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Postural analysis of adolescent young athletes in different sports branches[1]

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Abstract
The effects of posture on athletic performance have been the focus of attention of many researchers and the importance of body posture in achieving success has become undeniable. This study aimed to perform the postural evaluation of adolescent youth athletes who are trained in basketball, soccer, volleyball, and swimming branches. A total of 88 adolescent athletes (32 boys and 56 girls) with an average age of ±12.37 years, an average height of ±1.58 cm, an average body weight of ±48.2 kg, an average BMI of ±18.19 and an average training age of ±2.06 years from football, volleyball, and swimming branches actively active in Manisa and Bursa provinces participated in the study. Posture analysis of the athletes was performed using the Apecs-AI Posture Evaluation and Correction System® mobile posture application. The data obtained from the athletes were evaluated with the NewYork Posture Assessment Test (NYPD). The data obtained from the study were analyzed using the SPSS 22.0 package program. One-way Analysis of Variance (ANOVA) was used for independent samples. According to the results of the analysis, there was a significant difference between training age and NYPD scores according to branches ($p<.05$). Significance was found between NYPD and body axis scores in volleyball and soccer athletes ($p<.05$). There was no difference between NYPD and other variables in swimming and basketball. As a result, it is thought that the effect of the training age variable on posture structures differs specifically according to the branches, and posture is negatively affected as the training age increases in volleyball and soccer players.

Keywords: Adolescence, posture, training load, training age, volleyball, soccer, basketball, swimming.

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1. Introduction

Movement and posture structure are very important for the physical and emotional development of children and young people (Solberg, 2008). It is stated that ideal posture occurs when all body segments are vertically aligned, and all joint axes cross the line of gravity (Kendall, 1993). Among the factors that determine success and performance in sports, are psychological and social characteristics, ability, mental characteristics, physical and physiological fitness as well as posture and anthropometric structures (Karakuş, 2006).

Postural regulation is organized by hierarchical and stereotyped processes, requiring the integration of afferent information from the visual, auditory, and proprioceptive systems. Sporting exercises increase the ability to use somatosensory and otolith (crystalline particles formed in the utriculus prostaticus and sacculus membrane) information. A natural consequence of this is the development of postural abilities. Postural changes are differentiated depending on sports practices (Paillard, 2006).

One of the causes of postural disturbances is a strong and tight antagonist muscle group and a weak and elongated agonist muscle group. The difference in strength and contractile ability between these agonist and antagonist muscles leads to postural disturbances. Strengthening exercises are thought to promote adaptive shortening of muscle-tendon length, reposition skeletal segments, and may play a role in reorganizing static posture (Hrysomallis, 2001).

Postural changes can be seen in athletes in sports where certain muscle groups specific to sports activities are used actively during training and sports activities compared to antagonist muscle groups or in sports where muscle groups are used unilaterally (Şahin, 2023).

When the studies on adolescent athletes in the literature were examined, it was determined that posture provides control of both static and dynamic balance (Simsek, 2011).

When other studies were examined, it was determined that doing sports in children in the younger age group positively affected the posture structure, but the difference in the branch of sports performed in the adolescence period did not have a positive effect on the postural structure (Tokgoz, 2022).

When other studies were examined, it was determined that the mat exercises performed by adolescent volleyball players improved the bio-motor properties of the athletes and had a positive effect on posture (Demir, 2018). Since children have a wide range of mobility, temporary defects in postural alignment are considered abnormal in adults (Penha, 2005). The importance of motor activity on children's development has increased even more, especially in today's conditions (Orhan, 2019).

