether there is a biological age effect on academy selection in soccer while taking into consideration the relative age effect on 472 boys from elite youth football academies. Skeletal maturation was estimated by using the Fels method (Roche, Chumlea & Thissen, 1988). They found that maturation status has a much stronger influence on selection than birth quarters in elite youth football academies, with early maturing athletes being systematically overrepresented.

Figueiredo, Gonçalves, Silva and Malina (2009) compared the differences in size, function, sport-specific skill, and goal orientation associated with differences in the biological maturity status of 159 male soccer players in two competitive age groups (11-12 and 13-14). Skeletal maturation was estimated by using the Fels method (Roche et al., 1988). The study found that late, on time, and early maturing boys are represented among 11-12-year-olds, whereas late maturing boys are under-represented among 13-14-year-olds. Players in each age group who advanced in maturity were taller and heavier than those on time and late in skeletal maturity, but players of contrasting maturity status do not differ significantly in functional capacities, soccer-specific skills, and goal orientation.

Buchheit and Mendez-Villanueva (2014) investigated the effects of age, maturity, and body dimensions on match running performance in 36 highly trained under-15 soccer players. Somatic maturity was estimated by using the APHV (Mirwald et al., 2002). The study found that players who were older, more mature, or had larger body dimensions showed greater locomotor and match running performances than their

younger, less mature, or smaller teammates. The study found that maturation had the greatest impact on match running performance compared to age and body size.

There are many other studies in soccer regarding the growth and maturation of young soccer players (Bradley, Johnson, Hill, McGee, Kana-Ah, Sharpin, Sharp, Kelly, Cumming & Malina, 2019; Clemente, Clark, Leão, Silva, Lima, Sarmento, Figueiredo, Rosemann & Knechtle, 2021; Deprez, Coutts, Fransen, Deconinck, Lenoir, Vaeyens & Philippaerts, 2013; Emmonds, Morris, Murray, Robinson, Turner & Jones, 2017; Johnson, Cumming, Bradley & Williams, 2022; Lovell, Towlson, Parkin, Portas, Vaeyens & Cobley, 2015; Morris, Emmonds, Jones, Myers, Clarke, Lake, Ellis, Singleton, Roe & Till, 2018; Müller, Gehmaier, Gonaus, Raschner & Müller, 2018; Ostojic, Castagna, Calleja-González, Jukić, Idrizovic & Stojanovic, 2014; Philippaerts, Vaeyens, Janssens, Van Renterghem, Matthys, Craen, Bourgois, Vrijens, Beunen & Malina, 2006; Radnor, Staines, Bevan, Cumming, Kelly, Lloyd & Oliver, 2021; Vandendriessche, Vaeyens, Vandorpe, Lenoir, Lefevre & Philippaerts, 2012). In brief, previous studies in youth soccer indicated that biological maturation status significantly influences the functional capacity, physical performance, and injury risk of young soccer players. Specifically, sexual maturity status, weight, and height were found to be primary contributors to various physical performance measures. Early-maturing players tend to perform better in physical performance tests, while late-maturing players may develop more adaptive self-regulation skills. Additionally, there is a bias towards selecting players advanced in maturity status for their chronological age, with early-maturing athletes being systematically overrepresented in elite youth football academies.

The studies on basketball have explored how biological maturity status, age, anthropometrics, and training experience influence body size, functional capacities, and basketball-specific skills. Additionally, they all examine the relationship between physical and technical characteristics and success in basketball, particularly at the elite level. Some of the studies also compare the performance of early and late-maturing players, and most of them focus on male basketball players, with a few exceptions that include female players.

Guimarães, Ramos, Janeira, Baxter-Jones, and Maia (2019) investigated the effects of age, maturity status, anthropometrics, and years of training on the physical performance and technical skill development of 150 11–14-year-old male basketball players. Somatic maturity was estimated by using the APHV (Mirwald et al., 2002). Early maturers were found to have greater strength, power, speed, agility, and basketball-specific technical skills, while maturity status and years of training were found to be the primary contributors to variance in physical and technical skills, respectively.

Arede, Ferreira, Gonzalo-Skok, and Leite (2019) aimed to identify variables that could be used to select under-16 national-team basketball players and investigate how biological age influences physical and technical parameters among young basketball players. Somatic maturity was estimated by using the APHV (Mirwald et al., 2002). Maturational status and training experience were found to be the most important attributes in predicting under-16 national-team selection, and players with more than 5.5 years of training experience and less than 1.4 years to the APHV were most likely to be selected.

Wierike, Elferink-Gemser, Tromp, Vaeyens, and Visscher (2015) examined the relationship between maturity timing, playing positions, and physical and technical characteristics of male and female adolescent basketball players. Somatic maturity was estimated by using the APHV (Mirwald et al., 2002). Results showed that early-maturing boys and late-maturing girls were more likely to play at higher levels, with early maturers having a greater height advantage and late maturers having better technical skills.

The study by Torres-Unda, Zarrazquin, Gil, Ruiz, Irazusta, Kortajarena, Seco, and Irazusta (2013) examined the characteristics associated with success in basketball among young players (13-14 years old). Somatic maturity was estimated by using the APHV (Mirwald et al., 2002). Elite players were found to be taller, heavier, and have a higher percentage of muscle mass, as well as performing better in jump, endurance, speed, and agility tests. Early-maturing boys and those born in the first semester of the year were also more likely to be selected for the elite team, highlighting the importance

of considering physical and physiological parameters associated with maturity and chronological age in player selection.

There are many other studies in basketball regarding the growth and maturation of young basketball players (Carvalho, Gonçalves, Collins & Paes, 2018; Jakovljević, Macura, Radivoj, Janković, Pajić & Erčulj, 2016; Leonardi, Paes, Breder, Foster, Gonçalves & Carvalho, 2018; Silva, Figueiredo, Carvalho & Malina, 2008; Silva, Carvalho, Gonçalves, Figueiredo, Elferink-Gemser, Philippaerts & Malina, 2010; Ramos, Volossovitch, Ferreira, Fragoso & Massuça, 2019). In brief, previous studies in youth basketball indicated that early maturers have greater physical and technical skills, and maturity status and years of training are the primary contributors to variance in physical and technical skills, respectively. Other variables such as training experience, APHV, and morphological characteristics are also found to be significant predictors of success in basketball.

Albaladejo-Saura, Vaquero-Cristóbal, García-Roca, and Esparza-Ros (2022a) aimed to investigate differences in kinanthropometric characteristics and physical fitness performance between 96 adolescent male and female volleyball players. Somatic maturity was estimated by using the APHV (Mirwald et al., 2002). The study found significant differences between male and female players in bone and muscle-related variables and strength and power production-related physical tests, with males performing better in these areas, while females had higher values in fat-related variables and performed better in flexibility tests. Age, maturity offset, and birth quartile were found to have a statistical influence on the differences between the sexes.

Albaladejo-Saura, Vaquero-Cristóbal, García-Roca, and Esparza-Ros (2022b) aimed to analyze differences in anthropometric characteristics and physical fitness test performance based on biological maturation status in adolescent male sub-elite volleyball players. Somatic maturity was estimated by using the APHV (Mirwald et al., 2002). The study found significant differences in body mass, height, sitting height, arm span, body mass index (BMI), muscle girths, skinfolds, fat mass and percentage, muscle and bone mass, and physical fitness test performance between early and late maturers. The results showed that fat mass percentage predicted worse physical test

performance, while age, maturation offset, muscle, and bone variables were predictors of better physical performance.

Albaladejo-Saura, Vaquero-Cristóbal, García-Roca, and Esparza-Ros (2022c) aimed to analyze differences in physical characteristics and performance in 152 female volleyball players aged 14.16 ± 1.25 years old in relation to their maturity status. The sample was divided into three groups based on biological maturation, with early maturers showing higher values in most kinanthropometric variables. Somatic maturity was estimated by using the APHV (Mirwald et al., 2002). The more mature players showed higher values in most kinanthropometric variables, especially those related to adiposity and absolute body composition, while structural variables were the most influential on the physical tests. Age also had a determinant influence on the differences found between groups in strength and power-related test performance.

Gantois, Pinto, De Castro, João, Dantas, and De Araújo Tinoco Cabral (2017) aimed to compare and correlate explosive strength with biological maturation, assessed by skeletal age based on anthropometric variables, in 239 children aged 10 to 13 years of both sexes. Maturation was assessed by the skeletal age predictive equation. The upper and lower limbs' explosive strength was measured using medicine ball throw and vertical jump tests, respectively. The results showed that delayed biological development was associated with worse performance in medicine ball throw and vertical jump tests compared to accelerated development, with statistically significant differences in both boys and girls. The results indicated that skeletal age explained a significant portion of the variance in explosive strength for both sexes, with accelerated biological development showing higher performance in the tests.

Baxter-Jones, Barbour-Tuck, Dale, Sherar, Knight, Cumming, Ferguson, Kowalski, and Humbert (2020) aimed to identify the differences in growth and maturity-related factors between those selected and deselected in youth sports teams (baseball, basketball, football, hockey, soccer, and volleyball) and identify short-term associations with continued participation. 870 participants aged 11-17 years were recruited from six sports tryouts in Canada, and z-scores for PAH ranged from 0.1 to 1.8 and were significantly different between sports. Somatic maturity was estimated

by using the APHV (Mirwald et al., 2002). Height and APHV differences were found between selected and deselected male participants, while weight differed between selected and deselected female hockey players. The study found that youth who attended sports team try-outs were more likely to be born early in the selection year, be tall for their age, and in some sports early maturers. The majority of both selected and deselected participants continued to participate in sports 36 months after tryouts, with the majority continuing to participate in their try-out sport.

Peltenburg, Erich, Bernink, Zonderland, and Huisveld (1984) investigated the differences in puberty onset, body composition, and growth between 668 female gymnasts, 298 schoolgirls, and 98 female swimmers. Sexual maturation was estimated by using the Tanner (1962) staging method. The results showed a delay of about 1 to 2 years in the onset of puberty for gymnasts compared to swimmers and a clear difference in body composition between the groups. The delay in puberty onset affects the standard deviation scores for body height. The findings suggest that genetic growth regulation plays an important role in these athletic groups and that physical exercise and low body weight may prolong the prepubertal state of ballet dancers. The study also found that weekly training duration influences body height, body weight, lean body weight, and pubic hair growth only within the swimming group.

Erlandson, Sherar, Mirwald, Maffulli, and Baxter-Jones (2008) compared the somatic growth, sexual maturation, and final adult height of elite adolescent female athletes in gymnastics, swimming, and tennis. Sexual maturation was estimated by using the Tanner (1962) staging method. The study found that gymnasts were significantly shorter than tennis players and swimmers during adolescence and attained menarche at an older age. However, there were no significant differences in adult heights. The study concluded that regular training did not affect final adult stature and that the tempo of sexual maturation was similar across the three sports when aligned by biological age.

In their longitudinal study, Baxter-Jones, Helms, Maffulli, Baines-Preece, and Preece (1995) analyzed the growth and development of 231 male athletes in four sports (gymnastics, swimming, soccer, and tennis). Sexual maturation was estimated by

using the Tanner (1962) staging method. Based on the study findings, they concluded that in sports such as tennis and swimming, where a large physique was considered an advantage, athletes had advanced sexual maturation. In contrast, late maturation occurred in sports such as gymnastics, where prepubertal physiques mean an advantage. They claim that although a training effect before entering the study cannot be excluded, it is highly possible that these children were selected due to their physical properties and stage of sexual maturity.

2.4.1. Growth and Maturation in Racket Sports

Previous studies in racket sports in terms of growth and maturation indicated that the studies were mostly conducted in tennis, whereas there is a lack of information especially in badminton and squash.

Myburgh, Cumming, Silva, Cooke, and Malina (2016) compared the growth and maturation status of 91 elite junior British tennis players (47 males and 44 females) between the ages of 8 and 17, with an average age of 12.5 years, to population norms. Skeletal maturation was estimated by using the Fels method (Roche et al., 1988). The study found that females were advanced in skeletal age relative to chronological age from 8 years old, while males were average to delayed in maturation from 8-12 years but advanced in skeletal age from 14-16 years old.

Söğüt, De Oliveira Luz, Kaya, and Altunsoy (2019) investigated the association between various physical, functional, experiential, and training-related characteristics and ranking among 119 nationally ranked Turkish players aged 9.6-12.3 years old under-12 competitive tennis players. Somatic maturity was estimated by using the APHV (Mirwald et al., 2002). Girls were found to be taller and more advanced in maturation than boys. The study found that experience, training volume, and motor performance were significantly associated with ranking for both genders, with age to start regular training being the most correlated variable for girls and weekly training volume for boys.

Söğüt, Ödemiş, and Durmuş (2023) aimed to determine the growth and maturity status of 70 U14 competitive tennis players and their relationship with national rankings. Somatic maturity was estimated by using the APHV (Mirwald et al., 2002). The study found that, regardless of gender, the mean height and body mass percentiles of players were above the 60th centile. More advanced maturation and higher BMIs were associated with higher rankings in girls. However, no significant differences were observed among the groups for boys.

Myburgh, Cumming, Coelho-E-Silva, and Malina (2020) aimed to develop age- and sex-specific developmental curves for sprint acceleration in elite youth tennis players and address variation in performance relative to chronological and biological age. Somatic maturity was estimated using the PAH percentage (Roche et al., 1983). The study collected measures of acceleration from 3120 elite youth tennis players aged 8-15 years attending National and Regional Talent Identification days. Variation in acceleration by chronological and estimated biological ages was evaluated in corresponding data for an independent sample of elite youth players 8.9 to 15.1 years. The findings showed that acceleration varied as a function of chronological and biological age relative to developmental curves. Early maturing males and females had significantly poorer performances when acceleration was considered relative to biological age.

