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Functional Movement Analysis, Posture and Examination of Dynamic Balance of Team and Individual Athletes

Takım ve Bireysel Sporcuların Fonksiyonel Hareket Analizi, Postürleri ve Dinamik Denge İncelemesi

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Abstract

The research aims to examine the functional movement analysis, posture and dynamic balances of team and individual athletes in different branches in Adana. 112 athletes (team sports = 59; individual sports = 53) participated in the study. The age of the athletes participating in the survey is 19.02±1.36 years, body weight is 71.92±8.98 kg, average height is 1.79±0.07 m, sports age is 6.50±2.48 years, and the number of weekly training sessions is 5. .27±0.97 days and weekly training hours were found to be 12.01±2.61 hours. Independent t-test and one-way ANOVA test were applied to compare the differences between the means. No significant difference was found between the functional movement analysis, lower extremity Y dynamic balance, anterior posture analysis, angle values in upright posture and trunk flexion-extension angle results of team and individual athletes ($p>0.05$). A significant difference was found in favour of team sports (Basketball) in the medial direction of the upper extremity ($p<0.05$). A significant difference was found in lateral postural asymmetry in favour of team sports in the acromion (Volleyball) ($p=0.04$) and trochanter major (Handball) ($p=0.01$). It is thought that the difference in upper extremity balance and postural asymmetry is due to the fact that branches in team sports are generally branches in which the upper extremity plays an active role. In addition, it can be said that the actions in the game (changing places, cheating, double combat) create a change in the centre of gravity and, accordingly, postural asymmetry.

Keywords Functional Movement Analysis, Posture, Dynamic Balance, Spine Angle, Postural Asymmetry.

Öz

Bu araştırma, Adana'daki farklı branşlardaki takım ve bireysel sporcuların fonksiyonel hareket analizi, postürleri ve dinamik dengelerinin incelenmesini amaçlamaktadır. Çalışmaya 112 sporcu katılmıştır (takım sporları = 59; bireysel sporlar = 53). Ankete katılan sporcuların yaş ortalaması 19,02±1,36 yıl, vücut ağırlıkları 71,92±8,98 kg, boy ortalaması 1,79±0,07 m, spor yaşları 6,50±2,48 yıl, haftalık antrenman gün sayısı 5,27±0,97 gün ve haftalık antrenman süreleri 12,01±2,61 saat olarak bulunmuştur. Ortalama değerler arasındaki farkları karşılaştırmak için bağımsız t-testi ve tek yönlü ANOVA testi uygulanmıştır. Takım ve bireysel sporcuların fonksiyonel hareket analizi, alt ekstremite Y dinamik dengesi, anterior postür analizi, dik postürde açı değerleri ve gövde fleksiyon-ekstansiyon açısı sonuçları arasında anlamlı bir farklılık bulunmamıştır ($p>0,05$). Üst ekstremitenin medial yönünde takım sporları (Basketbol) lehine anlamlı bir farklılık bulunmuştur ($p<0,05$). Lateral postüral asimetride, akromion bölgesinde takım sporları (Voleybol) lehine ($p=0,04$) ve trokanter major bölgesinde takım sporları (Hentbol) lehine ($p=0,01$) anlamlı farklılıklar saptanmıştır. Üst ekstremite dengesi ve postüral asimetrideki farklılığın, takım sporlarında branşların genellikle üst ekstremitenin aktif rol oynadığı branşlar olmasından kaynaklandığı düşünülmektedir. Ayrıca, oyundaki hareketlerin (yer değiştirme, aldatma, ikili mücadele) ağırlık merkezinde değişime ve buna bağlı olarak postüral asimetriye neden olduğu söylenebilir.

Anahtar Kelimeler Fonksiyonel Hareket Analizi, Postür, Dinamik Denge, Omurga Açısı, Postüral Asimetri.

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Introductıon

In recent years, increasing sports competition all over the world has also caused some deficiencies in terms of health and athletic performance. The results obtained in the studies conducted show that the health of the athlete is of critical importance in achieving success in sports fields (Smith et al., 2017). The fact that long-term sports injuries and disabilities negatively affect the sports performance of athletes or teams has created awareness among athletes, coaches and sports experts working in this field about preventing sports injuries and developing protective methods. Therefore, the tendency towards tests showing neuromuscular control during basic motor movements has increased recently (Yel et al., 2023). Functional Movement Screen Analysis (FMS), which is actively used in major European clubs such as Bayern Munich, Liverpool, Ajax and Milan, is an assessment system that observes the basic movements of the individual. This system, which is usually evaluated in the athlete population, consists of seven fundamental movement patterns that require mobility, balance and stability (deep squat, high step, single-line squat, shoulder mobility, active straight leg raise, trunk stability push-up, rotation stability). These movement patterns allow the performance of basic locomotor, manipulative and stabilizing movements to be observed. These movements include the entire functional movement of the body and also evaluate all body segments included in the test separately. As a result of the evaluation, the mobility of the athletes and the weaknesses of the movement, if any, and the existing muscle strength imbalances are determined (Cook, 2001; Cook et al., 1999). In line with the results obtained, the athlete or coaches are informed and corrective exercise programs are applied for the athlete's development, and the injury risk levels are tried to be reduced.

However, the FMS test alone may not be sufficient to ensure neuromuscular control of athletes. Evaluating athletes' performance as a component will increase the validity and reliability of performance follow-ups. Therefore, it is thought that evaluating athletes' dynamic balance and posture together with the FMS test will provide more support in predicting athletes' injury susceptibility rates. Keeping the body's centre of gravity between the support surfaces under dynamic conditions is one of the main components in performing appropriate physical activities. Therefore, when we consider that it may affect the quality of functional movement patterns used by athletes during daily or sports activities, balance skills also form the basis of athletic success (Ishizuka et al., 2011). In addition, the body needs a healthy spine to function flawlessly. The spine has a complex structure. However, when its basic functions are considered, it transfers the head, upper body, and any external loads carried and the bending moments associated with them to the pelvis, stabilising the body (Türkeri, 2019). In addition, the spine works as a whole with other segments of the body to provide stability with the support of connective tissue during muscle activation or to achieve a proper posture with the synchronised operation of many muscles in order to perform a movement in a proper form. Any disorder that may occur in the spine prevents the athlete from performing the movement at a correct angle with the correct range of motion. This will cause the athlete's posture to deteriorate and, accordingly, problems that disrupt the symmetry of the body such as muscle imbalance, muscle weakness or muscle shortness will pave the way for injury to the athlete (Üzer, 2020). Considering these factors, it is important to evaluate dynamic balance, FMS, spinal angles and postures to follow the development of athletes and determine injury risk rates.

