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Research Article / Araştırma

Comparison of subtalar angle, Q angle, trunk endurance and physical performance in ındividuals with pes planus and controls

Düz tabanlığı olan bireyler ile sağlıklı kontrollerde subtalar açı, Q açısı, gövde dayanıklılığı ve fiziksel performansların karşılaştırılması

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ABSTRACT

Aim: Pes planus is a health problem that develops due to the decrease in the height of the medial longitudinal arch (MLA) and affects the individual negatively in daily life by causing changes in the foot and trunk alignment. This study aimed to compare subtalar angle, Q angle, trunk endurance, and physical performance in individuals with pes planus and controls. **Materials and Methods**: Volunteers who did not have any history of surgery related to the lower extremities between the ages of 18-35 were divided into two groups as pes planus and control group. A total of 57 people, 28 from the pes planus group and 29 from the control group were included in the study. Subtalar Angle and Q Angle was determined with universal goniometer, Mcgill Trunk Flexion, Extension and Lateral Bridge Test was used to evaluate trunk endurance, and Xbox 360Kinect™ game console was used to evaluate physical performance. **Results**: The left subtalar angle was higher in individuals with pes planus ($p<0.05$). The groups were found to be similar in terms of right and left Q angles ($p>0.05$). There was no significant difference between the groups in terms of trunk endurance values ($p>0.05$). Discus throw distances of individuals with pes planus were higher than healthy controls ($p<0.05$). There was no significant difference physical performances ($p>0.05$). **Conclusion**: Pes planus can negatively affect individuals in terms of subtalar angle and physical performance. Therefore, individuals with pes planus should be evaluated in terms of subtalar angle and physical performance during the rehabilitation process.

ÖZ

Amaç: Düz tabanlık, medial longitudinal ark (MLA) yüksekliğinin azalmasına bağlı olarak gelişen, ayak ve gövde diziliminde değişikliklere neden olarak bireyi günlük yaşamda olumsuz etkileyen bir sağlık sorunudur. Çalışmamızda düz tabanlığı olan ve sağlıklı bireylerde subtalar açı, Q açısı, gövde dayanıklılığı ve fiziksel performans karşılaştırmayı amaçladık. **Gereç-Yöntem**: 18-35 yaşları arasında alt ekstremite ile ilgili herhangi bir ameliyat öyküsü olmayan gönüllüler pes planus ve kontrol grubu olarak iki gruba ayrıldı. Düz taban grubundan 28 ve kontrol grubundan 29 olmak üzere toplam 57 kişi çalışmaya dahil edildi. Subtalar Açı ve Q Açısı üniversal gonyometre ile belirlendi, gövde dayanıklılığını değerlendirmek için Mcgill Gövde Fleksiyonu, Ekstansiyon ve Lateral Köprü Testi, fiziksel performansı değerlendirmek için Xbox 360Kinect™ oyun konsolu kullanıldı. **Bulgular**: Düz tabanlığı olan bireylerde sol subtalar açı daha yüksekti ($p<0.05$). Sağ ve sol Q açıları açısından gruplar benzer bulundu ($p>0.05$). Gövde dayanıklılık değerleri açısından gruplar arasında anlamlı fark yoktu ($p>0.05$). Düz tabanlığı olan bireylerin disk atma mesafeleri sağlıklı kontrollere göre daha yüksekti ($p<0.05$). Fiziksel perfomans açısından gruplar arasında anlamlı fark yoktu ($p>0.05$). **Sonuç**: Düz tabanlık, subtalar açı ve fiziksel performans açısından bireyleri olumsuz etkileyebilir. Bu nedenle rehabilitasyon sürecinde düz tabanlığı olan bireyler subtalar açı ve fiziksel performans açısından da değerlendirilmelidir.

ARTICLE INFO/MAKALE BİLGİSİ

Key Words: Pes planus, Xbox 360Kinect, Performance, Subtalar angle, Q angle

Anahtar Kelimeler: Düz tabanlık, Xbox 360Kinect, Performans, Subtalar açı, Q açısı

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INTRODUCTION

Pes planus, called flat feet, is one of the most common orthopedic problem that develop due to the decrease in the height of the medial longitudinal arch (MLA) (1). It is defined as an increased pronation of the foot biomechanically (2). The decrease in MLA height due to pes planus affects the individual negatively in daily life by causing changes in subtalar angle, Q angle, physical performance and trunk endurance. Some recent studies have reported the incidence of pes planus to be 29% (4) among individuals aged 18-25. Again, in another study conducted on young individuals between the ages of 19-26, the incidence of pes planus was found to be 34.7%.