Fernandez-Fernandez, Alvarez-Dacal, Hernández-Davó, and Granacher (2023) investigated how maturity status and gender affected physical fitness in 81 young badminton players divided into pre-PHV, circa-PHV, and post-PHV groups. Fitness tests were conducted, and the results showed that pre-PHV players had lower performance levels than post-PHV players in countermovement jump, linear sprints, and change of direction (COD) tests. Boys outperformed girls in most measures, except for COD deficit %.

2.4.1.1.Growth and Maturation in Table Tennis

Doherty, Martinent, Martindale, and Faber (2018) investigated whether a multidimensional profiling approach could predict the actual and future performance

of elite youth male table tennis players. The researchers collected data on anthropometrics, APHV, motor skills, psychological skills, and training histories from 14 Scottish players. Somatic maturity was estimated by using the APHV (Mirwald et al., 2002). The results showed significant correlations between actual performance rating and APHV, sprint test, years of practice, positive refocusing, self-regulation in learning, and evaluation. The study also found significant correlations between performance rating one year later and positive refocusing, self-monitoring, and years of practice. Moreover, the study provided preliminary evidence for the usefulness of a multidimensional profiling approach for predicting performance and progression in youth table tennis players.

Coelho-E-Silva et al. (2021) examined the growth and skeletal maturation among 99 male table tennis players aged 10 to 14.63. Skeletal maturation was estimated by using the Fels method (Roche, 1992). The results showed that the majority of male youth table tennis players were early maturing based on skeletal age and average maturing based on somatic indicators. Their heights and body masses were above the reference medians from 10 to 13 years, and their skeletal ages were generally advanced relative to chronological age. The study suggested that table tennis tends to retain taller and heavier participants who are somewhat advanced in skeletal maturity, and that age- and maturity-associated variations should be considered in youth table tennis competitions.

The existing literature on growth and maturation in racket sports has highlighted a gap in knowledge, particularly in the context of table tennis, badminton, and squash. Studies have primarily focused on tennis, with limited research available on table tennis specifically. The few studies conducted in table tennis either did not report medal-winning status or ranking information, or they examined the influence of multidimensional approaches without considering medal-winning or ranking outcomes. This indicates a lack of emphasis on investigating the relationship between growth, maturity status, and the medal-winning status of young competitive table tennis players. Therefore, conducting a study on the growth and maturity status of young medal-winning table tennis players is crucial to fill this research gap and provide valuable insights for policymakers, talent identification programs, and long-

term athlete development plans in table tennis. Additionally, considering the variations in growth, maturation, and physical characteristics of table tennis players can enhance the fairness and effectiveness of youth table tennis competitions.

CHAPTER 3

METHODS

3.1.Participants

The sample included 117 young competitive table tennis players, consisting of 57 boys (mean age = 12.86 ± 1.35 years, training age = 4.97 ± 1.68 years, weekly training volume = 14.64 ± 6.81 hours/week) and 60 girls (mean age = 12.99 ± 1.24 years, training age = 5.22 ± 1.25 years, weekly training volume = 15.30 ± 5.49 hours/week). Birth dates, training age, and weekly training information were collected from the players, coaches, and parents. Information on medal-winning status was obtained from the annual activity reports of the Turkish Table Tennis Federation. The inclusion criteria consisted of: (i) being registered with the Turkish Table Tennis Federation and (ii) having at least two years of training experience in organized and competitive table tennis. The ethical approval was obtained from the Human Subjects Ethics Committee of Middle East Technical University (0149-ODTUİAEK-2022), and written informed consents were obtained from the children (See Appendix D) and their parents or legal guardians (See Appendix E) after explaining the measurements and purpose of the study.

3.2. Measurements and Procedures

Measurements were taken at three national table tennis championship tournaments in Turkey, starting with the U-15 tournament held in Kırşehir on 8th March 2022. A month later, measurements were taken at the U-13 tournament in Karaman on 26th April 2022, followed by the U-11 tournament in Sakarya on 16th May 2022. In addition to gathering data from these championship tournaments, measurements were taken from players of table tennis clubs in Ankara on two different dates: 22nd May 2022 and 17th November 2022.

3.2.1. Anthropometry

Standing and sitting heights were measured using a portable stadiometer (Seca 213, Hamburg, Germany), while body mass was measured using a digital weighing scale. The leg length was calculated by subtracting the sitting height from the standing height. BMI was calculated by dividing body mass (kg) by the squared height (m). All anthropometric measurements were conducted according to the manual of the International Society for the Advancement of Kinanthropometry (ISAK) (Eston & Reilly, 2009).

3.2.1.1. Standing Height

The participants were positioned with their backs against the stadiometer, heels together, and their heads in the Frankfort plane (a horizontal line from the lower margin of the orbit to the upper margin of the external auditory meatus). The vertex, the highest point on the head, was identified by locating the point where the highest point of the head meets the Frankfort plane. The heads of the participants were gently pressed down to ensure accuracy, and the sliding headpiece of the stadiometer was then brought down to the vertex. Measurements were taken to the nearest 0.1 cm.

3.2.1.2. Sitting Height

The participants were instructed to sit on a bench with their backs straight. The buttocks and backs of the participants were checked by the measurer for contact with the stadiometer. The distance from the stadiometer to the top of the heads of the participants was measured by the measurer while keeping the measurement perpendicular to the bench. Measurements were taken with accuracy to the nearest 0.1 cm.

3.2.1.3. Body Mass

The participants were asked to stand at the center of the weighing scale with bare feet and minimal clothing. It was ensured that the participant was standing still and that

their body masses were evenly distributed. The measurements were taken to the nearest 0.1 kg.

3.2.2. Estimation of Physical Growth and Biological Maturation

3.2.2.1. Physical Growth

Physical growth refers to the measurable changes that occur in the body of an organism over time, such as changes in height, weight, and body composition, and it is calculated and monitored to track an individual's development and assess whether they are growing as expected based on their age, gender, and other factors (Malina et al., 2014). Anthropometric measurements, including height for age, weight for age, and BMI for age, were obtained and compared to Frisancho's reference data (Frisancho, 2008), and percentile and z-score values were calculated for height, body mass, and BMI.

3.2.2.2. Biological Maturation

In sports science, there are several models used for assessing biological maturation, including Tanner's, Mirwald's, Khamis-Roche, and Carter's models. For the purpose of this study, the APHV was used to estimate the somatic maturity of the players. This method was selected as it is considered one of the most practical and frequently used models in sports science. The APHV was determined using the predictive equation proposed by Mirwald, Baxter-Jones, Bailey, and Beunen (2002). The maturity offset was calculated by subtracting the difference between the APHV and chronological age. The chronological ages of the players were calculated by subtracting the date of their birth from the date on which they were measured.

Mirwald et al. (2002) equations provide a non-intrusive method for estimating the APHV that occurs, using leg and trunk length growth patterns. By inputting variables such as leg length, sitting height, chronological age, standing height, and weight, these equations estimate APHV, offering a non-invasive measure of somatic maturity. However, recent research questions the validity and reliability of the maturity offset method (Mirwald et al., 2002). This method is most effective near PHV in boys with

average maturation rates and a narrow age range (13-14.99 years) (Malina & Koziel, 2013; Moore, McKay, Macdonald, Nettlefold, Baxter-Jones, Cameron & Brasher, 2015), limiting its usefulness (Malina, Rogol, Cumming, Coelho-E-Silva & Figueiredo, 2015). Validation studies comparing predicted ages to actual ages at PHV found that early-maturing individuals were predicted to be older, while late-maturing individuals were predicted to be younger. Therefore, the authors of the equation emphasize that maturity should be viewed as a categorical rather than a continuous assessment. (Mirwald et al., 2002). In this study, the following equations proposed by Mirwald et al. (2002) were utilized to estimate the APHV values of players.

Boys:

Maturity Offset = -9.236 + 0.0002708 x Leg Length and Sitting Height interaction - 0.001663 x Age and Leg Length interaction + 0.007216 x Age and Sitting Height interaction + 0.02292 x Weight by Height ratio, where R = 0.94, R^2 = 0.891, and Standard Error of Equation = 0.592.

Girls:

Maturity Offset = -9.376 + 0.0001882 x Leg Length and Sitting Height interaction + 0.0022 x Age and Leg Length interaction + 0.005841 x Age and Sitting Height interaction - 0.002658 x Age and Weight interaction + 0.07693 x Weight by Height ratio, where R = 0.94, R^2 = 0.890, and Standard Error of Equation = 0.569.

3.3. Statistical analysis

A descriptive analysis of the data was conducted according to gender. All values were reported as means and standard deviations. The Kolmogorov-Smirnov test was used to analyze the normality of the data. Independent samples t-tests were conducted to analyze the differences between medal-winning and non-medal-winning players, and boys and girls separately. Cohen's d was used to measure the effect size and interpreted as follows: <0.20 (trivial), 0.20–0.59 (small), 0.60–1.19 (moderate), 1.20–1.99 (large), 2.0–3.9 (very large), and >4.0 (extremely large) (Hopkins, Marshall, Batterham & Hanin, 2009). The significance level was set at $p < 0.05$. Each statistical analysis

procedure in this study was performed using the IBM SPSS Statistic for Windows, Version 26.0 (SPSS Inc., Chicago IL).

CHAPTER 4

RESULTS

The descriptive statistics for chronological ages, height, sitting height, body mass, BMI, height z-score, height percentile, body mass z-score, body mass percentile, BMI z-score, BMI percentile, APHV, and maturity offset are presented by five age groups (11, 12, 13, 14, and 15) in Table 1 for girls and Table 2 for boys.

Table 1. Descriptive statistics for girls

Ages	11 (n = 5)	12 (n = 16)	13 (n = 13)	14 (n = 15)	15 (n = 11)
Chronological age (years)	10.87 ± 0.15	11.51 ± 0.26	12.49 ± 0.34	13.54 ± 0.24	14.73 ± 0.33
Height (cm)	145.73 ± 1.36	149.89 ± 4.49	156.09 ± 6.12	157.48 ± 4.96	161.04 ± 7.29
Sitting height (cm)	77.33 ± 0.86	76.97 ± 2.85	81.35 ± 4.02	82.79 ± 3.01	84.89 ± 3.61
Body mass (kg)	35.30 ± 4.45	37.65 ± 5.24	46.49 ± 8.81	52.06 ± 9.44	52.95 ± 5.16
Body Mass Index (kg/m^2)	16.63 ± 2.06	16.85 ± 2.23	19.14 ± 3.41	21.02 ± 3.44	20.59 ± 2.16
Height (z-scores)	-0.03 ± 0.21	0.13 ± 0.60	0.30 ± 0.82	-0.13 ± 0.69	-0.04 ± 1.05
Height (percentiles)	48.10 ± 7.37	53.67 ± 19.85	57.65 ± 22.81	46.25 ± 24.31	49.59 ± 34.63
Body mass (z-scores)	-0.37 ± 0.57	-0.33 ± 0.60	0.17 ± 0.79	0.31 ± 0.84	0.16 ± 0.44
Body mass (percentiles)	36.57 ± 18.32	38.62 ± 21.32	55.73 ± 25.21	61.27 ± 25.86	55.76 ± 16.45
Body Mass Index (z-scores)	-0.47 ± 0.76	-0.50 ± 0.78	-0.02 ± 0.93	0.28 ± 0.87	0.07 ± 0.57
Body Mass Index (percentiles)	35.83 ± 24.89	34.31 ± 24.92	48.71 ± 29.81	59.97 ± 25.97	53.19 ± 19.95
APHV (years)	11.87 ± 0.06	12.04 ± 0.34	11.98 ± 0.43	12.31 ± 0.36	12.64 ± 0.49
Maturity offset (years)	-1.00 ± 0.20	-0.52 ± 0.31	0.49 ± 0.49	1.23 ± 0.39	2.06 ± 0.43

Table 2. Descriptive statistics for boys

Ages	11 (n = 12)	12 (n = 7)	13 (n = 19)	14 (n = 7)	15 (n = 12)
Chronological age (years)	10.73 ± 0.21	11.47 ± 0.37	12.65 ± 0.23	13.41 ± 0.28	14.52 ± 0.35
Height (cm)	148.61 ± 6.50	152.25 ± 8.49	158.80 ± 5.85	160.37 ± 6.70	168.36 ± 6.98
Sitting height (cm)	77.09 ± 3.28	78.60 ± 3.74	81.94 ± 3.93	81.89 ± 3.74	86.97 ± 3.78
Body mass (kg)	41.20 ± 8.25	46.47 ± 17.39	47.79 ± 6.76	51.51 ± 8.70	61.44 ± 9.60
Body Mass Index (kg/m^2)	18.69 ± 3.97	19.63 ± 4.97	19.04 ± 2.89	19.98 ± 2.40	21.79 ± 3.23
Height (z-scores)	0.71 ± 0.96	0.57 ± 1.20	0.48 ± 0.65	0.18 ± 0.72	0.37 ± 0.75
Height (percentiles)	70.51 ± 27.83	62.48 ± 26.34	65.51 ± 20.87	56.41 ± 25.21	60.47 ± 21.97
Body mass (z-scores)	0.11 ± 0.85	0.22 ± 1.29	0.13 ± 0.52	0.18 ± 0.69	0.61 ± 0.64
Body mass (percentiles)	55.81 ± 25.52	49.87 ± 28.57	53.69 ± 17.90	58.23 ± 23.01	69.23 ± 17.41
Body Mass Index (z-scores)	0.28 ± 1.22	0.40 ± 1.34	0.05 ± 0.84	0.22 ± 0.80	0.47 ± 0.86
Body Mass Index (percentiles)	57.42 ± 34.43	54.53 ± 29.71	50.76 ± 25.46	60.40 ± 22.45	63.50 ± 24.63
APHV (years)	13.14 ± 0.44	13.35 ± 0.62	13.63 ± 0.46	13.98 ± 0.49	13.87 ± 0.49
Maturity offset (years)	-2.40 ± 0.32	-1.85 ± 0.56	-0.98 ± 0.49	-0.60 ± 0.61	0.67 ± 0.58

The mean height percentiles of female players are given in Figure 1. The heights of female players fell within the range of the 45th - 57th percentiles. The average percentile was found to be the lowest in 15-year-old girls and the highest in 12-year-old girls. The percentiles of other age groups were fairly consistent around the 50th percentile mark. Within the female groups, the lowest individual percentile was recorded in a 15-year-old girl at the 11th percentile, while the highest individual percentile belonged to a 12-year-old girl at the 99th percentile. According to Figure 1, there is a noticeable increase in height percentiles between the ages of 11 and 12, with a tendency to decrease from 12 to 15, although there was a slight increase from 13 to 14.