When the literature is examined, many studies have been conducted to determine neuromuscular control. However, the studies conducted were generally conducted to measure a single parameter such as FMS, dynamic balance, spine angles and posture parameters (Aktuğ et al., 2019; Şahin, Doğanay and Bayraktar, 2018; Cengizhan and Eyüpoğlu, 2017; Bulğay et al., 2019). There are very few studies examining neuromuscular control using more than one test (Koçak and Ünver, 2019; Cemil and Günel, 2014; Vatansever, 2018; Başar, 2018). Today, it is aimed to improve the performance of athletes and to ensure that the athlete participates in competitions with the same performance for a long time without injury. In this context, our study was conducted to examine the functional movement analysis, balance, spine angles and postures of team and individual athletes.

Materials and Methods

Research Model

This research is structured within the framework of the causal comparative research model, which is one of the quantitative research designs. The aim of the study is to examine the differences between the functional movement patterns, postural alignment and dynamic balance performances of individual and team athletes who have active licenses in different sports branches.

Participants

In order to investigate the functional movement analysis, posture and dynamic balance of team and individual athletes, the required sample size was calculated as α = 0.05, Power = 0.80 (1-ß) in the G*Power program (ver 3.1.9.2) and n=102 for the between-group factor design in the measurements in the independent two group comparisons (Faul et al., 2007). However, in order to prevent data loss, the study was carried out with a total of 112 athletes. One hundred twelve male athletes (individual athletes=53, team athletes=59) who actively participate in competitions in the province of Adana participated in our study voluntarily. Athletes from the branches of Athletics (Short Distance Runners) (n=17), Kick Boxing (n=19) and Taekwondo (n=17) participated in the study as representatives of individual branches. Representing team sports, athletes from Football (n=16), Basketball (n=13), Handball (n=14) and Volleyball (n=16) participated. Consent forms were obtained from their participants.

Data Collection

Anthropometric Measurements

Arm Length

While the athletes were waiting in anatomical position with their minimum clothing, the distance between the acromion and the longest fingertip of the hand was measured using an anthropometer and the athlete's total arm length was read and recorded.

Leg Length

While the athletes were waiting in anatomical position with their minimum clothing, the distance between the trochanter major and the ground was measured using an anthropometer and the athlete's leg length was read and recorded.

Upper Extremity Y (Upper Quarter) Dynamic Balance Test

The test was applied to both arms of the subjects (dominant and non-dominant). While the subjects were standing in a push-up position (front position) on the Y balance test platform with their hands fixed at the center point, wearing sports clothing that would not restrict their movements, the feet were shoulder-width apart. The legs and hip center were fixed together (Türkeri, Büyüktaş, & Öztürk, 2020). The athlete then reached out with only the upper extremity, maintaining a fixed stance with one hand, without support from the lower extremity and hip center, and pushed the blocks with the fingertips in the medial (0°), inferolateral (from the inside of the other hand) (45°) and superolateral (45°) directions with his hand. The athlete performed the application by bringing the hand back to the fixed stance point without touching the ground each time. The test was repeated three times in each of the three directions (medial, inferolateral, superolateral), and the measurement averages were taken and the normalization formula was used.

Lower Extremity Y (Lower Quarter) Dynamic Balance Test

The Lower Extremity Y dynamic balance test was applied at Çukurova University BESYO Performance Measurement Laboratory on the same day and at the same hours, two weeks apart. The test was applied separately with both feet of the subjects (dominant and non-dominant). The subjects stood in balance on the Y balance test platform with their hands fixed in the waist area and their feet fixed at the center point, wearing sportswear that would not restrict their movements. Then, maintaining a fixed stance with one foot, he pushed the blocks with his toe (each time bringing the foot back to the fixed stance point without touching the ground) with his other foot in the anterior (0°), posteroedial (45°) and posterolateral (45°) directions. The test was repeated three times in each of the three directions (anterior, posteroedial, posterolateral) and then the normalization formula was used.

Posture Analysis

The photographing method was used in posture analysis. A GoPRO Hero 7 brand camera was used in taking photographs. A symmetrygraph poster consisting of squares with 5 cm length on each side was used for posture analysis. The distance between the subject and the symmetrygraph was 30 cm, the distance between the tripod on which the camera was placed and the symmetrygraph was 2.5 m, the height of the camera from the ground was 85 cm, and the test setup was prepared in such a way that the point where the subject would stand in front of the symmetrygraph was marked on the ground.

Posture measurement was made in the frontal and sagittal planes. Postural reference points were selected according to the available information about body reference points in relation to the frontal and sagittal gravity line (Pausic and Dizdar, 2017). Anteriorly, body reference points were determined as right and left ear helices, right and left acromion, right and left spina iliaca anterior, right and left epicondylus medialis and right and left malleolus medialis. Laterally, the measurement was made from the right side. Laterally, body reference points were determined as ear tragus, acromion, trochanter major, epicondylus lateralis and lateral malleolus. Postural analysis of the subjects was performed using a two-dimensional motion analysis program called “Kinovea”. The Kinovea program is an open access free software used for motion analysis, comparison and evaluation (Puig et al., 2018). It is generally used to determine the technical skills of an athlete and to follow and evaluate the athlete's development in training (Guzman et al., 2013). Puig-Diví et al., (2017) examined the validity and reliability of the program called "Kinovea" in determining angular deviations and found that the program was valid and reliable (Puig et al., 2018). The height of the athletes participating in the study was measured in cm with a steel stadiometer with a sensitivity of 0,1 cm, while barefoot, and their body mass was measured in kg with a digital scale with a sensitivity of 0,1 kg. The participants were measured barefoot, wearing shorts and a t-shirt. The athletes' BMI measurements were calculated using the formula of the ratio of their body weight to the square of their height (kg/ m2).