Posture is one of the important factors that affect a person's physical and mental state throughout life. Posture in humans is under the influence of various factors. Among these, familial factors, habits, the occupation of the person, and the sports branch he/she is engaged in have a determining effect on posture. In addition, posture disorders can have many different causes such as bone muscle system lesions, central nervous system deficiency, inappropriate environment, nutrition, and lack or excess of physical activity. Experts often identify primary (innervation) and later secondary (osteogenic) posture disorders (scoliosis and kyphosis), for example, 75% of all cases of scoliosis have a tendency to progress (Daulenskiene, 2003). The susceptibility to postural defects is quite high in adolescence when change is most critical and rapid (Grabara, 2016).

In light of the information obtained from the literature and in line with the information given, this study aimed to evaluate the postural status of adolescent youth athletes in different sports branches (soccer, basketball, swimming, and volleyball). Our study aimed to perform the postural evaluation of adolescent youth athletes who are trained in basketball, soccer, volleyball, and swimming branches.

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2. Method

2.1. Participants

A total of 88 adolescent youth athletes (32 boys and 56 girls) between the ages of 12 and 16, with an average age of 12.37 years, an average height of 1.58 cm, an average body weight of 48.2 kg, an average BMI of 18.19 and an average training age of 2.06 years, who have been regularly participating in training for at least one year in youth clubs operating in Manisa and Bursa provinces, participated in our study.

2.2. Data Collection Tools and Data Collection

APECS is a software created for the assessment of posture with non-invasive photogrammetry techniques and for the correction and prevention of posture disorders through various exercises. The app has been developing since 2017 and was first available on Google Play in 2018. Since 2018, more than 100,000 users have benefited from APECS. When the literature was examined, no validity and reliability study of the APECS mobile posture analysis application was found, but there are many studies in the literature using the APECS mobile application (Belli, 2023; Akbulut, 2023; Trovato, 2022; Welling, 2023).

2.3. New York Posture Assessment

The athletes participating in the study were categorized from four different branches as football (N=14), volleyball (N=35), basketball (N=24), and swimming (N=15). Posture analysis of the athletes was performed with the mobile posture analysis program "Apecs-AI Posture Evaluation and Correction System® (Apecs Posture Analysis Pro Plus 8.2.6 Version)". The data obtained after the posture analysis were evaluated with the "New York Posture Evaluation Method". Posture analysis of the athletes was performed individually in a screen. Anterior, posterior, and lateral posture analyses were performed by taking photographs of each athlete from five different angles in total, including "front, back, right, left, and bending position" based on anatomical posture. The data for the study were planned and collected during the preparation period when the athletes were out of the competition season.

During the posture evaluation of the athletes, symmetry between body parts and distortions were examined. In the anterior position, the distance between the heels of the feet was approximately 8 cm. The imaginary line for the evaluation was determined as the line drawn perpendicular to the ground from the center of the distance between both heels upwards. As is well known, this line passes through the pelvis, spine, sternum, and skull midlines, dividing the body into two equal halves. Body weight is distributed between the two halves. During the measurement, the symphysis pubis, spina iliac anterior superior, and shoulders were at the same level in the horizontal plane. According to the anterior alignment, it was checked whether the head, abdomen, and waist did not shift left and right; whether the shoulders were at the same level; whether the arms were of equal length; whether both sides of the hips were at the same height; whether the knees did not shift medially and laterally; whether the feet were in normal extension; and whether the toes did not shift laterally and superiorly (Otman, 1995).

In the lateral position, the earlobe, the midpoint of the shoulder blade, the trochanter major, the lateral center of the patella, and the lateral malleolus were evaluated as the points where the gravity line should pass. This alignment was accepted as an indicator that the muscle balance was in place and there was no strain in the joints and ligaments (Adar, 2004). According to lateral alignment, lordosis, kyphosis, kypho-lordosis, anterior pelvic tilt (increase in inclination angle), posterior pelvic tilt (decrease in inclination angle), genu recurvatum (hyperextension in the knee joint), pes cavus and pes planus were evaluated (Nalbant, 2018).