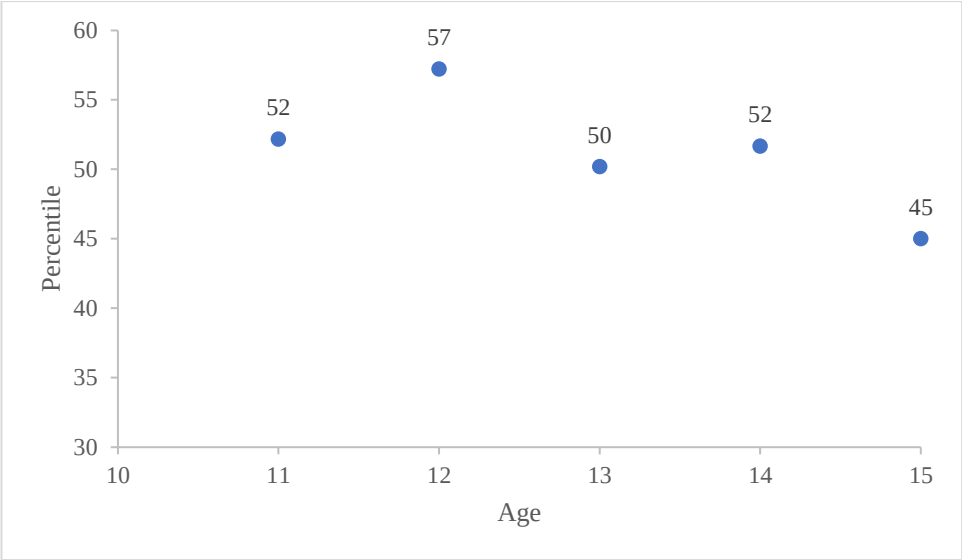


Figure 1. Height percentile chart for girls

The mean body mass percentiles of female players are given in Figure 3. The body masses of the female players ranged from the 40th to 65th centiles, with the lowest average percentile observed in 11-year-old girls and the highest in 14-year-old girls. The percentiles of the other age groups fell within the range of 44th to 56th centiles. Within the female groups, the lowest individual percentile was recorded in a 13-year-old girl at the 6th percentile, while the highest individual percentile belonged to another 13-year-old girl at the 94th percentile. Based on Figure 3, there was a tendency for body mass percentiles to increase as age increased from 11 to 14, but a decrease was observed from 14 to 15.

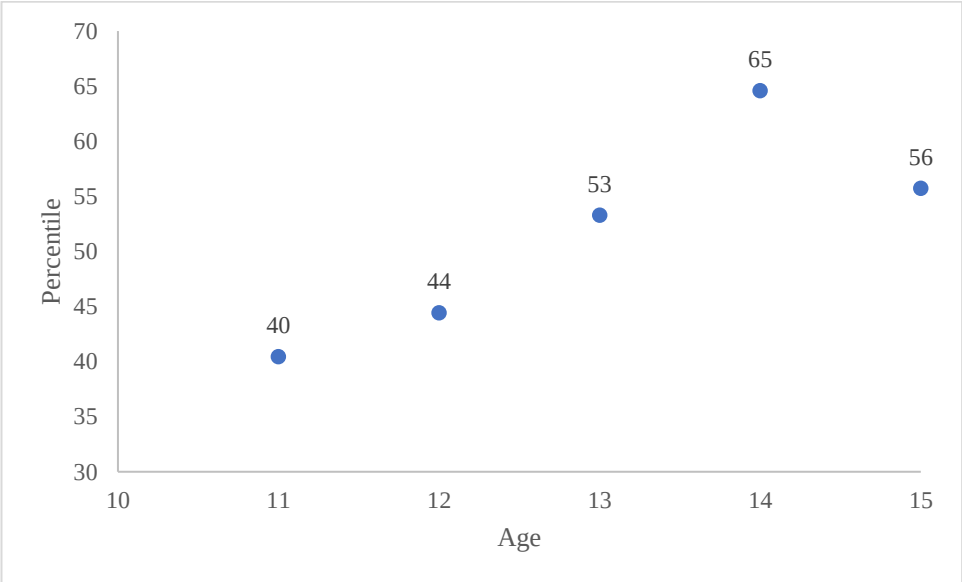


Figure 3. Body mass percentile chart for girls

The mean BMI percentiles of female players are given in Figure 5. The BMI values of the female players ranged between the 37th and 62nd centiles. The lowest average percentile was found in 12-year-old girls, while the highest average percentile was observed in 14-year-old girls. The percentiles of the other age groups fell within the range of 39th to 55th centiles. Within the female groups, the lowest individual percentile was recorded in a 12-year-old girl at the 3rd percentile, while the highest individual percentile belonged to a 14-year-old girl at the 95th percentile. Based on Figure 5, there was a tendency for BMI percentiles to increase as age increased from 11 to 14, despite a slight decrease from 11 to 12. However, from 14 to 15, a decrease in BMI percentiles was observed.

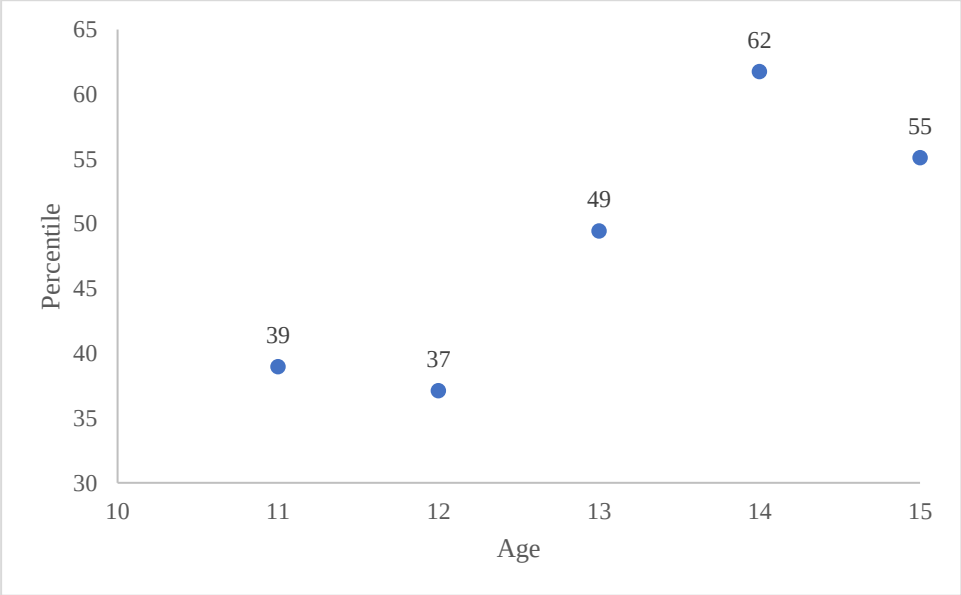


Figure 5. BMI percentile chart for girls

The mean height percentiles of male players are given in Figure 2. The heights of male players fell within the range of 54th to 69th centiles, with the lowest average percentile observed in 14-year-old boys and the highest in 11-year-old boys. The percentiles of the other age groups were found to be between the 60th and 65th centiles. Within the male groups, the lowest individual percentile was recorded in an 11-year-old boy at the 14th percentile, while the highest individual percentile belonged to another 11-year-old boy at the 99th percentile. Based on Figure 2, there was a tendency for height percentiles to decrease as age increased from 11 to 14, but an increase was observed from 14 to 15.

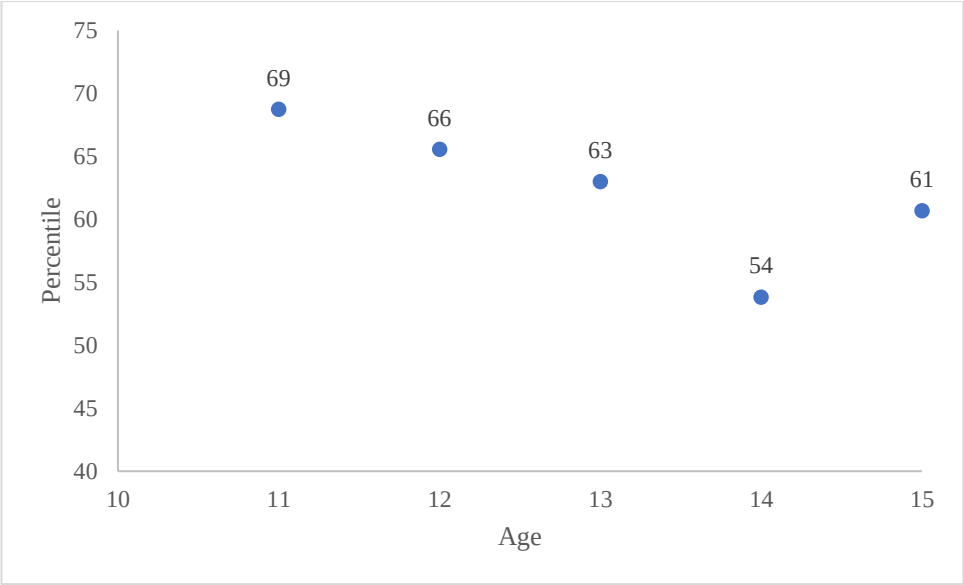


Figure 2. Height percentile chart for boys

The mean body mass percentiles of male players are given in Figure 4. The body masses of male players were within the range of 49th to 74th centiles, with the lowest average percentile observed in 12-year-old boys and the highest in 14-year-old boys. The percentiles of the other age groups were found to be between the 55th and 64th centiles. Within the male groups, the lowest individual percentile was recorded in an 11-year-old boy at the 4th percentile, while the highest individual percentile belonged to another 11-year-old boy at the 99th percentile. Based on Figure 4, there were increases in body mass percentiles as age increased from 12 to 14, while there were decreases from 11 to 12 and from 14 to 15.

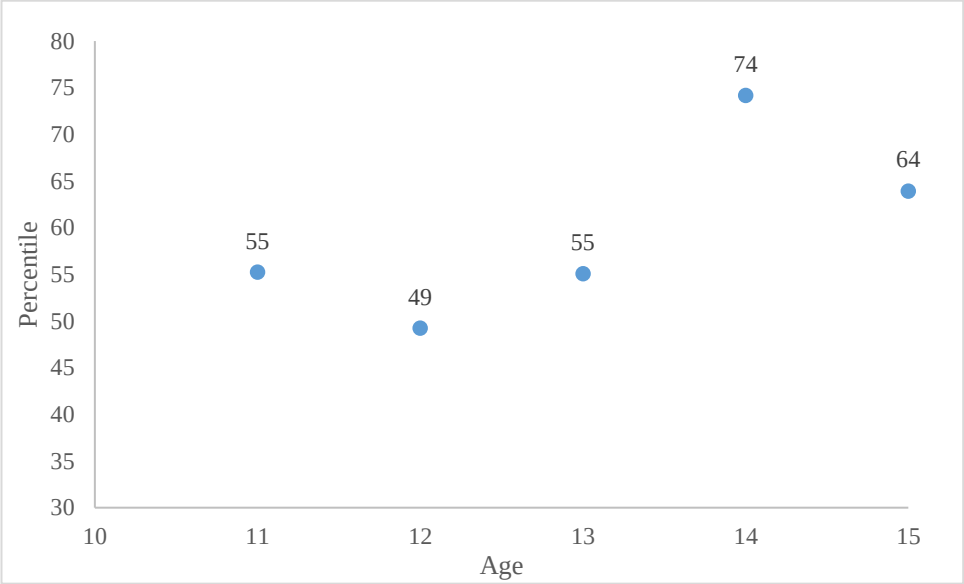


Figure 4. Body mass percentile chart for boys

The mean BMI percentiles of male players are given in Figure 6. The BMI values of male players ranged from the 48th to the 80th centiles, with the lowest average percentile observed in 12-year-old boys and the highest in 14-year-old boys. The percentiles of the other age groups were around the 55th centile. Within the male groups, the lowest individual percentile was recorded in a 13-year-old boy at the 2nd percentile, while the highest individual percentile belonged to an 11-year-old boy at the 99th percentile. According to Figure 6, there were increases in the BMI percentiles as age increased from 12 to 14, while there were decreases from 11 to 12 and from 14 to 15.

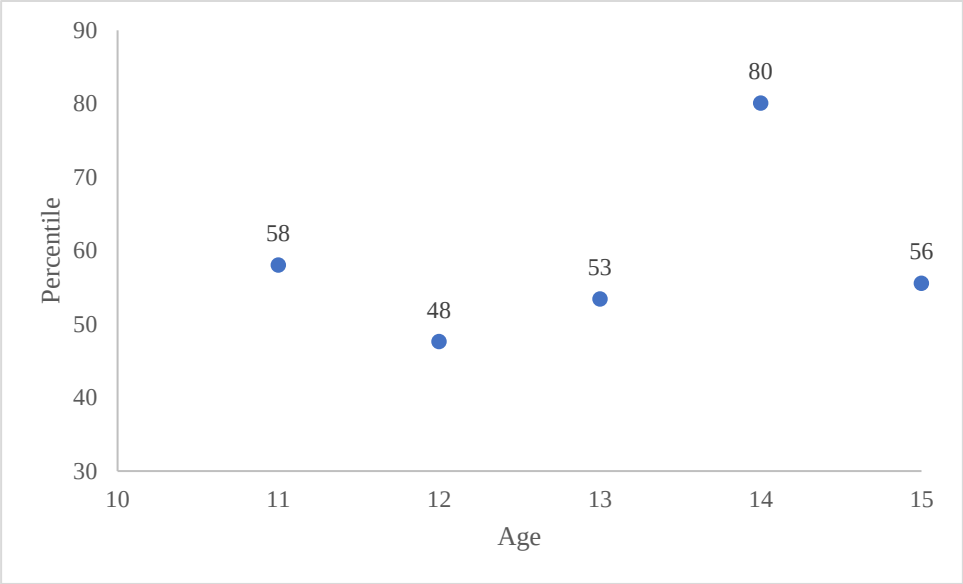


Figure 6. BMI percentile chart for boys

The descriptive statistics and gender differences are presented in Table 3. Significant gender differences were observed in several variables. Boys were found to be significantly taller than girls ($p < 0.05$) when their heights were compared. Boys also had significantly higher height z scores ($p < 0.05$) and percentiles ($p < 0.05$) than girls. In terms of APHV, girls reached their PHV significantly earlier than boys ($p < 0.001$). Girls were also significantly more advanced in maturation than boys ($p < 0.001$) when maturity offset values were analyzed. No significant differences were observed between boys and girls in other variables.