Functional Movement Screen Analysis (FMS)

Seven basic movement patterns were evaluated with Functional Movement Analysis and simultaneous scoring was performed by 2 researchers (trained in the same field) according to the quality of the movement. The total score that can be obtained as a result of the seven subtests performed in the Functional Movement Analysis (FMS) test is 21. The lower score of the subtests applied bilaterally was taken in obtaining the total score. In addition, a "Clearing test" was applied in 3 of the subtests. These tests were performed after the shoulder mobility, trunk stability, push-up and rotation stability tests were applied. If the athlete experienced pain during the "Clearing test, "0 points were given for these subtests regardless of the score they received (Rowan et al., 2015; Cook et al., 2014). Each movement pattern is scored between 0-3. Here, 3 points are given when the movement is performed completely and correctly in the desired pattern. In addition, 2 points are given in cases where the movement is partially or completely completed but correction (compensation) mechanisms are activated. One point is given in cases where the movement cannot be achieved despite this. 0 points indicate pain that occurs during the movement. All tests were applied in the order specified in the FMS guidelines and the athletes were shown a video containing correct movement patterns before proceeding to the test phase. The athletes were given the right to try each test 2 times so that they could fully learn the test. After the trials, the measurements were applied in 3 repetitions to evaluate the athletes' actual performance. A 5-second rest period was given for the repetitions within the applied tests and a 1-minute rest period was given between the tests.

Movements Evaluated:

1. Deep Squat
2. Hurdle Step
3. In-Line Lunge
4. Shoulder Mobility
5. Active Straight Leg Raise
6. Trunk Stability Push Up
7. Rotary Stability

Vertebral Angles, Flexibility

Vertebral flexibility measurements; In the upright stance, the midpoint of the sacrum (A), the thoracolumbar junction (B) and the cervicothoracic junction (C) were made at three levels in the flexion and extension of the trunk. These measurements were made with a Saunders brand Digital Inclinometer and using the Curve – Angle method.

Vertebra Angle Measurements in the Upright Stance

While the athlete was standing, the reference points A (midpoint of the sacrum-sacral midpoint), B (thoracolumbar joint between T12-L1) and C (cervicothoracic joint between C7-T1) were marked. The inclinometer was fixed at 0 ° (Calibration) in the longitudinal horizontal plane. The inclinometer was placed at point 'A' and the value was recorded and the calibration process was repeated and placed at point B, then the value at point B was recorded and the calibration was repeated and the measurement at point C was taken.

Trunk Flexion and Extension ROM (Curve Angle Method)

While the athlete was standing, the A (Sacrum midpoint-sacral midpoint), B (T12- L1- thoracolumbar joint) and C (C7-T1- cervicothoracic joint) reference points were marked. First, the athlete's trunk flexion measurements were made. The athlete was asked to perform maximal flexion. The inclinometer was calibrated at point A and placed at point B and measured. After the measurement at point B was completed, the inclinometer was recalibrated and measurements were taken at point C and the trunk flexion values were recorded. Then, the athlete's trunk extension measurements were made. The athlete was asked to perform maximal extension. The inclinometer was calibrated at point A and placed at point B and measured. After the measurement at point B was completed, the inclinometer was recalibrated and measurements were taken at point C and the trunk extension values were recorded.

Statistical Analyses

The data obtained in the study are given as arithmetic mean (±) standard deviation (SS). Kolmogorov-Smirnov test was applied to determine whether the data showed normal distribution. It was found that the data showed normal distribution and therefore parametric tests were applied. Independent t test was used to compare the differences between the means. One-way ANOVA test and Tukey test were applied in more than two group comparisons to determine which branch the difference between the groups originated from. The confidence interval was selected as 95% and $p \leq 0.05$ values were considered statistically significant.

FINDINGS

Demographic information of participants

Table 1: Demographic information of participants

Variable	Individual	Team	Total
	X ± SS	X ± SS	X ± SS
Age (years)	19,05±1,47	19,00±1,27	19,02±1,36
Height (m)	1,76±0,06	1,81±0,07	1,79±0,07
Body mass (kg)	71,11±9,12	72,65±8,88	71,92±8,98
BMI	22,90±2,37	21,98±2,15	22,42±2,29
Sport Age (years)	6,79±2,51	6,25±2,46	6,50±2,48
Weekly Training Day	5,39±1,00	5,16±0,94	5,27±0,97
Weekly Training Hours	12,07±3,01	11,94±2,20	12,01±2,61

The average age of the athletes participating in the study was 19.02±1.36 years, height 1.79±0.07 m, body mass 71.92±8.98, sports age 6.50±2.48 years, weekly training days 5.27±0.97 days and weekly training hours 12.01±2.61 hours. When the BMI values of the athletes were examined, it was found to be 22.42±2.29 kg/m2 [Table 1].

Findings on FMS scores of individual and team athletes

Table 2. Lower-upper y dynamic balance asymmetry values of individual team Athletes

		Individual X ± SS	Team X ± SS	Total X ± SS
Lower Extremity	Anterior (cm)	7,53±5,91	6,63±5,54	7,07±5,71
	Posteromedial (cm)	13,03±9,02	10,05±7,08	11,44±8,15
	Posterolateral (cm)	12,00±13,64	11,24±9,40	11,59±11,51
	Composite (cm)	8,80±7,57	7,63±5,94	8,19±6,76
Upper Extremity	Medial (cm)	6,37±5,05	7,57±5,11	7,00±5,09
	İnferolateral (cm)	6,71±6,11	9,25±8,32	8,05±7,43
	Superolateral (cm)	9,11±11,92	6,38±6,03	7,67±9,35
	Composite (cm)	5,88±5,26	6,85±4,67	6,39±4,96

When the lower extremity Y dynamic balance asymmetries of the athletes participating in the study were examined, it was found that anterior 7.07±5.71, posteromedial 11.44±8.15, posterolateral 11.59±11.51 and composite 8.19±6.76 cm. When the upper extremity Y dynamic balance scores of the athletes were examined, it was found that medial 7.00±5.09, inferolateral 8.05±7.43, superolateral 7.67±9.35 and composite 6.39±4.96 cm. [Table 2].