The proximity of the athletes to the ideal posture was recorded in centimeters with the analyzed mobile program. The degree of ideal posture was accepted as zero and the proximity of the measured values to zero was evaluated as positive. The measurements of the athletes were made by analyzing the photographs taken from five directions with shorts and corset-athletes with the analysis of the posture analysis program, and the comparison of the mean values of the five measurements

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was made statistically. The photographs of the athletes were taken with an iPhone 12 device compatible with the mobile program.

The New York assessment method helps to analyze the posture of the person easily and to reach the correct result. In this evaluation system, posture changes that may occur in thirteen (13) different parts of the body are observed and scored. Accordingly, five (5) points are given if the person has a proper posture, (3) if it is moderately impaired, and (1) if it is severely impaired. The total score obtained as a result of the test is a maximum of 65 and a minimum of 13 (İnal, 2013).

2.4. Ethical permission

General information about our study was explained to the athletes and coaches of the sports clubs, and the athletes who met the inclusion criteria and wanted to participate voluntarily by signing the informed consent form were included in the study. Athletes with injuries in any part of their body were not included in the study. Since the athletes were under the age of 18, their parents signed an informed parental consent form.

2.5. Analysis of Data

To explore whether a significant difference exists among soccer, volleyball, basketball, and swimming athletes regarding body alignment and NYPD, we performed a set of one-way analyses of variance (ANOVA). After significant ANOVA results, post hoc Tukey tests were performed. Afterward, we calculated the Pearson correlation coefficients among the training age, NYPD, and BMI.

3. Findings

Table 1. Descriptive Statistics of Participants

% Descriptive Statistics							
		Branche	**Age (year)**	**Height (cm)**	**Weight (kg)**	**BMI (kg/ m²)**	**Training Age (year)**
N	**Valid**	88	88	88	88	88	88
	Missing	0	0	0	0	0	0
Mean		2,30	12,375	1,5869	48,295	18,918	2,06
Minimum		1	10,0	1,35	28,0	14,609	1
Maximum		4	16,0	1,88	82,0	25,469	5

When the descriptive statistics of the participants given in Table 1 are analyzed; the mean age of the participants was 12.37 years, the mean height was 1.58 cm, the mean weight was 48.29 kg, the mean BMI was 18.91 and the mean training age was 2.06 years.

Table 2. One-Way Analysis of Variance Results Between Body Alignment and NewYork Posture Assessment Scores (NYPD) According to Branches

		Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**	**Significant Difference**
Body Alignment	**Between Groups**	,551	3	,184	,447	,720	
	Within Groups	34,528	84	,411			
	Total	35,080	87				
NYPD	**Between Groups**	2388,843	3	796,281	7,948	**,000**	Volleyball Football
	Within Groups	8415,520	84	100,185			
	Total	10804,364	87				

The results of the one-way ANOVA demonstrated that body alignment scores among the athletes from volleyball, soccer, basketball, and swimming were not statistically significant [F (3, 87) = .447, P = .720]. On the contrary, NYPD scores differed significantly among the athletes from

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volleyball, soccer, basketball, and swimming [F (3, 87) = .7.95, P = .001]. Table 3 illustrates one-way ANOVA results concerning body alignment and NYPD (Table 2).

Table 3. Pearson Correlation Analysis Test Results Between Training Age, NYPD, and Body Mass Index (BMI)

Correlations				
		Training Age (year)	**NYPD**	**BMI (kg/m²)**
Training Age	**Pearson Correlation**	1		
	Sig. (2-tailed)			
	N	35		
NYPD	**Pearson Correlation**	**,373***	1	
	Sig. (2-tailed)	,027		
	N	35	35	
BMI	**Pearson Correlation**	,140	**,419***	1
	Sig. (2-tailed)	,423	,012	
	N	35	35	35

Table 3 shows the Pearson correlation coefficients among the training age, NYPD, and BMI. Results indicated a statistically significant correlation between NYPD and training age (r = .37). NYPD was also significantly correlated to BMI (r = .42).