Table 3. Gender differences

	Gender					
	Girls (n = 60)	Boys (n =57)	*t*	*p*	*d*	qualitative
Chronological age (years)	12.99 ± 1.24	12.86 ± 1.35	0.551	0.583	0.003	Trivial
Training age (years)	5.22 ± 1.25	4.97 ± 1.68	0.891	0.375	0.007	Trivial
Weekly training (hours/week)	15.30 ± 5.49	14.64 ± 6.81	0.576	0.566	0.003	Trivial
Height (cm)	155.88 ± 7.01	159.32 ± 9.37	-2.257	0.026	0.042	Trivial
Sitting height (cm)	81.50 ± 4.29	82.14 ± 4.97	-0.745	0.458	0.005	Trivial
Body mass (kg)	47.19 ± 9.62	50.92 ± 11.63	-1.892	0.061	0.030	Trivial
Body Mass Index (kg/m^2)	19.41 ± 3.28	19.95 ± 3.43	-0.875	0.383	0.007	Trivial
Height (z-scores)	0.07 ± 0.78	0.44 ± 0.80	-2.540	0.012	0.053	Trivial
Height (percentiles)	51.66 ± 24.99	62.90 ± 23.33	-2.511	0.013	0.052	Trivial
Body mass (z-scores)	0.09 ± 0.72	0.27 ± 0.74	-1.358	0.177	0.016	Trivial
Body mass (percentiles)	53.12 ± 23.68	58.59 ± 21.65	-1.302	0.195	0.015	Trivial
Body Mass Index (z-scores)	-0.03 ± 0.84	0.26 ± 0.94	-1.813	0.072	0.028	Trivial
Body Mass Index (percentiles)	49.40 ± 26.55	57.42 ± 26.24	-1.643	0.103	0.023	Trivial
APHV (years)	12.21 ± 0.47	13.66 ± 0.55	-15.210	0.001	0.668	Moderate
Maturity offset (years)	0.77 ± 1.04	-0.79 ± 1.18	7.589	0.001	0.334	Small

The comparison between medal-winning and non-medal-winning players for girls is presented in Table 4. There were no significant differences between medal-winning and non-medal-winning girls in any variable.

Table 4. Comparison between Medal-Winning and Non-Medal-Winning players for girls

	Medal Status					
	Medal Winning (n=16)	Non-medal winning (n=44)	*t*	*p*	*d*	qualitative
Chronological age (years)	13.07 ± 1.23	12.97 ± 1.26	-0,282	0,779	0,001	Trivial
Training age (years)	5.66 ± 1.15	5.06 ± 1.25	-1,672	0,100	0,046	Trivial
Weekly training (hours/week)	15.91 ± 6.73	15.08 ± 5.04	-0,512	0,610	0,004	Trivial
Height (cm)	157.93 ± 6.57	155.13 ± 7.09	-1,373	0,175	0,031	Trivial
Sitting height (cm)	82.79 ± 4.79	81.03 ± 4.06	-1,414	0,163	0,033	Trivial
Body mass (kg)	46.63 ± 9.67	47.40 ± 9.70	0,274	0,785	0,001	Trivial
Body Mass Index (kg/m^2)	18.62 ± 2.92	19.70 ± 3.39	1,130	0,263	0,022	Trivial
Height (z-scores)	0.29 ± 0.93	-0.02 ± 0.72	-1,333	0,188	0,030	Trivial
Height (percentiles)	58.18 ± 27.66	49.29 ± 23.84	-1,224	0,226	0,025	Trivial
Body mass (z-scores)	0.01 ± 0.72	0.12 ± 0.72	0,489	0,626	0,004	Trivial
Body mass (percentiles)	51.46 ± 23.98	53.72 ± 23.82	0,325	0,746	0,002	Trivial
Body Mass Index (z-scores)	-0.26 ± 0.74	0.05 ± 0.86	1,289	0,203	0,028	Trivial
Body Mass Index (percentiles)	42.71 ± 24.11	51.83 ± 27.24	1,181	0,242	0,023	Trivial
APHV (years)	12.16 ± 0.59	12.23 ± 0.43	0,564	0,575	0,005	Trivial
Maturity offset (years)	0.91 ± 0.97	0.72 ± 1.07	-0,646	0,521	0,007	Trivial

The comparison between medal-winning and non-medal-winning players for boys is presented in Table 5. Except for training age, no significant differences were observed in any of the variables between medal-winning and non-medal-winning boys. When the training age of male players was analyzed, it was found that medal-winning boys had significantly more experience in regular table tennis training than non-medal-winning boys ($p < 0.05$).

Table 5. Comparison between Medal-Winning and Non-Medal-Winning players for boys

	Medal Status					
	Medal Winning (n=11)	Non-medal winning (n=46)	*t*	*p*	*d*	qualitative
Chronological age (years)	12.48 ± 1.34	12.95 ± 1.35	1.039	0.303	0.019	Trivial
Training age (years)	5.95 ± 1.27	4.74 ± 1.69	-2.230	0.030	0.083	Trivial
Weekly training (hours/week)	17.95 ± 6.15	13.85 ± 6.78	-1.833	0.072	0.058	Trivial
Height (cm)	157.63 ± 11.91	159.73 ± 8.77	0.664	0.509	0.008	Trivial
Sitting height (cm)	80.90 ± 5.98	82.43 ± 4.73	0.917	0.363	0.015	Trivial
Body mass (kg)	47.85 ± 12.80	51.65 ± 11.37	0.972	0.335	0.017	Trivial
Body Mass Index (kg/m^2)	18.98 ± 2.82	20.18 ± 3.54	1.047	0.300	0.020	Trivial
Height (z-scores)	0.50 ± 0.99	0.42 ± 0.76	-0.290	0.773	0.002	Trivial
Height (percentiles)	63.85 ± 26.50	62.67 ± 22.83	-0.149	0.882	0.000	Trivial
Body mass (z-scores)	0.12 ± 0.77	0.31 ± 0.74	0.760	0.450	0.010	Trivial
Body mass (percentiles)	55.24 ± 22.47	59.39 ± 21.62	0.568	0.572	0.006	Trivial
Body Mass Index (z-scores)	0.08 ± 0.77	0.31 ± 0.98	0.714	0.478	0.009	Trivial
Body Mass Index (percentiles)	54.76 ± 24.94	58.06 ± 26.77	0.371	0.712	0.002	Trivial
APHV (years)	13.61 ± 0.57	13.67 ± 0.56	0.311	0.757	0.002	Trivial
Maturity offset (years)	-1.14 ± 1.34	-0.70 ± 1.13	1.102	0.275	0.022	Trivial

CHAPTER 5

DISCUSSION

This study aimed to determine the growth and maturity status of young medal-winning table tennis players and compare them with their non-medal-winning counterparts. There were three main findings of the study. First, the mean height, body mass, and BMI percentiles for both boys and girls were above the 37th percentile when compared to normative references of the same age and gender. These findings indicate that table tennis players are taller, heavier, and have higher BMI values than the 37% of the population. Second, boys were significantly taller than girls, with higher height z-scores and percentiles. On the other hand, girls were more advanced in maturation than boys and reached their PHV earlier than boys. Third, regarding performance, there were no significant differences between medal-winning and non-medal-winning girls in any variable, and except for training age, no significant differences were found among boys.

The study found that the heights of female table tennis players generally fell within the range of the 45th to 57th percentiles. On the other hand, the heights of male players ranged from the 54th to the 69th centiles. These findings are consistent with previous studies in racket sports, supporting the notion that height variations are common among players in racket sports players (Baxter-Jones et al., 1995; Coelho-E-Silva et al., 2021; Erlandson et al., 2008; Myburgh et al., 2016; Söğüt et al., 2019; Söğüt et al., 2023). In a study conducted with young male table tennis players (10-14.63 years), Coelho-E-Silva et al. (2021) found that the mean heights varied between the 75th and 90th percentiles, except for the 14-year-old players approximating the 50th percentile. The study by Söğüt et al. (2019) revealed that the heights of both 12-year-old boys (54.9) and girls (56.3) were higher than the average compared to normative references of the same age and gender.

The study observed that female table tennis players had a range of body masses falling between the 40th and 65th percentiles. On the other hand, male players exhibited body masses ranging from the 49th to the 74th centiles. These results align with previous studies conducted in racket sports, indicating that body mass variations are commonly observed among players (Baxter-Jones et al., 1995; Coelho-E-Silva et al., 2021; Erlandson et al., 2008; Myburgh et al., 2016; Söğüt et al., 2019; Söğüt et al., 2023). According to a study conducted by Coelho-E-Silva et al. (2021) on young male table tennis players, the mean body masses were close to the median at 10-year-olds. Between the ages of 11 and 13, the mean body masses shifted to the 75th percentile, indicating a higher weight range. However, at the age of 14, the mean body masses returned to being close to the median. The findings of Söğüt et al. (2023) displayed similar results with both U14 male (53.5) and female (53.6) tennis players above the 50th percentile when compared to age- and gender-matched normative references for mean body masses. Myburgh et al. (2016) found that the mean body masses of boys in the U10 age group are approximately at the 75th percentile, while for the other age groups (U12, U14, and U16), they range between the 75th and 90th percentiles.

Regarding BMI percentiles, the study reported that female table tennis players had BMI values ranging between the 37th and 62nd centiles. In comparison, the BMI values of male players ranged from the 48th to the 80th percentiles. These findings are consistent with previous research conducted in racket sports (Coelho-E-Silva et al., 2021; Erlandson et al., 2008; Myburgh et al., 2016; Söğüt et al., 2019; Söğüt et al., 2023). The study by Söğüt et al. (2019) revealed that the BMI percentiles of 12-year-old male and female tennis players were higher than the average compared to normative references of the same age and gender. Another study by Söğüt et al. (2023) revealed that the BMI percentiles of U14 male tennis players were slightly below the median (49.5), whereas the BMI percentiles of U14 female tennis players were above the median (57.3). Findings indicate that there appears to be a tendency towards larger body sizes among young table tennis players.

Notable gender differences were observed, with boys being significantly taller than girls and having higher height z-scores and percentiles. Conversely, girls were more advanced in maturation, reaching their PHV earlier than boys. These results are in line

with the previous studies in racket sports (Myburgh et al., 2016; Söğüt et al., 2019; Söğüt et al., 2023). A study by Söğüt et al. (2019) examined the relationship between growth, maturity status, body composition, motor performance, and sport-specific experience with the national ranking of U-12 male and female tennis players. The study results indicated that girls exhibited more advanced maturation than boys. Contrary to the findings of the present study, it was observed that girls were significantly taller than boys. Another study by Söğüt et al. (2023) revealed that boys exhibited greater height and lower BMI values than girls. Conversely, girls were observed to be more advanced in terms of maturation than boys. The reason for this outcome could be attributed to the timing of the growth spurt since girls typically reach their maximum height about two years ahead of boys (Beunen & Malina, 2008; Malina et al., 2004).

Regarding performance, there were no significant differences between medal-winning and non-medal-winning girls in any variable, whereas, for boys, no significant differences were found except for the training age. Medal-winning boys had significantly more experience in regular table tennis training than non-medal-winning boys. In line with the findings of the current study, a previous study conducted by Söğüt et al. (2019) revealed that factors such as experience, training volume, and motor performance were significantly linked to ranking for both boys and girls, whereas no association between maturity status and rankings were found. However, another study conducted by Söğüt et al. (2023) reported different findings. Their results indicated no significant differences among the three groups (national team, main draw, and qualifying) for all parameters in boys. Conversely, for girls, both national and main draw players were found to be significantly more advanced in maturation and had higher BMI values compared to qualifying players.

The findings of the study have several practical implications for coaches, trainers, and policymakers. Firstly, the physical traits of medal-winning table tennis players, such as their heights, body masses, and BMI values, should be taken into account while developing talent identification and development programs. Second, gender differences should be considered since girls often mature earlier than boys and boys typically tend to be taller. It is vital to adjust training and development strategies to

these gender-specific traits. Thirdly, because training age was found to be connected with medal-winning in boys, policymakers should give priority to providing enough training opportunities and organized programs. Fourthly, a holistic approach to talent identification, considering multiple factors like physical attributes, maturation, and training experience, is recommended. Finally, coaches, trainers, and policymakers should take into account the distinctive growth patterns and physical traits of table tennis players when incorporating these findings into long-term athlete development programs.