Table 3. Comparison of FMS scores of individual and team athletes

Parameters	Group	n	X	± SS	t	p
Deep Squat	Individual	53	2,28	0,45	-0,04	0,96
	Team	59	2,28	0,67		
Hurdle Step	Individual	53	2,69	0,50	1,03	0,30
	Team	59	2,59	0,56		
In-line Lunge	Individual	53	2,33	0,61	0,14	0,88
	Team	59	2,32	0,65		
Shoulder Mobility	Individual	53	2,07	0,70	-0,89	0,37
	Team	59	2,20	0,80		
Active Straight Leg Raise	Individual	53	2,39	0,63	-0,91	0,92
	Team	59	2,40	0,59		
Trunk Stability Push Up	Individual	53	2,35	0,59	0,58	0,55
	Team	59	2,28	0,67		
Rotary Stability	Individual	53	2,00	0,62	0,83	0,40
	Team	59	1,89	0,66		
FMS Total	Individual	53	15,66	1,41	-0,36	0,71
	Team	59	15,77	1,94		

According to the results of the independent t-test conducted to determine the functional movement analysis of the individual and team athletes participating in the study, no significant difference was found between the functional movement analysis sub-scores and total scores of the individual and team athletes (p>0.05) [Table 3].

Table 4. Comparison of FMS scores of individual and team athletes

	Parameters	Group	n	X	SS	t	p
Right	Anterior (cm)	Individual	53	67,35	14,58	-0,56	0,57
		Team	59	68,79	12,20		
	Posteromedial (cm)	Individual	53	96,62	17,01	-1,47	0,14
		Team	59	101,25	16,20		
	Posterolateral (cm)	Individual	53	93,09	21,88	-0,63	0,52
		Team	59	95,71	21,82		
	Composite	Individual	53	94,65	17,27	-0,95	0,33
		Team	59	97,79	17,31		
Left	Anterior (cm)	Individual	53	67,66	13,18	-0,43	0,66
		Team	59	68,84	15,70		
	Posteromedial (cm)	Individual	53	96,45	17,39	-1,40	0,16
		Team	59	101,11	17,74		
	Posterolateral (cm)	Individual	53	96,45	18,80	-0,82	0,41
		Team	59	99,30	17,75		
	Composite (cm)	Individual	53	95,88	16,66	-0,98	0,32

According to the independent t test results conducted to determine the lower extremity Y dynamic balance results of individual and team athletes participating in the study, no significant difference was found between the dynamic balance results of the right and left lower extremities of individual and team athletes (p>0.05). [Table 4].

Table 5. Comparison of upper extremity Y dynamic balance results of individual and team athletes

	Parameters	Group	n	X	SS	t	p
Right	Medial (cm)	Individual	53	66,28	10,70	-3,32	0,00*
		Team	59	72,40	8,51		
	Inferolateral (cm)	Individual	53	70,26	9,13	0,27	0,96
		Team	59	70,22	10,34		
	Superolateral (cm)	Individual	53	62,30	11,96	0,75	0,36
		Team	59	59,71	10,09		
	Composite (cm)	Individual	53	87,98	9,88	0,62	0,89
		Team	59	87,61	10,72		
Left	Medial (cm)	Individual	53	65,56	10,81	-2,94	0,00*
		Team	59	71,18	9,19		
	Inferolateral (cm)	Individual	53	71,96	9,10	0,19	0,67
		Team	59	69,67	10,48		
	Superolateral (cm)	Individual	53	61,52	12,18	0,15	0,33
		Team	59	59,49	10,25		
	Composite (cm)	Individual	53	88,09	8,71	0,68	0,68
		Team	59	86,10	8,60		

*p<0,05

According to the independent t-test results conducted to determine the upper extremity Y dynamic balance results of individual and team athletes participating in the study, no significant difference was found between the inferolateral, superolateral and composite results of the right and left upper extremities of individual and team athletes (p>0.05). However, a significant difference was found in the medial direction in the right and left extremities (p<0.05). [Table 5].

Table 6. Investigation of differences in medial direction of upper extremity Y dynamic balance of team athletes

Parameters	Branch	n	X	SS	f	p
Right Medial (cm)	Football	16	70,46	7,85	3,22	0,00*
	Basketball	13	76,37	5,59		
	Handball	14	68,00	10,00		
	Volleyball	16	73,87	8,50		
Left Medial (cm)	Football	16	70,23	11,13	2,65	0,01*
	Basketball	13	**74,62**	5,12		
	Handball	14	67,14	10,93		
	Volleyball	16	72,06	8,25		

p<0,05*

When the One-Way ANOVA results applied to determine the source of the difference in the right and left medial directions in Table 5 were examined, it was found that the difference in the right and left medial directions was due to the athletes in the basketball branch (p<0.05). [Table 6].

Table 7. Comparison of anterior posture asymmetry results of individual and team athletes

Parameters	Group	n	X	SS	t	p
Helis°	Individual	53	1,65	1,41	0,28	0,77
	Team	59	1,58	1,27		
Acromion°	Individual	53	1,69	1,25	-0,15	0,87
	Team	59	1,73	1,32		
Spina Iliaca Anterior°	Individual	53	1,15	0,85	0,21	0,98
	Team	59	1,15	0,86		
Epicondylus Medialis°	Individual	53	1,85	3,05	0,19	0,84
	Team	59	1,76	1,58		
Malleolus Medialis°	Individual	53	1,41	1,37	0,26	0,79
	Team	59	1,36	0,96		

According to the independent t-test results conducted to determine the anterior posture asymmetries of the individual and team athletes participating in the study, no significant difference was found between the anterior posture results of the individual and team athletes (p>0.05). [Table 7].