Any pathology occurring in the foot and ankle can also affect the knee, hip and core region due to the biomechanical alignment. McKeon PO et al. stated that the foot arch and posture may be related to the lumbopelvic region. The averege of the second cervical vertebrae is 1-2 cm the displacement of the body's center of gravity, which should be in front of it, due to pes planus, causes trunk effect. Any change in the kinetic chain and biomechanical disorders affecting foot function affect trunk muscles and performance.

The Microsoft Xbox Kinect® application is a technological approach that can observe the movements of the body with a special technology and transfer these movements into the game. It is used for evaluation and treatment at certain stages of rehabilitation (1,2). The Microsoft Xbox Kinect® , which includes virtual games used in Virtual Reality method, provides more motivational participation of people (3). Many parameters such as gait, posture, postural control, body oscillations, ergonomic evaluations, balance and physiological function can be evaluated with Kinect (4,5,6,7,8,9,10). Many parameters can be evaluated with Kinect, but the evaluations about participants physical performance are limited, so we aimed to evaluate participants physical performance with Kinect in our study.

Studies have found significant consistency between clinical scales and Kinect One, showing that the Kinect One can be a valuable, affordable and reliable tool for movement assessment that can quantitatively evaluate neuro-motor performance (11).

In their study, Iman Kheyrandish et al. observed loss of lower extremity functions in adolescents with pes planus(12). Zhao et al.(13) reported that they found a negative relationship between arch height, foot, ankle muscle strength and physical performance. When the studies in the literature were examined, it was seen that similar parameters were evaluated together and the studies conducted with young people were insufficient (14-16). Therefore, we aimed to compare the subtalar angle, Q angle, trunk endurance and physical performance in individuals with pes planus and controls.

MATERIALS AND METHOD

Study Design

This study is a crosssectional study which was carried out at the University of XXXXXX, XXXXXX Physiotherapy and Rehabilitation Faculty rehabilitation center, between January 2022- May 2022. This study has been approved by Gülhane Scientific Research Ethics Committee with protocol number 2022-170. All patients provided written consent personally or by proxy before participation. This trial was registered with clinicaltrials.gov (registration no: NCT05420272). This study is carried out in accordance with the guidelines of the Helsinki Declaration.

Participants

Volunteers between the ages of 18-35, who did not have any history of surgery related to the lower extremities, who did not have any orthopedic, neurological and systemic problems that could affect the lower extremity and balance, and who were willing to participate to this study.

Individuals with congenital shortness of extremities and visual impairment were excluded from the study.

The feet of the participants who wanted to be included in the study were examined by the researchers with the Navicular drop test and the presence of pes planus was determined according to this test (17). Participants were divided into 2 groups as those with pes planus (Group 1; n=28) and those without pes planus (Group 2; n=29).

The age, gender and background of the individuals participating in the study were questioned, and their height (centimeters) and weight (kilograms) were measured and recorded in a form created by us.

Assessments

Navicular drop test; subjects were asked to stand barefoot with weight on their feet. In this position, the height of the tubercle of the navicular from the ground was measured with the help of a ruler. Then, the subjects were asked to sit on a chair with their feet touching the ground. The height of the tubercle of the navicular from the ground was measured again with the help of a ruler. Measurements were made bilaterally. The results obtained while standing and sitting were subtracted from each other and the amount of navicular fall was recorded in millimeters (mm) (17,18). The amount of navicular drop between 6 and 9 mm was considered as normal MLA (medial longitudinal arch), and if it was 10 mm or more, it was considered as pes planus. This test is a test used to measure the amount of pronation in the foot (19).

To measure the subtalar angle, the participants were asked to lie in a supine position with their feet hanging out of the bed. The subtalar neutral position (no pronation or supination of the foot) was determined. The calcaneal midline and the distal 1/3 tibial longitudinal midline were marked with a line. Measurements were made with a goniometer.

The pivot point of the goniometer was placed on the midline of the Achilles tendon, and one arm was referenced to the distal 1/3 tibial longitudinal midline, while one arm was referenced to the calcanel line, and the deviation angle was recorded. The deviation angle in the valgus direction was given a negative (-) value, and the deviation in the varus direction was given a positive (+) value (20).