There are several limitations to be acknowledged in this study. Firstly, the exclusion of tactical, technical, and psychological performance indicators limits the comprehensive understanding of the players' overall performance. These factors play a significant role in table tennis performance and should be considered in future studies to provide a more holistic assessment. Secondly, the sample is limited to young Turkish table tennis players within a specific age range of 10-15 years. This limited sample size and geographical focus may restrict the generalizability of the findings to a broader population of table tennis players from different regions and age groups. Including participants from diverse backgrounds would provide a more representative and inclusive analysis of physical growth and maturity in table tennis. Moreover, the study primarily adopts a cross-sectional design, providing a snapshot of the participants' characteristics at a specific point in time. Longitudinal studies are essential to fully understand the development and long-term implications of physical growth and maturity in table tennis. Long-term follow-up studies that track participants into young adulthood would provide valuable insights into the trajectory of physical growth and maturity and their impact on performance. Considering these limitations, future research should include a broader range of performance indicators, diversify the participant pool, and employ longitudinal designs with extended follow-up periods. These efforts would contribute to a more comprehensive understanding of the multifaceted nature of table tennis performance and the long-term implications of physical growth and maturity.

5.1. Conclusion

This study investigated the growth and maturity status of young medal-winning table tennis players and compared them with non-medal-winning players. Both boys and girls exhibited higher mean height, body mass, and BMI percentiles compared to normative references, indicating a trend towards larger body sizes in young table tennis players. Boys were taller, while girls were more advanced in maturation. However, these differences did not significantly affect the performance of medal-winning players, except for the training age in boys, where medal-winning players had more training experience than their non-medal-winning counterparts. The findings highlight the importance of individualized training programs considering gender-specific differences in growth and maturity. Coaches should monitor the growth and maturity status of the players and adapt training strategies by taking into account the physical characteristics of the players. Longitudinal studies and the inclusion of additional performance indicators are needed to gain a more comprehensive understanding of table tennis performance and its relationship to physical growth and maturity.

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APPENDICES

A. APPROVAL OF THE METU HUMAN SUBJECTS ETHICS COMMITTEE

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14 MART 2022

Konu : Değerlendirme Sonucu

Gönderen: ODTÜ İnsan Araştırmaları Etik Kurulu (İAEK)

İlgi : İnsan Araştırmaları Etik Kurulu Başvurusu

Sayın [redacted]

Danışmanlığını yürüttüğünüz [redacted]'in " Growth and maturity status of medal-winning young table tennis players." başlıklı araştırmanız İnsan Araştırmaları Etik Kurulu tarafından uygun görülmüş ve **0149-ODTUİAEK-2022** protokol numarası ile onaylanmıştır.

Saygılarımızla bilgilerinize sunarız.

[redacted]
İAEK Başkan

B. TURKISH SUMMARY / TÜRKÇE ÖZET

1. GİRİŞ

Başlıca raket sporları tenis, masa tenisi, badminton ve squashtır ve yüz yılı aşkın bir süredir milyonlarca insan bu sporlarla ilgilenmektedir (Lees, 2003; Robertson, Pion, Mostaert, Wazir, Kramer, Faber, Vansteenkiste & Lenoir, 2018). Araştırmalar raket sporlarının beyin ile el, göz ve ayak arasındaki koordinasyona olumlu etkilerinin yanı sıra hız, dayanıklılık, esneklik, çeviklik, refleksler, genel fiziksel kalite ve çalışma belleğini de geliştirebileceğini de göstermiştir (Jaworski, Lech, Ambroży & Żak, 2020; Schaefer & Scornaienchi, 2019).

Raket sporları görev gereksinimleri, maç performansları ve bireysel yetenek belirleyicileri açısından benzerlik göstermektedir ve yüksek yoğunluklu egzersizlerin sürekli olarak gerçekleştiği sporlardır (Faber, Bustin, Oosterveld, Elferink-Gemser & Nijhuis-Van Der Sanden, 2016; Pluim, 2004). Ancak görünüşteki benzerliklerine rağmen, raketi savurma şekilleri, saha büyüklüğü ve topun hızı gibi konularda ise büyük farklılık göstermektedirler (Ak & Koçak, 2010; Akpınar, Devrilmez & Kirazcı, 2012).

Büyükler tenis maçlarında top hızı genellikle saatte 100 km/sa (27 m/s) civarındayken genç maçlarında ise bu hız daha yavaş olabilmektedir (Ferrauti & Bastiaens, 2007; Iino & Kojima, 2009). Teniste iki servis çizgisi arasındaki mesafe 25 metredir, oyuncuların tepki süresi bir saniyeden daha azdır. Badmintonda kullanılan topun ortalama hızı yaklaşık olarak 125 km/sa (35 m/sn) (Chen, Pan, & Chen, 2009; Tsai, Huang, & Jih, 1997) ve oyuncular arasındaki mesafe de 13.4 metredir, bu da oyuncuların tepki süresinin 0.5 saniye civarında olduğunu gösterir. Masa tenisinde topun ortalama hızı yaklaşık olarak 36 km/sa (10 m/s) civarındadır (Durey & Seydel, 1994). Oyuncular arasındaki mesafe ise yaklaşık olarak ortalama 3 metredir ve bu da oyunculara 0.5 saniyeden daha az bir tepki süresi verir. Masa tenisi, diğer raket sporlarıyla kıyaslandığında daha küçük bir alanda daha hızlı reaksiyon gerektiren bir spordur (Ak & Koçak, 2010).

Küresel veya kıtasal çaptaki masa tenisi turnuvaları genellikle bir hafta sürer ve oyuncular bazen günde birden çok maç yaparlar. Bu turnuvalar yoğun program, güçlü rakipler, diyet ve uyku düzenindeki değişiklikler, farklı ortam ve zaman dilimi gibi çeşitli faktörler nedeniyle yorucu olabilir (Yan, 1992) ve bu nedenle bir masa tenisi oyuncusunun mükemmel fiziksel zindeliğini ve mental sağlığını koruması önemlidir (Kondrič, Zagatto & Sekulic, 2013). Hız, patlayıcı güç, teknik beceriler, ayak hareketleri, öngörü yeteneği ve tepki süresi masa tenisi performansını etkileyen önemli faktörlerdir (Ak & Koçak, 2010; Akpınar et al., 2012; Sève, Saury, Theureau & Durand, 2002). Bunların yanında oyuncuların büyüme ve olgunlaşma durumu, antrenman geçmişi, maç deneyimi ve fiziksel özellikler de masa tenisi performansında etkili olan faktörlerdir (Coelho-e-Silva et al., 2021).

12 yaşındaki bir çocuğun biyolojik olgunluğu 9 ila 15 yaş arasında değişebilir (Borms, 1986); bu nedenle, sınıflandırmada yalnızca takvim yaşına güvenmek uygun olmayabilir ve büyüme ve olgunlaşma durumları gibi faktörler de göz önünde bulundurulmalıdır. Masa tenisi, düzenli olarak ve müsabık bir şekilde milyonlarca insan tarafından oynanan popüler bir spordur ve masa tenisine yönelik yapılan çalışmalar artmaktadır; ancak genç masa tenisi oyuncularının büyüme ve olgunlaşma durumuyla ilgili literatürün kapsamı geniş değildir (Coelho-e-Silva et al., 2021). Bu nedenle, genç masa tenisi oyuncularının büyüme ve olgunlaşma durumuyla ilgili daha fazla araştırma yapılması önemlidir (Malina, Bouchard & Bar-Or, 2004).

1.1. Çalışmanın amacı

Bu çalışmanın amacı, madalya kazanan genç masa tenisi oyuncularının büyüme ve olgunluk durumlarını belirlemek ve madalya kazanan ve kazanmayan oyuncuları karşılaştırmaktı.

1.2. Araştırma soruları

Bu çalışmada, madalya kazanan ve madalya kazanamayan genç müsabık masa tenisi oyuncuları arasında büyüme ve olgunlaşma durumlarının farklılık gösterip göstermediği araştırılmıştır.

1.3. Çalışmanın önemi

Büyüme ve olgunlaşma ile ilgili raket sporlarındaki literatür, çalışmaların çoğunlukla teniste yapıldığını ve masa tenisiyle ilgili sadece iki çalışma olduğunu göstermektedir. Bunlardan biri sadece erkek oyuncularla yapılan ve madalya kazanma durumu veya oyuncuların sıralaması hakkında bilgi vermeyen bir çalışma iken, diğeri de madalya kazanma veya sıralama bilgisi olmadan genç masa tenisi oyuncuları üzerinde çok boyutlu bir yaklaşımın etkisine odaklanmıştır. Özet olarak, genç masa tenisine yönelik çalışmalar genç müsabık masa tenisi oyuncularının büyüme ve olgunlaşma durumu ile madalya kazanma durumu arasındaki ilişkiye odaklanmamıştır. Bu çalışma, büyüme ve olgunlaşma durumunun genç müsabık masa tenisi oyuncularının madalya kazanma durumunu nasıl etkilediğini ardışık yaşlarda araştırması açısından özgündür. Bu araştırmayı masa tenisiyle ilgili politika belirleme süreçlerine entegre etmek, masa tenisinde yetenek tespiti, geliştirme programları ve uzun vadeli sporcu gelişim planları için değerli bir bakış açısı sağlayabilir.

2. LİTERATÜR TARAMASI

Bu kısımda çocuklarda büyüme ve olgunlaşmayı etkileyen faktörler ve büyüme ve olgunlaşma durumu değerlendirme metotları incelenecektir. Ayrıca, büyüme ve olgunlaşmanın genç sporcular üzerindeki etkileri ve literatürdeki bunlarla ilgili çalışmalar incelenecektir.

2.1. Çocuklarda Büyüme ve Olgunlaşma

Birbirleriyle eşanlamlı olarak kullanılsalar da büyüme ve olgunlaşma terimleri tamamen farklı biyolojik süreçleri temsil eder (Cameron, 2022a; Malina, Bouchard ve Bar-Or, 2004). Olgunlaşma, vücudun iskelet, cinsel ve somatik sistemlerinin yetişkin haline doğru ilerlemesini ifade ederken, büyüme ise yaş aldıkça boyut ve vücut kompozisyonundaki değişiklikler olarak tanımlanabilir (Baxter-Jones, 1995; Baxter-Jones, Eisenmann ve Sherar, 2005; Cameron, 2022b; Malina ve ark., 2004).

Bu süreçlerin zamanlaması ve hızında önemli bireysel dalgalanmalar olabilirken, büyüme ve olgunlaşma genellikle tahmin edilebilir yollar takip eder (Baxter-Jones ve ark., 2002). Örneğin, ergenlik büyüme atağı genellikle hem boy hem de kiloda hızlı bir artışa neden olur ve erkekler genellikle kızlardan daha sonra bu atığı yaşar. Büyüme atağının zamanlaması ve süresi bireyler arasında önemli ölçüde farklılık gösterebilir, bu da antrenman ve spor performansını etkileyebilir.

2.2. Büyümeyi ve Olgunlaşmayı Etkileyen Faktörler

Büyüme ve olgunlaşma, çocukluk ve ergenlik döneminde meydana gelen karmaşık ve birbirine bağlı süreçlerdir (Malina ve ark., 2004). Bu süreç boyunca çocuklar boy, kilo, vücut kompozisyonu ve hormon seviyeleri gibi büyüme ve olgunlaşma ile ilgili önemli fiziksel değişiklikler geçirirler. Genetik, beslenme, çevresel faktörler ve fiziksel aktivite, bu değişiklikler üzerinde etkisi olan değişkenler arasındadır (Cameron ve Bogin, 2012; Rogol, Roemmich ve Clark, 2002).

2.3. Çocuklarda Büyüme ve Olgunlaşma Değerlendirmeleri

Fiziksel büyüme değerlendirmesi, zaman içindeki fiziksel gelişim değişikliklerini değerlendirmeyi ve izlemeyi içerir (Lohman, Roche & Martorell, 1988; Malina ve ark., 2004). Bu süreç genellikle vücut ağırlığı, boy uzunluğu, oturma yüksekliği ve deri kıvrım kalınlığı, uzuv çevresi ve iskelet genişlikleri gibi diğer fiziksel özelliklerin ölçülmesini ve kaydedilmesini içerir (Eston & Reilly, 2009).

Boy uzunluğu ve vücut ağırlığı değerlendirmeleri genellikle yaş ve cinsiyete özgü büyüme grafikleriyle karşılaştırılır ve bireyin büyüme durumunu değerlendirmek için büyüme grafikleri, farklı yaşlardaki bireylerin ortalama boy uzunluğu ve vücut ağırlığı ile her yaş grubu için beklenen büyüme hızı hakkında değerli veriler sunar (WHO, 2009).

Biyolojik olgunluğun değerlendirilmesi, çocuğun genel sağlık durumu ve gelişimi hakkında değerli bilgiler sağlayabilir. Ergenlik başlangıcı ve gelişimin hızı bireyler arasında farklılık gösterdiği için takvim yaşı biyolojik olgunluğun güvenilir bir göstergesi olmayabilir (Baxter-Jones, Helms, Maffulli, Baines-Preece & Preece, 1995; Kemper & Verschuur, 1981). Bu nedenle çocuğun biyolojik olgunluğunu değerlendirmek için objektif ölçümlere ihtiyaç vardır (Lloyd ve ark., 2014). Çocuğun gelişim aşamalarından geçerken meydana gelen fiziksel değişiklikleri ifade eden biyolojik olgunluk değerlendirmesi için iskelet, cinsel ve somatik olgunluk gibi çeşitli yöntemler vardır.

İskelet olgunluğu değerlendirmesi, bireyin iskelet sisteminin biyolojik yaşını belirlemek için kullanılan bir süreçtir. İskelet olgunluğu değerlendirmesi, ortodonti, ortopedi ve spor tıbbı gibi çeşitli alanlarda kullanılmaktadır (De Sanctis ve ark., 2010; Haiter-Neto ve ark., 2006; Martin ve ark., 2011). İskelet olgunluğunu değerlendirmek için Fels, Greulich-Pyle ve Tanner-Whitehouse yöntemleri gibi çeşitli yöntemler vardır. Her bir yöntem vücuttaki kemiklerin gelişimini değerlendirmek için farklı teknikler kullanır.