Table 8. Comparison of lateral posture asymmetry results of individual and team athletes

Parameters	Group	n	X	SS	t	p
Tragus°	Individual	53	1,68	1,27	-1,50	0,13
	Team	59	2,12	1,74		
Acromio°	Individual	53	1,03	0,90	-1,99	0,04*
	Team	59	1,37	0,93		
Trochanter Majör°	Individual	53	1,88	1,38	-2,41	0,01*
	Team	59	2,53	1,47		
Epicondylus Lateralis°	Individual	53	2,71	1,98	-0,51	0,61
	Team	59	2,90	1,92		

p<0,05*

According to the results of the independent t-test conducted to determine the lateral posture asymmetries of the individual and team athletes participating in the study, no significant difference was found between the results obtained from the tragus and epicondylus lateralis reference points of the individual and team athletes (p>0.05). However, a significant difference was found between the results obtained from the acromion and trochanter major reference points (p<0.05). [Table 8].

Table 9. Investigation of differences in lateral posture asymmetry, trochanter major and acromion reference points of team athletes

Parameters	Branch	n	X	SS	f	p
Trochanter Majör°	Football	16	1,67	1,29	4,41	0,00*
	Basketball	13	2,41	1,23		
	Handball	14	3,77	1,48		
	Volleyball	16	2,25	1,18		
Acromio°	Football	16	0,72	0,72	2,83	0,01*
	Basketball	13	1,28	1,00		
	Handball	14	1,66	0,78		
	Volleyball	16	1,75	0,91		

p<0,05*

When the One Way ANOVA results applied to determine the source of the difference in the trochanter major and acromion reference points in Table 9 were examined, it was found that the difference was caused by the handball athletes at the trochanter major reference point and by the volleyball athletes at the acromion reference point (p<0.05). [Table 9].

Table 10. Comparison of angle values of individual and team athletes in upright posture

Parameters	Group	n	X	SS	t	p
Sacral Midpoint Angle°	Individual	27	19,25	1,83	-0,29	0,76
	Team	30	19,40	1,73		
Thoracolumbaro Angle°	Individual	27	32,77	2,15	-1,13	0,26
	Team	30	34,00	5,19		
Cervicothoracic Angle°	Individual	27	41,18	2,18	-1,38	0,17
	Team	30	42,06	2,57		

According to the results of the independent t-test conducted to determine the angle values of the individual and team athletes participating in the study in upright posture, no significant difference was found between the sacral midpoint angle, thoracolumbar angle and cervicothoracic angle results of the individual and team athletes (p>0.05). [Table 10].

Table 11. Comparison of trunk flexion and extension range of motion of individual and team athletes

Parameters	Group	n	X	SS	t	p
Lumbar Flexion°	Individual	27	32,62	2,46	-0,29	0,76
	Team	30	32,86	3,46		
Lumbar Extension°	Individual	27	55,92	3,91	0,06	0,95
	Team	30	55,86	3,32		
Thoracic Flexion°	Individual	27	63,03	4,15	0,09	0,92
	Team	30	62,93	4,20		
Thoracic Extension°	Individual	27	15,18	2,43	1,25	0,21
	Team	30	14,43	2,09		

According to the results of the independent t-test conducted to determine the trunk flexion extension ROM values of the individual and team athletes participating in the study, no significant difference was found between the lumbar flexion, lumbar extension, thoracic flexion and thoracic extension ROM values of the individual and team athletes. (p>0.05) [Table 11].

Discussion

Along with the developing and changing world, the world of sports has also adapted to this environment. With the development of technology, many changes have occurred in the world of sports.

Sports are not only competitions or matches held on the field, on the tracks or in the halls, but also an important show in the background of which many studies are carried out and then concluded with a competition or match (Türkeri and Öztürk, 2020). The significant changes that have occurred in sports have also increased the competition in sports. This increasing sports competition in recent years has begun to highlight the elements of health and athletic performance. The results obtained in the studies conducted show that the health of the athlete is of critical importance in achieving success in sports fields (Smith et al., 2017). While athletes increase their athletic performance, they have also begun to try to protect the segments that make up this performance. Long-term sports injuries and disabilities negatively affect the sports performance of athletes or teams. Therefore, it has become necessary for athletes, coaches or sports experts to gain awareness about preventing sports injuries and developing protective methods. In this context, our study was conducted to examine the functional movement analysis, balance and posture of athletes participating in team and individual sports competitions in Adana province.

The average age of the athletes participating in the study was 19.02±1.36 years, height 1.79±0.07 m, body weight 71.92±8.98, sports age 6.50±2.48 years, and BMI 22.42±2.29 kg/m2. Zagatto et al., (2009), in their study on athletes aged 19.78 ±1.18 years, found the average body mass of the athletes to be 70.34±8.10 kg and their average height to be 176±0.53 cm. Özyayla (2019), in a study on athletes aged 19.94±1.98 years, found the average height of the athletes to be 181.22±7.45, body weight 70.60±6.88, and BMI values to be 21.50±1.66 kg/m2. Alam et al., (2012) found the average weight of the athletes to be 77±11.30 kg and the average height to be 177.40±4.92 in their study on elite athletes aged 17-19. Cengizhan and Eyüpoğlu (2017) found the height of the athletes to be 175.55±6.00 cm and the weight to be 74.86±11.18 in their study on athletes aged

21.41±1.56 years and in different branches. The values obtained in our study and these studies in the literature are seen as very close to each other.