The Q angle is the angle between the line extending from the anterior superior iliac spine to the middle of the patella and the line drawn from the middle of the patella to the tibial tubercle. 8-14° (average 10°) for men and 11-20° (average 15°) for women are considered normal values. Measurements were made with a goniometer. While measuring, the SIAS of the individuals in the comfortable supine position, the midpoint of the patella and tuberositas tibiae were found and marked by palpation (21,22).

Mcgill trunk flexion, extension and lateral bridge test is a test used to evaluate the endurance of the core muscles that provide stability. Before the test, individuals were informed about the tests and a trial was made for a few seconds. Time measurements were made with a stopwatch. In the Mcgill trunk flexion test, participants will be asked to cross their hands on their chest and will be positioned on the floor with their trunks flexed at 60° and their knees flexed at 90°. Sixty degrees of body flexion was provided by a stretcher with adjustable head. There was no support behind the person during the test (23-25).

In the McGill trunk extension test, the participants were positioned in the prone position with their spina iliaca anterior superior to the side of the bed. Participants were asked to extend their upper body straight forward from the edge of the table, and it was fixed above their knees with the help of a belt. Before the test started, the upper extremity was supported with the aid of a stool placed on the floor to prevent fatigue. When ready for the test, the participant was asked to raise their hands from the stool, cross them in front of their body and stand parallel to the ground (23-25).

In the Mcgill lateral bridge test, the participants were asked to lie on their dominant side, place their foot on the other foot, cross their non-dominant arm over their chest and place them on their dominant shoulder, and stand on their dominant forearm and elbow. As soon as he was ready, he lifted his hips and was asked to stand on his forearm with his body in a single straight line, starting the stopwatch. In all these measurements, the stopwatch was started and the test was started, when there was any deterioration in its position, the stopwatch was stopped and the test was terminated. The elapsed time was recorded in seconds. Mcgill trunk flexion extension and lateral bridge test were previously performed in healthy individuals and their validity and reliability were found to be high. (Mcgill trunk flexion intraclass correlation coefficient (ICC) = 0.97, Mcgill trunk extension intraclass correlation coefficient (ICC) = 0.97, mcgill lateral bridge intraclass correlation coefficient (ICC) = 0.99) (23-25).

The Microsoft Xbox Kinect® game console was used for upper and lower extremity performance evaluation. The Microsoft Xbox Kinect® ; there is an infrared kinect camera sensor that can detect user movements without the need for a special controller, the user's movements in the virtual reality environment can be monitored in real time on the screen (26). Before the start of play therapy, the participants were informed about the games by the physiotherapist and they were shown how to play the games. The Microsoft Xbox Kinect® game console was on a standard table and was placed directly in front of the participants 2.5m. For 100 m running performance, 100 m running game and hurdle running game in Kinect Sport were determined by long jump game to evaluate jump performance, discus throw and javelin throw game for upper extremity performance, and the scores of the participants were recorded. Participant was asked to run on the ground. The participant started to run where they were with the start signal and the game of the participants who crossed the finish line was ended and it was recorded how long it took to run the 100 meters. In the steeplechase game, the participants were asked to jump as soon as they saw the obstacles while running. The participants ran by jumping the obstacles where they were with the start signal. It was recorded how long it took to complete the given distance in the running game by jumping the obstacles (27,28).

In the puck throwing game, the participants were asked to choose the dominant hand and throw the puck to the furthest point they could throw. As a result of the trial performed 3 times, all measurements were recorded and their averages were taken. In the javelin throwing game, the participants were asked to choose their dominant hand and walk where it was with the javelin. When they saw that they came to the green area on the screen, they were asked to throw the javelin as far as they could throw. In the steeplechase game, the participants started to run with the start signal, and when the obstacles turned green, they were asked to jump over the obstacles by jumping where they were. The game of the participants who crossed the finish line was ended and the time it took to run the given distance was recorded (27,28).