4. Conclusion and Discussion

Sports science and athletes' training levels are constantly evolving. The foundations of this development are largely based on an ever-expanding understanding of how the body adapts to different physical and psychological loads (Bompa, 2015). Kaya (1991) conducted a study in different sports branches and found that postural disorders of athletes differed according to branches (Kaya, 1991). It was determined that these postural disorders were caused by the customized training of the athletes (Polat, 2019). In a study conducted by Tokgöz (2022) on young football players, a significant positive difference was found in the head, shoulder, and hip values in the posture analyses performed at the beginning, middle, and end of the season, while no significant difference was found in the rib cage value ($p<0.05$) (Tokgoz, 2022).

In a study conducted by Karakuş (2006) on the postures of athletes and sedentary groups studying in secondary education; they stated that the areas where posture disorders are generally concentrated are the neck, shoulder, spine, and knee regions. They also found that the posture disorders seen were head (anterior and posterior shift), dominant side drooping in the shoulder, kypholordosis in the spine, and inward and outward distortions in the knee region (Karakuş, 2006). In a study conducted by Secginli (2004), it was reported that postural kyphosis was mostly observed in adolescents and young adults (Secginli, 2004).

Since physical development is very high, especially in adolescence, exercises that support correct posture are very important. Studies in the literature also support this conclusion. Posture exercises positively affect the musculoskeletal system, and this is reflected positively on the individual, especially in terms of appearance. The sense of postural self-love in the individual provides happiness and self-confidence. As a result, flexion posture decreases, and spinal health is protected. It is thought that adolescent individuals should be trained about the changes in this age and adolescent individuals should be directed to activities such as sports and exercise to be done in this age (Kandeger, 2020).

Anterior head shift and shoulder protraction are two of the most common posture disorders in school-age adolescents (Ruivo, 2014). This is also seen as a cause of neck and shoulder pain (Straker, 2011).

In a study conducted by Nalbant (2018) on female volleyball players, some posture disorders were found in volleyball players. It was determined that almost all of them were successful above %50 in dunking performances, which is one of the determining criteria of the volleyball game, but

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they could not go above %75 success. As a result of the research, it was determined that female volleyball players with posture disorders achieved average success in dunking performances and the posture factor did not affect the dunking performance %100 (Nalbant, 2018).

In another study, when the posture of adolescent male volleyball players was compared with their non-athlete peers, no significant postural difference was observed between the groups; postural asymmetries were observed at the same rate in both groups (Grabara, 2015).

In a study comparing young male football players with their non-athlete peers, it was observed that the pelvis was more symmetrical in the participants who played football in the pelvis frontal plane analysis, but other postural analyses did not show significant differences (Grabara, 2012).

Thoracic kyphosis and shoulder muscle strength assessment in athletes were generally performed to determine physical profile (Arslan, 2022).

Although the number of initiatives aiming to provide sports to children in the growth period in our country is increasing day by day, the information on the effects and benefits of these sports is not sufficient. Especially the benefits of swimming for the physical and psychological development of children have been revealed in many scientific studies and studies have been conducted to encourage children to prefer this sport. In addition to swimming as a sport, its contribution to the development of children's bio-motoric characteristics and healthy posture is quite great (Dal, 2011).

Aginsky (2016) examined the postures and shoulder isokinetic internal and external rotator muscle strength of water polo athletes and observed that female water polo athletes typically had a thoracic kyphosis posture in which the head was forward, and the shoulders rounded anteriorly. According to the results of internal and external rotator muscle strength evaluations in eccentric and concentric modes at an angular velocity of 60°/sec; external rotator muscle strength was lower than internal rotator strength in both modes, but there was no difference between dominant and non-dominant shoulders in bilateral comparisons. As a result, they thought that changes in posture may be related to external rotator muscle weakness (Aginsky, 2016).