No significant difference was found between the functional movement analysis scores of the individual and team athletes participating in the study ($p>0.05$). When the total functional movement analysis scores of the athletes were examined, it was found that individual athletes had 15.66±1.41 and team athletes had 15.77±1.94. In a study conducted on baseball athletes, Lee et al. (2018) found the total FMS scores of the athletes as 15.85±2.17. In a study conducted on volleyball athletes in national teams from different nations, Aka et al. (2018) found the total FMS scores of the athletes as 15.77±1.39. In a study conducted on handball and football players, Kürklü et al. (2019) found the total FMS scores of the athletes to be 16.75±1.87. Portas et al., (2016) found the FMS scores of the athletes in a study conducted on young English footballers to be between 15 and 16. Lloyd et al., (2015) found the total FMS scores of the athletes to be 16.00±2.00 in a study examining the functional movement levels of young footballers. In another study, Slodownik et al. (2018) found the total FMS scores of handball players playing in the second league to be 15.4±2.6. Tafuri et al., (2016) found the total FMS scores of crossfit athletes to be 15.2±1.7 in a study conducted on individual athletes. In addition, Üzer (2020) found that 58% of the wrestlers scored 14 points below in a study conducted on wrestlers. In the literature, it is seen that individuals who do combat sports are included in the sports injury group (Üzer, 2020). Mokha et al. (2016) found the total FMS score to be 15.84±1.73 in a study conducted with 84 male athletes (n=20) and female athletes (n=64) from different sports branches (rowing, volleyball and football). There is a remarkable similarity between these studies and the values obtained in our study. In addition, Kiesel et al. (2011) found that the injury rates of athletes with total FMS scores below 14 points increased. In addition, Letafatkar et al. (2014) accepted the injury threshold score as 17 in their study examining the relationship between injury histories and FMS scores of football, handball and basketball athletes. They also found that athletes with total FMS scores below 17 had a 4.7 times higher risk of injury during the season. When we look at the results obtained in our study, it is seen that the total FMS values of the athletes are below or very close to the norm. In addition to performance and success in sports, continuing one's athletic life without injury is also important. Considering the results we obtained, it is thought that athletes with low total FMS scores and close to the threshold value can be reduced by applying individually prepared corrective exercise programs to athletes, whose injury risk rates can be reduced.

No significant difference was found between the lower extremity Y dynamic balance results of the individual and team athletes participating in the study ($p>0.05$). When the lower extremity Y dynamic balance scores of the athletes were examined, the right extremity of individual athletes was found to be 94.65±17.27 cm and that of team athletes was 97.79±17.31 cm. The left extremity was found to be 95.88±16.66 cm in individual athletes and 99.21±18.94 cm in team athletes. In a study examining the reliability of the Y dynamic balance test, Türkeri, Büyüktaş, and Öztürk (2020) found the right extremity to be 96.44±13.96 cm and the left extremity to be 96.58±14.25 cm. Butler et al. (2012) found the average Y dynamic balance values of the athletes to be 98.4±1.1 in a study conducted on football players. In a study examining the dynamic balance of volleyball players, Brummit et al. (2019) found the right extremity values of the athletes as 99.6±13.0 cm and the left extremity values as 100.1±12.1 cm. Butler et al. (2013) found the average Y dynamic balance value of the athletes as 97.8 ± 6.2 cm in a study on American football players. In another study, Garrison et al. (2013) found the Y dynamic balance value of baseball players as 95.8 ± 6.1 cm. Gorman et al. (2012) found the dynamic balance values of the athletes as 97.1 ± 8.4 cm in a study examining the dynamic balance of different branches. Butler et al. (2012) found the Y dynamic balance value of the football players as 101.8 ± 1.2 cm in their study on professional football players. In a study conducted on healthy athletes, Plisky et al. (2006) found the Y dynamic balance value of the athletes to be 98.4 ± 8.2 cm. In a study examining the Y dynamic balance of healthy athletes, Hudson et al. (2012) found the dynamic balance value of the athletes to be 94.1 ± 6.6 cm. The Y dynamic balance values obtained in studies in the literature and the Y dynamic balance values obtained in our study overlap. The Y balance test does not only provide the dynamic balance values of the athletes. It also reflects the athletes' trunk rotation, lower extremity mobility, ankle instability and lower extremity flexibility, lower extremity strength and neuromuscular control (Hubbard et al., 2007; Norris and Trudelle-Jackson, 2011; Plisky et al., 2009; Plisky et al., 2006). As the distance an athlete can reach in the test increases, it can be said that the athlete's neuromuscular capacity also increases. It is also stated that an athlete's balance asymmetry of more than 4 cm will increase the injury rate (Smith, Chimera, and Warren, 2015). When all these results are taken into consideration, it is seen that the average Y dynamic balance values of individual and team athletes are close to each other and the balance asymmetry results are more than 4 cm. Considering the current dynamic balance levels of athletes, it can be thought that it would be better for them to support their current training with balance and proprioceptive training. It is thought that this will improve their neuromuscular control, lower extremity strength, ankle mobility and stability in addition to the development of their dynamic balance and will positively increase their athletic performance.

When the upper extremity Y dynamic balance values of the individual and team athletes participating in the study were examined, no significant difference was found between the inferolateral, superolateral and composite results in the right and left upper extremities of the individual and team athletes ($p>0.05$). However, a significant difference was found in the medial direction in the right and left extremities in favor of the athletes in the basketball branch of team sports ($p<0.05$). In addition, when the upper extremity Y dynamic balance values of the athletes were examined, for the right extremity; the right extremity was found to be 87.98±9.88 cm in individual athletes and 87.61±10.72 cm in team athletes. The left extremity was found to be 88±8.71 cm in individual athletes and 86.10±8.60 cm in team athletes. In their study examining the reliability of the upper extremity Y dynamic balance test, Türkeri, Büyüktaş, and Öztürk (2020) found the average correct extremity values of athletes as 83.96±10.88 cm and the average left extremity values as 82.80±12.68 cm. In their study examining the upper extremity Y dynamic balance scores in individual sports (weightlifting athletes), Salo and Caconas (2017) found the average right extremity values as 87.06±8.78 cm and the left extremity as 85.07±9.45 cm. Westrick et al. (2012) found the average correct extremity values as 85.7±8.3 cm and the left extremity as 85.14±6.30 cm in the upper extremity Y dynamic balance test used to evaluate the upper extremity closed kinetic chain performance of healthy individuals. In a study comparing the upper extremity Y dynamic balance scores of athletes in different branches, Myers et al. (2017) found the average Y dynamic balance value of the athletes as 85.14 ±6.30 cm. In a study examining the reliability of the upper extremity Y dynamic balance test of athletes in different branches, Gorman et al. (2012) found the average dynamic balance value of the athletes as 85.1 ±8.0 cm. In a study examining the upper extremity dynamic balance of individual athletes (swimmers), Butler et al. (2014) found the average dynamic balance value as 88.3±8.9 cm. In another study, Borms and Cools (2018) found the upper extremity Y dynamic balance average of tennis players as 86.30±8.92 cm in a study examining the upper extremity functional performance of overhead athletes. When the studies conducted are examined, the upper extremity Y dynamic balance values obtained and the upper extremity Y dynamic balance values obtained in our study are broadly similar. It is thought that the reason why athletes doing team sports are better than individual athletes in the medial direction is that the group that makes up team sports is especially the branches where the upper extremity is actively used.