Statistical Analysis

Data analysis and calculations were conducted using IBM SPSS Statistics 21.0 (IBM Corp., Armonk, NY, USA). An overall P-value of less than 0.05 was considered to show a statistically significant result. The variables were investigated using visual (histograms and probability plots) and analytical methods (Shapiro– Wilks test) to determine whether they were normally distributed. Descriptive statistics of normally distributed variables were presented as means and standard deviations, and those of nonnormally distributed and ordinal variables were presented as medians, minimum–maximum values, interquartile range, and frequency tables. Baseline demographic and physical characteristics were compared between groups using independent sample t-tests or Mann–Whitney U tests for numeric variables and the chi-square test for categorical variables. Q angle, subtalar angle, trunk endurance and physical performance values were compared of between groups using independent samples t-tests or Mann–Whitney U tests (29).

A power analysis was performed to determine sample size before starting the study. The sample size was calculated by G*Power program (version 3.0.10 Universität Düsseldorf, Düsseldorf, Germany). The article by Elataar at al. was taken as a reference for the power analysis. With a power of 90%, an error >5%, the minimal sample size for each group was estimated at 22 participants (30).

RESULTS

A total of 57 people were included in the study, 29 from the control group and 28 from the pes planus group. The physical characteristics of the individuals are given in Table 1. The groups were similar in terms of age and BMI values (p>0.05). Gender distributions between groups are different from each other (p<0,05). The results of Q angle, subtalar angle, trunk endurance, and physical performance tests of individuals with pes planus and controls are shown in Table 2.

The groups were found to be similar in terms of right and left Q angles (p>0.05). The left subtalar angle is higher in individuals with pes planus (p<0.05). There was no significant difference between the groups in terms of trunk endurance values. Disc throw distances of individuals with pes planus are higher than healthy controls (p<0.05). There was no significant difference between the groups in terms of 100 meters running, javelin throw, long jump and hurdle race values (p>0.05).

Table 1 The physical characteristics of the groups

Characteristic	Pes Planus (n=28)	Control (n=29)	p
Gender [(male; female), n (%)]	11(39.3); 17(60,7)	2(6.9); 27(93.1)	0.004a*
Age (year) [Median (min; max)]	21 (19;27)	21 (19;28)	0.76b
Height (cm) [(Mean±SD)]	171.79±9.91	164.62±6.32	0.012b*
Weight (kg) [(Mean±SD)]	65.89±14.69	57.31±8.88	0.011c*
BMI (kg/m2) [(Mean±SD)]	28±4.80	30.11±6.03	1.96c

BMI: Body Mass Index /a Chi-Squared Test / bMann Whitney U test/ cIndependent Samples T test

Table 2: Comparison of Q angle, subtalar angle, trunk endurance and physical performance between groups

		Pes Planus Median (IQR) Mean±SD	Control Median (IQR) Mean±SD	p	z/t
Q Angle	right	10 (4.50)	10 (6.50)	0.961	-0.049a
	left	10.92±3.35	10.72±2.11	0.791	-0.266b
Subtalar Angle	Right	10 (6.50)	9(5.50)	0.058	-1.898a
	Left	9 (5)	5(2.50)	0.012*	-2.517a
Lateral Bridge	Right	32 (36.45)	28 (31.81)	0.260	-1.126a
	Left	32.91 (40.27)	27.64 (27.55)	0.288	-1.062a
Trunk Flexion		99 (119.05)	121 (125.49)	0.734	-0.340a
Trunk Extension		73 (45.50)	78 (51)	0.975	-0.032a
Sprint		10 (1.21)	10.43 (1.14)	0.288	-1.062a
Javelin Throw		42.20±18.45	35.62±14.97	0.144	-1.483b
Long Jump		9.22±2.59	8.30±1.79	0.127	-1.551b
Throw Discus		31.60±13.22	39.48±10,64	0.013*	2.559b
Hurdle-Race		20.51 (3.55)	21.32 (3.16)	0.207	-1.261a

a Mann Whitney U test / bIndependent Samples T test/ IQR: Interquartile range; *p<0,05

DISCUSSION

In this study it was aimed to compare the subtalar angle, Q angle, trunk endurance and performance in individuals with pes planus and healthy controls. According to the results of this study individuals with pes planus and healthy controls shows similar Q angles and trunk endurances. There are differences between subtalar angle and trunk performance. To our best knowledge this is the first study about evaulating the trunk performance of individuals with a technological material as the Microsoft Xbox Kinect®.