Cinsel olgunluk değerlendirmesi, çocuklarda ve ergenlerde cinsel gelişim düzeyini ve fiziksel olgunluğu belirlemek için kullanılan bir tıbbi değerlendirme yöntemidir. Değerlendirme, Tanner Ölçeği'ne dayanır ve ergenlik dönemindeki fiziksel değişiklikleri sınıflandırır (Tanner & Tanner, 1962). Tanner-Whitehouse yöntemi, ergenlik dönemindeki fiziksel değişiklikleri beş aşamada sınıflandırır. Bu aşamalar, ikincil cinsel karakteristiklerin gelişimine, kızlarda meme gelişimine ve erkeklerde testis büyümesine, ayrıca pubik kıllanma ve vücut şeklindeki değişikliklere dayanır (Spear, 2002).

Somatik olgunluğun değerlendirilmesi, zirve boy hızı yaşı (ZBHY) ve tahmini yetişkinlik boy uzunluğu (TYBU) yüzdesi gibi çeşitli göstergelerle yapılabilir. TYBU yüzdesi, çocuğun mevcut boyu ve biyolojik ebeveynlerinin ortalama boyu temel alınarak, çocuğun nihai yetişkin boyunu tahmin etmek için kullanılan bir yöntemdir. TYBU yüzdesi hesaplanarak, çocuğun yaş ve cinsiyetine göre ortalama boyun yüzdesi ifade edilir. ZBHY çocuğun en yüksek büyüme hızına ulaştığı yaşını ifade eder ve genellikle ergenlik döneminde gerçekleşir (Hebestreit & Bar-Or, 2008; Malina ve ark., 2021). ZBHY, çocuğun boy ölçümlerini bir büyüme grafiğine yerleştirerek ve büyüme hızının en yüksek olduğu noktayı belirleyerek hesaplanır. Bu yöntemde hızlı büyüme dönemlerinde, örneğin hayatın ilk yılı ve ergenlik büyüme atağı gibi zamanlarda, ölçümlerin sıklığını artırmak önerilir. Yaşamın ilk yılı için aylık ölçümler önerilirken, ergenlik büyüme atılımı için üç ayda bir ölçüm yapılması önerilmektedir (Eston & Reilly, 2009).

2.4. Genç Sporlarında Büyüme ve Olgunluk

Bu kısımda futbol, basketbol ve voleybol ağırlıklı olmak üzere genç sporlarında büyüme, olgunlaşma ve spor performansı arasındaki ilişki tartışılmıştır.

Futbolda büyüme ve olgunluk durumlarıyla ilgili yapılan araştırmalar, biyolojik olgunlaşmanın genç sporcuların fiziksel performansı, beceri gelişimi, oyuncu seçimi ve başarısı üzerindeki etkisine odaklanmıştır. Erken olgunlaşan futbolcuların genellikle fiziksel testlerde daha iyi performans gösterdiğini, geç olgunlaşan futbolcuların ise uyarlanabilir otokontrol becerileri için potansiyel gösterdiğini buldu.

İskelet ve cinsel olgunluk, ağırlık, boy ve maruz kalma süresi gibi faktörlerin performansı ve yaralanma riskini etkilediği bulundu. Çalışmalar ayrıca, yaşlarına göre olgunluk açısından ilerlemiş oyuncuları seçmeye yönelik bir eğilim olduğunun altını çizdi. Genel olarak araştırmalar, genç futbolcuların seçiminde ve geliştirilmesinde biyolojik olgunlaşma ve diğer faktörlerin dikkate alınmasının önemli olduğunu göstermektedir.

Basketboldaki araştırmalar, biyolojik olgunluk durumunun, yaşın, antropometrinin ve antrenman deneyiminin vücut boyutunu, fonksiyonel kapasiteleri ve basketbola özgü becerileri nasıl etkilediğini araştırdı. Erken olgunlaşan basketbol oyuncularının, geç olgunlaşan oyunculara kıyasla daha fazla fiziksel ve teknik beceri sergiledikleri bulundu. Olgunluk durumunun ve antrenman yaşının, bu becerilerdeki farklılıklara etki eden birincil faktörler olduğu bulundu. Araştırmalar, genç basketbolcuların seçiminde ve gelişiminde biyolojik olgunlaşma, yaş ve antrenman yaşının dikkate alınmasının gerektiğini vurgulamaktadır.

Voleybolda çalışmalar, biyolojik olgunlaşma durumuna dayalı olarak kinantropometrik özellikler, fiziksel uygunluk ve performanstaki farklılıkları incelemiştir. Erken olgunlaşan voleybolcular, özellikle erkekler, daha iyi güç, güç ve fiziksel test performansına sahip olma eğilimindedir. Yağ kütlesi yüzdesi, yaş, olgunlaşma ofseti ve kas ve kemik değişkenleri voleybolda fiziksel performansın belirleyicileridir.

Voleyboldaki çalışmalar, erkek ve kadın oyuncular arasındaki antropometrik özellikler ve fiziksel uygunluk performansındaki farklılıklara yoğunlaştı. Çalışmalar erkeklerin güç ve güçle ilgili testlerde üstünlük gösterdiği, kadınların ise esneklik testlerinde daha iyi performans göstermektedir. Cinsiyetler arasındaki bu farklılıklar, genç voleybolcuların seçiminde ve gelişiminde belirli fiziksel özelliklerin dikkate alınması gerektiğini vurgulamaktadır.

Genel olarak futbol, basketbol ve voleyboldaki çalışmalar, genç sporcuların seçiminde ve geliştirilmesinde biyolojik olgunlaşmanın, fiziksel performansın ve beceri gelişiminin önemini vurgulamaktadır. Erken olgunlaşma genellikle futbol ve

basketbolda daha iyi fiziksel performans ve teknik becerilerle ilişkilendirilirken, geç olgunlaşan oyuncular, futbolda uyarlanabilir otokontrol becerileri potansiyeli gösterdi. Çalışmalar ayrıca genç voleybolcuları seçerken ve geliştirirken fiziksel özelliklerde cinsiyet farklılıklarının dikkate alınmasının önemini vurguladı. Genel olarak, biyolojik olgunlaşmayı, yaşı, antrenman deneyimini ve belirli fiziksel özellikleri hesaba katan kapsamlı bir yaklaşım, bu sporlardaki yetenekleri belirlemeye ve geliştirmeye yardımcı olabilir.

2.4.1. Raket Sporlarında Büyüme ve Olgunluk

Raket sporlarıyla ilgili yapılan çalışmalar, özellikle teniste, genç oyuncuların büyüme ve olgunlaşma durumlarıyla performansları arasındaki ilişki hakkında bilgi sağlamıştır. Badminton ve squash gibi sporlarla ilgili bilgi eksikliği bulunmaktadır ve bu sporlarda daha fazla araştırmaya ihtiyaç duyulmaktadır.

Myburgh, Cumming, Silva, Cooke ve Malina (2016) çalışmasında, 8-17 yaş arasındaki 91 İngiliz genç tenis oyuncusunun büyüme ve olgunluk durumlarını incelemiştir. Bulgular kızların 8 yaşından itibaren kronolojik yaşlarına göre kemik yaşında ilerlemiş olduğunu, erkeklerin ise 8-12 yaşları arasında normal veya gecikmiş bir olgunlaşma gösterdiğini, ancak 14-16 yaşları arasında kemik yaşında ilerleme gösterdiğini belirtmiştir.

Söğüt, De Oliveira Luz, Kaya ve Altunsoy (2019) çalışmasında, 9.6-12.3 yaş arasındaki Türk tenis oyuncuları arasındaki fiziksel özellikler, deneyim, antrenman ve sıralama arasındaki ilişkileri incelemiştir. Kızlar, erkeklere göre daha uzun boylu ve olgunlaşma açısından daha ileri düzeyde bulunmuşlardır. Deneyim, antrenman hacmi ve motor performans her iki cinsiyet için de sıralama ile ilişkili bulunmuştur.

Söğüt, Ödemiş ve Durmuş (2023) çalışmasında, 70 14 yaş altı müsabık tenis oyuncusunun büyüme ve olgunlaşma durumları ile sıralama arasındaki ilişkileri incelemiştir. Çalışma, cinsiyet fark etmeksizin, oyuncuların ortalama boy uzunluğu ve vücut ağırlığı yüzdeliklerinin 60. yüzdelik dilimin üzerinde olduğunu buldu. Daha ileri

olgunlaşma ve daha yüksek VKİ'ler, kızlarda daha yüksek sıralamalarla ilişkilendirildi. Ancak erkekler için gruplar arasında anlamlı bir fark gözlenmedi.

Myburgh, Cumming, Coelho-E-Silva ve Malina (2020) çalışmasında, genç tenis oyuncularında yaş, cinsiyet ve biyolojik olgunluk düzeyi arasındaki ilişkileri incelemiştir. Bulgular, hızlanmanın gelişim eğrilerine göre kronolojik ve biyolojik yaşın bir fonksiyonu olarak değiştiğini gösterdi. Erken olgunlaşan erkekler ve kızlar, biyolojik yaşa göre hızlanma dikkate alındığında önemli ölçüde daha düşük performans gösterdi.

Fernandez-Fernandez, Alvarez-Dacal, Hernández-Davó ve Granacher (2023) çalışmasında, genç badminton oyuncularının olgunluk durumunu ve cinsiyetin fiziksel uygunluklarına etkisini incelemiştir. Pre-PHV (büyüme hızının öncesi), circa-PHV (büyüme hızının çevresi) ve post-PHV (büyüme hızının sonrası) gruplarına ayrılan oyuncular arasında fiziksel uygunluk testlerinde farklılıklar bulunmuştur. Erkekler, genellikle kızlardan daha iyi performans göstermişlerdir.

2.4.1.1. Masa Tenisinde Büyüme ve Olgunluk

Coelho-E-Silva ve ark. (2021) tarafından yapılan bir araştırmada, 99 genç erkek masa tenisi oyuncusunun büyüme ve olgunluk durumları incelendi. Bulgular, çoğu genç erkek masa tenisi oyuncusunun iskelet yaşına göre erken olgunlaştığını ve somatik göstergelere göre ortalama olgunlaştığını gösterdi. Sporcuların boy ve vücut ağırlıkları 10-13 yaş aralığında referans ortalamalarının üzerindeydi ve iskelet yaşları genellikle kronolojik yaşa göre ileriydi. Çalışma, masa tenisinin genellikle daha uzun boylu ve daha ağır olan, biyolojik olarak daha ilerlemiş sporcuları tutma eğiliminde olduğunu ve genç masa tenisi yarışmalarında yaş ve olgunlukla ilişkili değişkenlerin dikkate alınması gerektiğini önerdi.

Doherty, Martinent, Martindale ve Faber (2018) tarafından yapılan başka bir çalışmada ise, çok boyutlu profil oluşturma modelinin masa tenisi oyuncularının mevcut ve gelecekteki performansını tahmin edebilme potansiyelini araştırıldı. Sonuçlar, mevcut performans ile ZBHY, sprint testi, antrenman yaşı, olumlu

odaklanma, öğrenme sürecinde otokontrol ve öz değerlendirme arasında önemli ilişkiler olduğunu gösterdi. Ayrıca, pozitif odaklanma, öz denetim ve antrenman yılı ile gelecekteki performans (1 yıl sonraki performans) arasında da anlamlı ilişkiler bulundu. Bu çalışma, genç masa tenisi oyuncularının performansını ve gelişimini tahmin etmede çok boyutlu profil oluşturma yaklaşımının kullanışlı olabileceğine dair ön kanıtlar sunmuştur.

Raket sporlarında büyüme ve olgunlaşma üzerine mevcut literatür, özellikle masa tenisi, badminton ve squash bağlamında bilgi eksikliğine dikkat çekmektedir. Çalışmalar genellikle tenise odaklanmış olup, özellikle masa tenisi üzerine sınırlı sayıda araştırma bulunmaktadır. Masa tenisi üzerinde yapılan az sayıdaki çalışmalar ya madalya kazanma durumunu veya sıralama bilgisini raporlamamış ya da çok boyutlu yaklaşımların etkisini madalya kazanma veya sıralama sonuçlarını dikkate almadan incelemiştir. Bu durum, genç müsabık masa tenisi oyuncularının büyüme, olgunlaşma durumu ve madalya kazanma durumu arasındaki ilişkinin yeterince araştırılmadığını göstermektedir. Bu nedenle, genç madalya kazanan masa tenisi oyuncularının büyüme ve olgunlaşma durumu üzerine bir çalışma yapmak, bu araştırma boşluğunu doldurmak ve masa tenisinde yetenek belirleme programları ve uzun vadeli sporcu gelişim planları için karar vericilere değerli bilgiler sağlamak açısından önemlidir. Ayrıca, masa tenisi oyuncularının büyüme, olgunlaşma ve fiziksel özelliklerindeki farklılıkların genç masa tenisi yarışmalarının adil ve etkili olmasını artırabileceği dikkate alınmalıdır.

3. YÖNTEM

3.1. Örneklem

117 genç müsabık masa tenisi oyuncusundan oluşan bir örneklem kullanıldı. Örneklem, 57 erkek ve 60 kız oyuncudan oluşuyordu. Doğum tarihleri, antrenman süresi ve haftalık antrenman bilgileri oyunculardan, antrenörlerden ve ebeveynlerden toplandı. Madalya kazanma durumu bilgileri Türkiye Masa Tenisi Federasyonu'nun yıllık faaliyet raporlarından elde edildi. Dahil edilme kriterleri şunlardan oluşuyordu: (i) Türkiye Masa Tenisi Federasyonu'na kayıtlı olmak ve (ii) düzenli ve rekabetçi masa tenisi alanında en az iki yıl antrenman deneyimi sahibi olmak. Bu çalışmanın yürütülmesi, Orta Doğu Teknik Üniversitesi İnsan Araştırmaları Etik Kurulu tarafından "0149-ODTUİAEK-2022" protokol numarası ile uygun bulunmuştur ve çalışmanın ölçümlerini ve amacını açıkladıktan sonra çocuklardan ve ebeveynlerinden veya yasal vasilerinden yazılı onay alınmıştır.