Unilateral and repetitive exercises in sports activities significantly affect the postural structure of athletes (Grabara, 2015; Kim et al., 2016). Intensive anatomical pressure applied to the organism during competition in performance sports and asymmetry in the extremities used affect the postural structure (Grabara, 2016). Karakuş and Kılınç (1997) and Greenfield et al. (1995) stated that children who constantly train in one direction develop in this direction and asymmetries occur in other directions. This situation activates the adaptation (compensation) mechanism in athletes and ensures the completion of the movement, but causes the postural structure to change. No study comparing the angular deviations in the anterior and lateral posture analyses of individual and team athletes could be found in the literature. In our study, no significant difference was found in the comparison of the anterior posture angular deviations of individual and team athletes ($p>0.05$). However, in the lateral posture analyses of individual and team athletes, a significant difference was found in the reference points of acromion and trochanter major in team sports ($p<0.05$). It is thought that this result may be related to the constant change in the centre of gravity depending on the training and competitions in team sports and the fact that athletes take appropriate positions in situations such as constantly changing places, making feints, engaging in dual combats, and charging during the game. While performing such technical movements, the lower and upper extremities are constantly actively bending forward and backward, twisting, trunk rotations, etc., which continue at different angles but with the unilateral use of the extremities. It can be thought that these activities, which continue for a long time, may cause postural deviations in athletes (if there is no other underlying structural disorder). Jurjiu and Pantea (2018) found that the training, competitions, and positions of athletes in team sports lead to postural changes. It should be taken into consideration that postural asymmetry in athletes may negatively affect the health and performance parameters of the body, such as injury, loss of performance, and movement restriction in the future. Therefore, the postural conditions of athletes participating in team sports should be monitored, and corrective exercise programs should be created to bring the deviations detected in their postural structures to normal limits.

When the vertebral angle results (curve angle method) of the individual and team athletes participating in the study were examined, no significant difference was found between the sacral midpoint angle, thoracolumbar angle and cervicothoracal angle results of the individual and team athletes ($p>0.05$). When the vertebral angle values of the athletes in upright stance were examined, the sacral midpoint angle was found to be 19.25±1.83o, the thoracolumbar angle was 32.77±2.15o and the cervicothoracal angle was 41.18±2.18o in individual athletes. When the vertebral angle values of the athletes doing team sports in upright stance were examined, the sacral midpoint angle was found to be 19.40±1.73o, the thoracolumbar angle was 34.00±5.19o and the cervicothoracal angle was 42.06±2.57o. In a study conducted by Waś et al. (2016) to determine the spinal posture characteristics of healthy adult individuals, the sacral midpoint angle was found to be 19.00±8.20o, the thoracolumbar angle was found to be 32.00±11.10o, and the cervicothoracic angle was found to be 43.00±8.40o. In a study conducted by Czaprowski et al. (2012) to determine the spinal angles of healthy individuals, the sacral midpoint angle was found to be 20.60±5.90o, the thoracolumbar angle was found to be

34.30±8.00o and the cervicothoracic angle was found to be 45.01±8.70o. Macintyre et al. (2011) found the sacral midpoint angle of individuals as 22.70±3.60o, the thoracolumbar angle as 36.00±11.30o and the cervicothoracic angle as 42.70±3.80o in a study in which they tried to determine the spinal angles with different measurement devices. In a study conducted in the Karate branch of individual sports, Türkeri (2007) found the sacral midpoint angle of karate athletes as 17.20±4.15o, the thoracolumbar angle as 28.20±6.26o and the cervicothoracic angle as 41.50±6.91o. The values obtained in our study with the sacral midpoint angle, thoracolumbar angle and cervicothoracic angle obtained in the studies in the literature are very similar to each other. When the values we obtained were compared with the normality levels, it was seen that the sacral midpoint vertebral angle and thoracolumbar vertebral angle values were within the normal angle value limits in individual and team athletes. The fact that the athletes were elite (participating in active competitions), their ages and sports ages were close to each other, may be the reason why there was no significant difference in the sacral midpoint angle, thoracolumbar angle and cervicothoracic angle values, especially in the upright position. However, it was determined that the cervicothoracic vertebral angle values of both groups of athletes (team athletes +2.06° and individual athletes +1.18°) slightly exceeded the upper limit of normal angle values. This may have been caused by the athletes' abdominal and back muscle strength differences.