Overload in the lower extremities is transferred to the foot, which absorbs the mechanical stress of ground contact, shaping the pattern of postural alignment and joint movement throughout the lower extremity. Repeated overloading of the foot can stretch the ligaments beyond their elastic limits, damaging soft tissues and transferring loads of proxima segments thougrout ankle and knee(31). Foot deformity may result to patella rotation which increases Q angle and may possibly predispose the knee pathologies (32). Kwon et al. (33) showed that the Q angles of young adults with patellofemoral pain and controls was similar degrees in young in their study. Unver et al (34) also comaped Q angle in young adults with and without pes planus and found that there is no difference between each group. Similar to the results of these studies, it was observed that the Q angles of young people with pes planus and controls were similar in this current study. The authors think that these results concluded that lower extremity involvement is not high in individuals with pes planus included in this study.

Pes planus is the result of excessive subtalar joint pronation occurring during the stance phase of the gait cycle (35). Subtalar (and midtarsal) joint pronation is associated with depression of the medial arch, producing the clinically described pes planus deformity (36). Koh et al (37) reported that the angle of subtalar eversion was significantly greater in pes planus feet than in normal feet during active ankle dorsiflexion. Agoada et al stated that (38) certain angular measurements of the calcaneus are associated with arch height in the modern human foot. In the comparison analysis, there was significant difference between subtalar angles of individuals with pes planus and controls. The subtalar angles of indidivudals with pes planus were higher than controls and pronated. The authors suggest that due to the increase in the subtalar angle, exercises for the extrinsic muscles of the ankle should be added to the rehabilitation program.

The trunk muscles considered the center of the kinetic chain and their dysfunction could disrupt the kinetic chain of motion and it has been associated with lower limb injuries (39). Elaatar et al (30) found that there was no difference between trunk flexion and extansion muscle endurance indivivuals with and without pes planus but there was a difference between trunk lateral muscle endurance between pes planus and controls. Ghafar et al (40) stated that no difference of lateral core muscles between individuals with and without pes planus. In this study, the level of core muscle endurance were similar between individuals with pes planus and controls. Despite the similarity between patients with pes planus and controls in this study, they completed endurance tests of the trunk lateral muscles in a longer time than the controls. The authors interpreted that this difference was not due to pes planus, but due to better physical activity levels and trunk muscle strength. More precise and objective performance tests (for example, motion analyses) may be more effective as well as to elicit definitive results.

Contarlı et al. (41) found that the pes planus had no effect on vertical jump performance. Kumala et al (42) investigated that there was no difference about physical performance as Single leg hop test on male athletes with and wtihout pes planus. Bakırhan et al (43) demonstrated that pes planus severity does not affect the physical performance of the young female adults with pes planus. In this current study the results of physical performance test were similar between indidivduals with and without pes planus. Only there was a difference on the throw discus test which based on trunk and upper extremity performance. The authors concluded that younger adults were active and participate regular physical routines. Many factors such as activity level, anthropometric, physiological and biomechanical characteristics play a role in the physical performance (43). The physcial performance is an higher level activity that requires neuromuscular muscle activations of the lower extremity joints and trunk (41). To our knowledge, this study is one of the research from a limited number of studies to evaluate performance with The Microsoft Xbox Kinect® technology in individuals with pes planus and shed light in the future studies. Thus the authors may conclude that the The Microsoft Xbox Kinect® technology could be used for evaluating physical performance like other physical tests.

Limitations

The current study has some limitations. Degree of pes planus, physical activity levels of participants that may affect physical performance and trunk endurance were not evaluated.

Furthermore, there is no equal distribution about gender between individuals with pes planus and controls.

For future research, the sample population should be expanded to include female subjects

CONCLUSION

In this study, the Q angle and trunk endurance were similar in individuals with pes planus and controls in younger adults. The subtalar angle of pes planus group has higher scores than controls with a tendency to pronation. The physical performance of pes planus group was lower than controls in younger adults.

The results of this study could be of interesting for both clinicians and researchers interested in the prevention of lower limb injuries in younger adults. Prevention and/ or therapeutic strategies based on foot postures according to a trunk endurance and physical performance have not seemed to be effective in pes planus and controls in younger ages. Other characteristics, such as core muscle strengths, and physical activity level involved in pes planus, should be considered. Other characteristics, such as core muscle strengths, and physical activity level involved in pes planus, should be considered. Factors that may affect physical performance and trunk endurance as core muscle strength, physical activity level, and dominancy of lower extremity characteristics may be evaluated in the future research.

Disclosure

The authors declare no conflicts of interest.

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