Anderson et al (2007) observed a statistically significant increase in hand and foot length parameters as a result of their study on the anthropometric characteristics of swimmers as a result of their research on 40 swimmers, 24 males and 16 females from the younger age group, which they observed for 3.6 years (Anderson, 2007).

Bolzan (2004), in a study conducted with 321 swimmers between the ages of 6-13 and taking physical education classes, did not find statistically significant findings in hand and foot width variables (Bolzan, 2004).

Orakoğlu et al., in their study on functional tests in young basketball players (2021) found that they could not detect a significant result between important performance characteristics such as balance, flexibility, coordination, and strength in athletes and that this situation was due to the negative relationship between postural stabilization and dynamic balance (Cengiz, 2022). According to the results of our research, no difference was found between NYPD and other variables in swimming and basketball branches ($p>05$). The results of our are parallel to the studies in the literature.

In contrast to this study, Canbolat and Aytar. obtained positive results in terms of performance in both pilates group and basketball players in their 6-week study on Stabilization in Adolescent Girls Basketball Players in 2021. When the studies and the field index are examined, the results obtained show that negative and positive results were obtained in terms of both postural and performance in basketball players (Cengiz, 2022).

In a study conducted by Afyon (2007) on handball and basketball players in the puberty period; when the postural structures of the two groups were examined, it was determined that the postural disorders in this group were more than the basketball players as a percentage (%) according to the data obtained from the handball group. The parameters with more postural disorders were determined as shoulder right, vertebral lordosis, vertebral scoliosis and vertebral dosplat, abdominal weakness, foot pes palnus, and toe hallux valgus (Afyon, 2007).

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In sports branches, various measurement, test, and analysis methods are applied to determine the predisposition to the sports branch, to understand the efficiency, and to determine the risk of of injury. Functional Movement Screening (FMS) test is a screening tool that can be applied quickly and easily in the field without the need for a laboratory or expensive equipment to predict injuries that may occur in athletes. The content of the FMS test battery provides an analysis of basic movement patterns in athletes with simple methods (Kraus, Schütz, Taylor, & Doyscher, 2014).

The FMS test battery is a biomechanical screening and assessment method used to evaluate the quality of functional movements and to detect limitations and asymmetries in movements (Chorba, 2010).

In addition, the FMS test battery is used to assess muscle strength, flexibility, range of motion coordination, balance, and proprioception (Cook, 2010), as well as pain in athletes (Narducci, 2011). Through the FMS test, basic movements can be analyzed to observe asymmetry, mobility, and stability in athletes and to estimate the athlete's risk of injury (Kiesel, 2007).

In a study conducted by Minick et al. in 2010, they reported that although observational evaluations were made with the FMS test, the results of the test were reliable (Minick, 2010). In screening with FMS, limitations, asymmetries, and dysfunctions in functional movements are determined (Chorba, 2010). Bagherian (2018) found that core stability training programs three days a week for eight weeks increased total scores in athletes, especially in high-stepping movement patterns ($p<.001$) in order to determine functional movement analysis scores as a result of the core training program. As a result, it was determined that it increased functional movement analysis scores and dynamic postural control (Bagherian, 2018; Çembertaş, 2020).

As a result, there is insufficient and contradictory information regarding the effects of exercises or training performed in different sports branches during adolescence on people's posture structures. As a result of the findings obtained from our research posture structures. As a result of the findings obtained from our research, it is thought that the effect of the training age variable on posture structures varies, especially according to branches, and as the training age and training loads increase in volleyball and football players, posture is negatively affected.

5. Suggestions

Due to the high susceptibility to postural defects in adolescence, it is thought that the training programs applied to adolescent athletes should be supported with corrective exercises and the studies in the literature on the detection of asymmetries should be increased to shed light on sports trainers. At the same time, it is recommended that tests such as the FMS test battery, which are widely used for the detection of asymmetries, have high applicability and are economical, should be widespread in schools and sports clubs and the body postures of individuals in the pediatric population should be closely monitored.

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