When the trunk flexion and extension ROM values of the athletes were examined, lumbar flexion was found to be 32.62±2.46o, lumbar extension 55.92±3.91o, thoracic flexion 63.03±4.15o and thoracic extension 15.18±2.43o in individual athletes. When the trunk flexion and extension ROM values of the athletes doing team sports were examined, lumbar flexion was found to be 32.86±3.46o, lumbar extension 55.86±3.32o, thoracic flexion 62.93±4.20o and thoracic extension 14.43±2.09o. In his study examining the trunk flexion and extension ROM values of karate athletes using different techniques, Türkeri (2007) found that the athletes had lumbar flexion of 32.80±5.20o, lumbar extension of 59.60±14.05o, thoracic flexion of 64.40±8.45o and thoracic extension of 16.50±5.15o. The results of the study and our study are similar. When the trunk flexion and extension ROM values of the individual and team athletes participating in the study were examined, no significant difference was found between the individual and team athletes in terms of lumbar flexion, lumbar extension, thoracic flexion and thoracic extension ROM values. ($p>0.05$). When the individual and team sports participating in the study were examined, it was seen that the branches were branches where flexion and extension of the trunk and rotational movements were frequently used actively depending on the position during the competition or contest. It is possible that flexion, extension and rotational movements that occur frequently depending on the position occur with the presence of sufficiently strengthened and flexible muscles in the spinal axis. Considering that the average age, sports age and training hours of the groups participating in the study were homogeneous, it can be thought that the athletes have strong and flexible core muscles as a result of repeated technical and motoric studies for many years and that this is the reason why there is no difference between trunk flexion and extension ROM values.

Considering the findings obtained in our study, it can be said that the FMS, Lower-Upper extremity Y dynamic balance and postural structures of team and individual athletes are similar to each other. It is thought that the values obtained by team and individual athletes in FMS measurements being close to threshold values may cause injuries in athletes and accordingly may negatively affect athletic performance. In the data we obtained from anterior and lateral posture analysis, postural deviations in team and individual athletes do not match the standard posture structure. It is thought that this situation may negatively affect the athletic performance of athletes. It can be said that the increase in lower and upper extremity Y dynamic balance asymmetries may negatively affect trunk rotation, lower extremity mobility, ankle instability and lower extremity flexibility, lower extremity strength and neuromuscular control in the lower extremity and spine and upper extremity mobility, shoulder joint instability, upper extremity flexibility and balance performance in the upper extremity. It is thought that having the vertebral angles and trunk flexion and extension ROM values within normal values in an upright position can have a positive effect on the healthy performance of technical, motoric, etc., actions required by the sports branch.

Conclusion and Recommendations

Considering the findings obtained in our study, it can be said that the FMS, Lower-Upper extremity Y dynamic balance and postural structures of team and individual athletes are similar to each other. It is thought that the values obtained by team and individual athletes in FMS measurements being close to threshold values may cause injuries in athletes and accordingly may negatively affect athletic performance. In the data we obtained from anterior and lateral posture analysis, postural deviations in team and individual athletes do not match the standard posture structure. It is thought that this situation may negatively affect the athletic performance of athletes. It can be said that the increase in lower and upper extremity Y dynamic balance asymmetries may negatively affect trunk rotation, lower extremity mobility, ankle instability and lower extremity flexibility, lower extremity strength and neuromuscular control in the lower extremity and spine and upper extremity mobility, shoulder joint instability, upper extremity flexibility and balance performance in the upper extremity. It is thought that having the vertebral angles and trunk flexion and extension ROM values within normal values in an upright position can have a positive effect on the healthy performance of technical, motoric, etc., actions required by the sports branch

By considering the positions and sub-branches within the sports branches, the injury rates occurring in competitions and contests should be investigated together with FMS, Lower-Upper Extremity Y Dynamic Balance and Posture analyses. The effects of corrective exercise programs on FMS, Lower-Upper Extremity dynamic balance and posture should be investigated by designing an experimental study design. It is recommended to examine the injury rates occurring throughout the season in different branches together with FMS, Lower-Upper Extremity Y Dynamic Balance and Posture analyses by designing a longitudinal study design.

Abbreviations

SS	Standard Deviation
X	Mean
p-value	Probability Value
s	Second
FMS	Fonctional Movement Screen
n	Number of Participants
BMI	Body Mass Index
kg	kilogram
m	meter

Beyanlar / Declarations

Etik Onay ve Katılım Onayı / Ethics approval and consent to participate

Bu çalışmanın hazırlanma ve yazım sürecinde "Yükseköğretim Kurumları Bilimsel Araştırma ve Yayın Etiği Yönergesi" kapsamında bilimsel, etik ve alıntı kurallarına uyulmuş olup; toplanan veriler üzerinde herhangi bir tahrifat yapılmamış ve bu çalışma herhangi başka bir akademik yayın ortamına değerlendirme için gönderilmemiştir. Makale ile ilgili doğabilecek her türlü ihlallerde sorumluluk yazara aittir. Çalışma, Çukurova Üniversitesi Tıp Fakültesi Klinik Dışı Araştırmalar Etik Kurulu tarafından onaylanmıştır (Tarih: 14.06.2019, Toplantı Sayısı: 89/53).

During the preparation and writing process of this study, scientific, ethical and citation rules were followed within the scope of the "Higher Education Institutions Scientific Research and Publication Ethics Directive"; no falsification was made on the collected data, and this study was not sent for evaluation to any other academic publication environment. The responsibility for any violations that may arise regarding the article belongs to the author. The study was approved by the Çukurova University Faculty of Medicine Non-Clinical Research Ethics Committee (Date: 14.06.2019 Number of meetings: 89/53)..

Veri Ve Materyal Erişilebilirliği / Availability of data and material

Bu çalışmanın bulgularını destekleyen veriler, makul talepler üzerine sorumlu yazardan temin edilebilir. Veri seti yalnızca akademik amaçlar için erişilebilir olacak ve verilerin herhangi bir kullanımı, orijinal çalışmayı referans gösterecek ve katılımcıların gizliliğini koruyacaktır.

The data that support the findings of this study are available from the corresponding author upon reasonable request. The dataset will be accessible only for academic purposes, and any use of the data will recognize the original study and maintain the confdentiality of the participants.

Çıkar Çatışması / Competing interests

Yazarlar, bu makalede sunulan çalışmayı etkileyebilecek herhangi bir çıkar çatışması veya kişisel ilişkiye sahip olmadıklarını beyan etmektedirler.

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Yazar Katkıları / Authors' Contribution Statement

Bu çalışmada birinci yazarın katkısı %50, ikinci yazarın katkısı %50 dir.r.
The contribution of the first author in this study is 50%, the contribution of the second author is 50%.

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