3.2. Ölçümler ve Prosedürler

Ölçümler, Türkiye'de üç milli takım seçme turnuvasında alındı. 8 Mart 2022'de Kırşehir'de 15 yaş altı, 26 Nisan 2022'de Karaman'da 13 yaş altı ve 16 Mayıs 2022'de Sakarya'da 11 yaş altı turnuvalarında ölçümler alındı. Turnuvalardan alınan ölçümlere ek olarak, Ankara'daki iki masa tenisi kulübünün oyuncularından 22 Mayıs 2022 ve 17 Kasım 2022'de ölçümler alındı.

3.2.1. Antropometri

Boy uzunluğu ve oturma yüksekliği, taşınabilir boy ölçer (Seca 213, Hamburg, Almanya) ile, vücut ağırlığı ise dijital tartı ile ölçüldü. Katılımcıların boy uzunlukları baş Frankfort düzleminde, topuklar birleşik konumda ve sırt, kalça ve topuklar boy ölçere temas edecek şekilde olacak şekilde ölçüldü. Oturma yükseklikleri boy ölçer bir bankın üstüne alınarak, baş Frankfort düzleminde ve sırt ve kalça boy ölçere temas edecek şekilde ölçüldü. Ölçümler 0.1 cm hassasiyetle alındı. Katılımcılardan çıplak

ayakla ve minimal giysilerle tartının ortasında durmaları istendi. Katılımcının hareketsiz durduğu ve vücut ağırlığının dengeli dağıldığından emin olundu. Ölçümler 0.1 kg hassasiyetle alındı. Bacak uzunluğu, boy uzunluğundan oturma yüksekliğinin çıkarılmasıyla hesaplandı. Vücut kitle indeksi (VKİ) vücut ağırlığının (kg), boy uzunluğunun karesine (m) bölünmesiyle hesaplandı. Tüm antropometrik ölçümler, Uluslararası Kinantropometri Geliştirme Topluğu (ISAK) kılavuzuna göre gerçekleştirildi (Eston ve Reilly, 2009).

3.2.2. Fiziksel Büyüme ve Biyolojik Olgunluğun Tahmini

Büyüme durumu normatif referans veri tabanı kullanılarak belirlendi. Boy uzunluğuna göre yaş, vücut ağırlığına göre yaş ve VKİ'ye göre yaş Frisancho'nun referans verileri (Frisancho, 2008) ile karşılaştırıldı ve yüzdelik dilim ve z-skor değerleri boy uzunluğu, vücut ağırlığı ve VKİ için hesaplandı. Oyuncuların somatik olgunluk durumları, ZBHY ve zirve boy hızı zamanına kalan süre hesaplanarak belirlendi. ZBHY ile kronolojik yaş arasındaki fark, zirve boy hızı zamanına kalan süreyi belirlemek için hesaplandı. Bu çalışmada, Mirwald ve ark. (2002) tarafından önerilen denklemler kullanılarak oyuncuların ZBHY değerleri tahmin edildi.

3.3. Veri Analizi

Verilerin cinsiyete göre betimsel analizi yapıldı. Tüm değerler ortalama ve standart sapma olarak rapor edildi. Verilerin normal dağılıma uygunluğunu analiz etmek için Kolmogorov-Smirnov testi kullanıldı. Madalya kazanan ve kazanmayan oyuncular ile erkek ve kızlar arasındaki farkları analiz etmek için bağımsız örneklem t-testleri yapıldı. Etki büyüklüğünü ölçmek için Cohen'in d değeri kullanıldı ve aşağıdaki şekilde yorumlandı: <0.20 (önemsiz), 0.20-0.59 (küçük), 0.60-1.19 (orta), 1.20-1.99 (büyük), 2.0-3.9 (çok büyük) ve >4.0 (son derece büyük) (Hopkins, Marshall, Batterham ve Hanin, 2009). Anlamlılık düzeyi $p < 0.05$ olarak belirlendi. Bu çalışmadaki tüm istatistiksel analiz prosedürleri IBM SPSS Statistic for Windows, Version 26.0 (SPSS Inc., Chicago IL) kullanılarak gerçekleştirildi.

4. BULGULAR

Betimleyici istatistikler beş ardışık yaş grubuna göre (11, 12, 13, 14 ve 15) kızlar için Tablo 1 ve erkekler için Tablo 2'de verilmiştir.

Tablo 1. Kızlar için betimleyici istatistikler

Yaş	11 (n = 5)	12 (n = 16)	13 (n = 13)	14 (n = 15)	15 (n = 11)
Takvim yaşı (yıl)	10.87 ± 0.15	11.51 ± 0.26	12.49 ± 0.34	13.54 ± 0.24	14.73 ± 0.33
Antrenman yaşı (yıl)	145.73 ± 1.36	149.89 ± 4.49	156.09 ± 6.12	157.48 ± 4.96	161.04 ± 7.29
Haftalık antrenman (saat/hafta)	77.33 ± 0.86	76.97 ± 2.85	81.35 ± 4.02	82.79 ± 3.01	84.89 ± 3.61
Boy uzunluğu (cm)	35.30 ± 4.45	37.65 ± 5.24	46.49 ± 8.81	52.06 ± 9.44	52.95 ± 5.16
Oturma yüksekliği (cm)	16.63 ± 2.06	16.85 ± 2.23	19.14 ± 3.41	21.02 ± 3.44	20.59 ± 2.16
Vücut ağırlığı (kg)	-0.03 ± 0.21	0.13 ± 0.60	0.30 ± 0.82	-0.13 ± 0.69	-0.04 ± 1.05
Vücut kitle indeksi (kg/m^2)	48.10 ± 7.37	53.67 ± 19.85	57.65 ± 22.81	46.25 ± 24.31	49.59 ± 34.63
Boy uzunluğu (z-skoru)	-0.37 ± 0.57	-0.33 ± 0.60	0.17 ± 0.79	0.31 ± 0.84	0.16 ± 0.44
Boy uzunluğu (yüzdelik)	36.57 ± 18.32	38.62 ± 21.32	55.73 ± 25.21	61.27 ± 25.86	55.76 ± 16.45
Vücut ağırlığı (z-skoru)	-0.47 ± 0.76	-0.50 ± 0.78	-0.02 ± 0.93	0.28 ± 0.87	0.07 ± 0.57
Vücut ağırlığı (yüzdelik)	35.83 ± 24.89	34.31 ± 24.92	48.71 ± 29.81	59.97 ± 25.97	53.19 ± 19.95
Vücut kitle indeksi (z-skoru)	11.87 ± 0.06	12.04 ± 0.34	11.98 ± 0.43	12.31 ± 0.36	12.64 ± 0.49
Vücut kitle indeksi (yüzdelik)	-1.00 ± 0.20	-0.52 ± 0.31	0.49 ± 0.49	1.23 ± 0.39	2.06 ± 0.43

Tablo 2. Erkekler için betimleyici istatistikler

Yaş	11 (n = 12)	12 (n = 7)	13 (n = 19)	14 (n = 7)	15 (n = 12)
Takvim yaşı (yıl)	10.73 ± 0.21	11.47 ± 0.37	12.65 ± 0.23	13.41 ± 0.28	14.52 ± 0.35
Antrenman yaşı (yıl)	148.61 ± 6.50	152.25 ± 8.49	158.80 ± 5.85	160.37 ± 6.70	168.36 ± 6.98
Haftalık antrenman (saat/hafta)	77.09 ± 3.28	78.60 ± 3.74	81.94 ± 3.93	81.89 ± 3.74	86.97 ± 3.78
Boy uzunluğu (cm)	41.20 ± 8.25	46.47 ± 17.39	47.79 ± 6.76	51.51 ± 8.70	61.44 ± 9.60
Oturma yüksekliği (cm)	18.69 ± 3.97	19.63 ± 4.97	19.04 ± 2.89	19.98 ± 2.40	21.79 ± 3.23
Vücut ağırlığı (kg)	0.71 ± 0.96	0.57 ± 1.20	0.48 ± 0.65	0.18 ± 0.72	0.37 ± 0.75
Vücut kitle indeksi (kg/m^2)	70.51 ± 27.83	62.48 ± 26.34	65.51 ± 20.87	56.41 ± 25.21	60.47 ± 21.97
Boy uzunluğu (z-skoru)	0.11 ± 0.85	0.22 ± 1.29	0.13 ± 0.52	0.18 ± 0.69	0.61 ± 0.64
Boy uzunluğu (yüzdelik)	55.81 ± 25.52	49.87 ± 28.57	53.69 ± 17.90	58.23 ± 23.01	69.23 ± 17.41
Vücut ağırlığı (z-skoru)	0.28 ± 1.22	0.40 ± 1.34	0.05 ± 0.84	0.22 ± 0.80	0.47 ± 0.86
Vücut ağırlığı (yüzdelik)	57.42 ± 34.43	54.53 ± 29.71	50.76 ± 25.46	60.40 ± 22.45	63.50 ± 24.63
Vücut kitle indeksi (z-skoru)	13.14 ± 0.44	13.35 ± 0.62	13.63 ± 0.46	13.98 ± 0.49	13.87 ± 0.49
Vücut kitle indeksi (yüzdelik)	-2.40 ± 0.32	-1.85 ± 0.56	-0.98 ± 0.49	-0.60 ± 0.61	0.67 ± 0.58

Betimleyici istatistikler ve cinsiyet farklılıkları Tablo 3'te verilmiştir. Çeşitli değişkenlerde önemli cinsiyet farkları tespit edilmiştir. Erkeklerin kızlara göre anlamlı şekilde daha uzun oldukları, daha yüksek boy uzunluğu z skorlarına ve persentillerine sahip oldukları bulunmuştur. Ayrıca, kızlar, erkeklere göre zirve boy hızına anlamlı şekilde daha erken ulaşmış ve olgunluk ofset değerlerini analiz ederken, kızların olgunlaşma konusunda erkeklere göre anlamlı şekilde daha ileri oldukları bulunmuştur. Ancak diğer değişkenlerde erkekler ve kızlar arasında anlamlı farklar gözlenmemiştir.

Tablo 3. Cinsiyet farklılıkları

	Cinsiyet					
	Kızlar (n = 60)	Erkekler (n = 57)	*t*	*p*	*d*	Nitel
Takvim yaşı (yıl)	12.99 ± 1.24	12.86 ± 1.35	0.551	0.583	0.003	Trivial
Antrenman yaşı (yıl)	5.22 ± 1.25	4.97 ± 1.68	0.891	0.375	0.007	Önemsiz
Haftalık antrenman (saat/hafta)	15.30 ± 5.49	14.64 ± 6.81	0.576	0.566	0.003	Önemsiz
Boy uzunluğu (cm)	155.88 ± 7.01	159.32 ± 9.37	-2.257	0.026	0.042	Önemsiz
Oturma yüksekliği (cm)	81.50 ± 4.29	82.14 ± 4.97	-0.745	0.458	0.005	Önemsiz
Vücut ağırlığı (kg)	47.19 ± 9.62	50.92 ± 11.63	-1.892	0.061	0.030	Önemsiz
Vücut kitle indeksi (kg/m^2)	19.41 ± 3.28	19.95 ± 3.43	-0.875	0.383	0.007	Önemsiz
Boy uzunluğu (z-skoru)	0.07 ± 0.78	0.44 ± 0.80	-2.540	0.012	0.053	Önemsiz
Boy uzunluğu (yüzdelik)	51.66 ± 24.99	62.90 ± 23.33	-2.511	0.013	0.052	Önemsiz
Vücut ağırlığı (z-skoru)	0.09 ± 0.72	0.27 ± 0.74	-1.358	0.177	0.016	Önemsiz
Vücut ağırlığı (yüzdelik)	53.12 ± 23.68	58.59 ± 21.65	-1.302	0.195	0.015	Önemsiz
Vücut kitle indeksi (z-skoru)	-0.03 ± 0.84	0.26 ± 0.94	-1.813	0.072	0.028	Önemsiz
Vücut kitle indeksi (yüzdelik)	49.40 ± 26.55	57.42 ± 26.24	-1.643	0.103	0.023	Önemsiz
ZBHY (yıl)	12.21 ± 0.47	13.66 ± 0.55	-15.210	0.001	0.668	Orta
ZBHY'a kalan süre (yıl)	0.77 ± 1.04	-0.79 ± 1.18	7.589	0.001	0.334	Küçük

Kızlar için madalya kazanan ve madalya kazanmayan sporcular arasındaki karşılaştırma Tablo 4'te verilmiştir. Kızlar için, iki grup arasında herhangi bir değişkende anlamlı farklar bulunmamıştır.

Tablo 4. Madalya kazanan ve kazanmayan kızların karşılaştırılması

	Madalya Kazanma Durumu					
	Madalya Kazanan (n=16)	Madalya Kazanmayan (n=44)	*t*	*p*	*d*	Nitel
Takvim yaşı (yıl)	13.07 ± 1.23	12.97 ± 1.26	-0,282	0,779	0,001	Önemsiz
Antrenman yaşı (yıl)	5.66 ± 1.15	5.06 ± 1.25	-1,672	0,100	0,046	Önemsiz
Haftalık antrenman (saat/hafta)	15.91 ± 6.73	15.08 ± 5.04	-0,512	0,610	0,004	Önemsiz
Boy uzunluğu (cm)	157.93 ± 6.57	155.13 ± 7.09	-1,373	0,175	0,031	Önemsiz
Oturma yüksekliği (cm)	82.79 ± 4.79	81.03 ± 4.06	-1,414	0,163	0,033	Önemsiz
Vücut ağırlığı (kg)	46.63 ± 9.67	47.40 ± 9.70	0,274	0,785	0,001	Önemsiz
Vücut kitle indeksi (kg/m^2)	18.62 ± 2.92	19.70 ± 3.39	1,130	0,263	0,022	Önemsiz
Boy uzunluğu (z-skoru)	0.29 ± 0.93	-0.02 ± 0.72	-1,333	0,188	0,030	Önemsiz
Boy uzunluğu (yüzdelik)	58.18 ± 27.66	49.29 ± 23.84	-1,224	0,226	0,025	Önemsiz
Vücut ağırlığı (z-skoru)	0.01 ± 0.72	0.12 ± 0.72	0,489	0,626	0,004	Önemsiz
Vücut ağırlığı (yüzdelik)	51.46 ± 23.98	53.72 ± 23.82	0,325	0,746	0,002	Önemsiz
Vücut kitle indeksi (z-skoru)	-0.26 ± 0.74	0.05 ± 0.86	1,289	0,203	0,028	Önemsiz
Vücut kitle indeksi (yüzdelik)	42.71 ± 24.11	51.83 ± 27.24	1,181	0,242	0,023	Önemsiz
ZBHY (yıl)	12.16 ± 0.59	12.23 ± 0.43	0,564	0,575	0,005	Önemsiz
ZBHY'a kalan süre (yıl)	0.91 ± 0.97	0.72 ± 1.07	-0,646	0,521	0,007	Önemsiz

Erkekler için madalya kazanan ve madalya kazanmayan sporcular arasındaki karşılaştırma Tablo 5'te verilmiştir. Erkekler için ise, antrenman yaşından başka değişkenler arasında madalya kazanan ve kazanmayan oyuncular arasında anlamlı farklar bulunmamıştır. Madalya kazanan erkeklerin madalya kazanmayan erkeklere göre düzenli masa tenisi antrenmanında anlamlı şekilde fazla deneyime sahip oldukları bulunmuştur.

Tablo 5. Madalya kazanan ve kazanmayan erkeklerin karşılaştırılması

	Madalya Kazanma Durumu					
	Madalya kazanan (n=11)	Madalya kazanmayan (n=46)	*t*	*p*	*d*	Nitel
Takvim yaşı (yıl)	12.48 ± 1.34	12.95 ± 1.35	1.039	0.303	0.019	Önemsiz
Antrenman yaşı (yıl)	5.95 ± 1.27	4.74 ± 1.69	-2.230	0.030	0.083	Önemsiz
Haftalık antrenman (saat/hafta)	17.95 ± 6.15	13.85 ± 6.78	-1.833	0.072	0.058	Önemsiz
Boy uzunluğu (cm)	157.63 ± 11.91	159.73 ± 8.77	0.664	0.509	0.008	Önemsiz
Oturma yüksekliği (cm)	80.90 ± 5.98	82.43 ± 4.73	0.917	0.363	0.015	Önemsiz
Vücut ağırlığı (kg)	47.85 ± 12.80	51.65 ± 11.37	0.972	0.335	0.017	Önemsiz
Vücut kitle indeksi (kg/m^2)	18.98 ± 2.82	20.18 ± 3.54	1.047	0.300	0.020	Önemsiz
Boy uzunluğu (z-skoru)	0.50 ± 0.99	0.42 ± 0.76	-0.290	0.773	0.002	Önemsiz
Boy uzunluğu (yüzdelik)	63.85 ± 26.50	62.67 ± 22.83	-0.149	0.882	0.000	Önemsiz
Vücut ağırlığı (z-skoru)	0.12 ± 0.77	0.31 ± 0.74	0.760	0.450	0.010	Önemsiz
Vücut ağırlığı (yüzdelik)	55.24 ± 22.47	59.39 ± 21.62	0.568	0.572	0.006	Önemsiz
Vücut kitle indeksi (z-skoru)	0.08 ± 0.77	0.31 ± 0.98	0.714	0.478	0.009	Önemsiz
Vücut kitle indeksi (yüzdelik)	54.76 ± 24.94	58.06 ± 26.77	0.371	0.712	0.002	Önemsiz
ZBHY (yıl)	13.61 ± 0.57	13.67 ± 0.56	0.311	0.757	0.002	Önemsiz
ZBHY'a kalan süre (yıl)	-1.14 ± 1.34	-0.70 ± 1.13	1.102	0.275	0.022	Önemsiz

Kadın masa tenisi oyuncularının boy uzunlukları genellikle 45. ile 57. yüzdelik dilimler arasında yer alırken, erkek oyuncuların boy uzunlukları ise 54. ile 69. yüzdelik dilimler arasında değişti. Ayrıca, kadın oyuncuların vücut ağırlığı yüzdelik dilim değerleri 40. ile 65. arasında değişirken, erkek oyuncuların vücut ağırlığı yüzdelik dilim değerleri 49. ile 74. arasında dağılım gösterdi. VKİ değerlerine göre, kadın oyuncuların yüzdelik dilim değerleri 37. ile 62. arasında bulunurken, erkek oyuncuların yüzdelik dilim değerleri 48. ile 80. arasında değişti. Bu bulgular, cinsiyetler arasında masa tenisi oyuncularının boy uzunluğu, vücut ağırlığı ve VKİ açısından belirgin farklılıklar olduğunu göstermektedir.

5. TARTIŞMA VE SONUÇ

Bu çalışma, genç müsabık masa tenisi oyuncularının büyüme ve olgunluk durumunu incelemeyi ve madalya kazanan ve kazanmayan oyuncular arasında karşılaştırma yapmayı amaçlamıştır. Araştırmanın üç temel bulgusu vardır. İlk olarak, her iki cinsiyet için madalya kazanan oyuncular, yaş ve cinsiyet normlarıyla karşılaştırıldığında genel nüfusun %37'sinden daha uzun, daha ağır ve daha yüksek VKİ değerlerine sahipti. İkinci olarak, erkekler kızlardan daha uzun boya sahipti ve daha yüksek boy z-skorlarına ve yüzdelik dilimlere sahipti. Kızlar ise erkeklerden daha ileri düzeyde olgunlaşmıştı ve zirve boy hızlarına erkeklerden daha erken ulaştı. Üçüncü olarak, performans açısından, madalya kazanan erkek oyuncuların kazanmayanlara göre daha fazla antrenman deneyimine sahip olduğu gözlendi.

Çalışmada, kadın masa tenisi oyuncularının boy uzunlukları genellikle %45 ila %57 aralığında iken, erkek oyuncuların boy uzunlukları %54 ila %69 arasında değişmektedir. Benzer şekilde, kadın oyuncuların vücut ağırlıkları genellikle %40 ila %65 aralığında iken, erkek oyuncuların vücut ağırlıkları %49 ila %74 arasında değişmektedir. VKİ yüzdelik dilimleri açısından, kadın oyuncuların VKİ değerleri genellikle %37 ila %62 arasında iken, erkek oyuncuların VKİ değerleri %48 ila %80 arasında değişmektedir. Bu bulgular, raket sporlarında boy uzunluğu, vücut ağırlığı ve VKİ farklılıklarının oyuncular arasında yaygın olduğunu destekleyen önceki çalışmalarla uyumludur. (Baxter-Jones ve ark., 1995; Coelho-E-Silva ve ark., 2021; Erlandson ve ark., 2008; Myburgh ve ark., 2016; Söğüt ve ark., 2019; Söğüt ve ark., 2023).

Cinsiyet farklılıkları açısından, erkekler genellikle kızlardan daha uzun boylu ve daha yüksek boy yüzdelik dilimlerine sahiptir. Bununla birlikte, kızlar erkeklere göre daha ileri düzeyde olgunlaşmıştır ve zirve boy hızına erkeklerden daha erken ulaşmıştır. Bu sonuçlar, raket sporlarında yapılan önceki çalışmalarla uyumludur (Myburgh ve ark., 2016; Söğüt ve ark., 2019; Söğüt ve ark., 2023).

Performans açısından, kızlar arasında madalya kazananlarla madalya kazanmayanlar arasında herhangi bir değişken açısından anlamlı fark bulunmazken, erkekler arasında antrenman yaşından başka anlamlı fark bulunmamıştır. Madalya kazanan erkekler, madalya kazanmayan erkeklere göre düzenli masa tenisi antrenmanında daha fazla deneyime sahiptir. Bu çalışmanın bulgularıyla uyumlu olarak, Söğüt ve arkadaşlarının (2019) yaptığı başka bir çalışma, deneyim, antrenman hacmi ve motor performans faktörlerinin hem erkeklerde hem de kızlarda sıralamayla ilişkili olduğunu göstermiştir.

5.1. Sonuç

Özetle bu çalışmanın sonuçları, genç müsabık masa tenisi oyuncularının vücut özelliklerinin, normatif referanslara kıyasla genellikle daha büyük olduğunu göstermektedir. Ayrıca, cinsiyet farklılıkları da gözlenmiştir. Erkekler kızlardan daha uzun boylu ve daha yüksek vücut kitle indeksine sahiptir. Bu bulgular, genç masa tenisi oyuncularının fiziksel özelliklerinin performanslarını etkileyebileceğini ve bu nedenle sporcuların büyüme ve olgunlaşma süreçlerinin dikkate alınması gerektiğini göstermektedir. Ancak, performans açısından, madalya kazanan ve kazanmayan oyuncular arasında önemli farklılıklar bulunmamıştır, bu da diğer faktörlerin (deneyim, antrenman vb.) performans üzerindeki etkisine işaret edebilir.

Araştırmanın Sınırlılıkları ve Gelecek Araştırmalar İçin Öneriler

Bu çalışma, genç masa tenisi oyuncularının fiziksel özelliklerini anlamak için önemli bilgiler sağlamaktadır. Ancak, bu çalışmanın sınırlamaları da bulunmaktadır. Örneğin, örneklem büyüklüğü sınırlı olmakla birlikte çalışmaya sadece Türkiye'deki oyuncular dahil edilmiştir, bu nedenle genellemeler yaparken dikkatli olunmalıdır. Ayrıca, çalışma sadece fiziksel özellikleri ele almıştır ve diğer faktörlerin (psikolojik, teknik, taktik vb.) performansa etkisini dikkate almamıştır. Bu nedenle, masa tenisi oyuncularının performansını etkileyen diğer faktörlerin de incelenmesi önemlidir.

C. INFORMED CONSENT FORM / ARAŞTIRMAYA GÖNÜLLÜ KATILIM FORMU

Bu araştırma Orta Doğu Teknik Üniversitesi Beden Eğitimi ve Spor yüksek lisans öğrencisi … tarafından yürütülmektedir. Bu form sizi araştırma koşulları hakkında bilgilendirmek için hazırlanmıştır.

Çalışmanın amacını madalya kazanan genç masa tenisi oyuncularının büyüme ve olgunluk durumlarını belirlemek ve madalya kazanan ve kazanmayan oyuncuları karşılaştırmak oluşturacaktır. Bu amaç doğrultusunda, boy uzunluğu, oturma yüksekliği, vücut ağırlığı, anne ve baba boy uzunluğu, antrenman yaşı ve haftalık antrenman hacmi tespit edilecektir. Araştırmaya katılımınız tamamen gönüllülük temelinde olmalıdır. Verileriniz tamamıyla gizli tutulacak, sadece araştırmacı tarafından değerlendirilecektir. Katılımcılardan elde edilecek bilgiler toplu halde değerlendirilecek ve bilimsel yayımlarda kullanılacaktır.

Bu çalışmaya katıldığınız için şimdiden teşekkür ederiz. Çalışma hakkında daha fazla bilgi almak için Beden Eğitimi ve Spor yüksek lisans öğrencisi … (E-posta: …) ile iletişim kurabilirsiniz.

Yukarıdaki bilgileri okudum ve bu çalışmaya tamamen gönüllü olarak katılıyorum.
(Formu doldurup imzaladıktan sonra uygulayıcıya geri veriniz).

Ad Soyad Tarih İmza

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D. PARENTAL APPROVAL FORM / VELİ ONAY FORMU

Sayın Veli,

Bu çalışma Orta Doğu Teknik Üniversitesi Beden Eğitimi ve Spor bölümü yüksek lisans öğrencisi … tarafından yürütülmektedir. Çalışmanın amacını madalya kazanan genç masa tenisi oyuncularının büyüme ve olgunluk durumlarını belirlemek ve madalya kazanan ve kazanmayan oyuncuları karşılaştırmak oluşturacaktır.

Bu amaç doğrultusunda, boy uzunluğu, oturma yüksekliği, vücut ağırlığı, anne ve baba boy uzunluğu, antrenman yaşı ve haftalık antrenman hacmi tespit edilecektir. Sizden çocuğunuzun katılımcı olmasıyla ilgili izin istediğimiz gibi, çalışmaya başlamadan çocuğunuzdan da sözlü olarak katılımıyla ilgili rızası mutlaka alınacaktır.

Çocuğunuzdan alacağımız veriler tamamen gizli tutulacak ve sadece araştırmacılar tarafından değerlendirilecektir. Elde edilecek bilgiler sadece bilimsel amaçla kullanılacak, çocuğunuzun ismi ve kimlik bilgileri veya sizin isminiz ve kimlik bilgileriniz, hiçbir şekilde kimseyle paylaşılmayacaktır.

Katılım sırasında ölçümlerden ya da herhangi bir uygulama ile ilgili başka bir nedenden ötürü çocuğunuz kendisini rahatsız hissettiğini belirtirse, ya da kendi belirtmese de araştırmacı çocuğun rahatsız olduğunu öngörürse, çalışmaya ölçümler tamamlanmadan ve derhal son verilecektir. Şayet siz çocuğunuzun rahatsız olduğunu hissederseniz, böyle bir durumda çalışmadan sorumlu kişiye çocuğunuzun çalışmadan ayrılmasını istediğinizi söylemeniz yeterli olacaktır.

Çalışma hakkında daha fazla bilgi almak için … ile (e-posta: …) iletişim kurabilirsiniz. Bu çalışmaya katılımınız için şimdiden teşekkür ederiz.

Yukarıdaki bilgileri okudum ve çocuğumun bu çalışmada yer almasını onaylıyorum (Lütfen alttaki iki seçenekten birini işaretleyiniz.

Evet onaylıyorum ___ ***Hayır, onaylamıyorum ___***

Veli adı-soyadı: _____ Bugünün Tarihi: _____

Çocuğun adı soyadı ve doğum tarihi: _____

(Formu doldurup imzaladıktan sonra araştırmacıya ulaştırınız).

D. THESIS PERMISSION FORM / TEZ İZİN FORMU

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