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Original Article

Comparison of lower extremity anthropometric measurements of healthy and pes planus patients in early adolescence

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Abstract

Aim: Pes Planus (PP) was defined as the decrease or loss of length of arcus longitudinalis medialis (MLA). The aim of the present study is to find out whether PP causes any anthropometric changes in individuals and to determine the relationship between PP and foot type.

Materials and Methods: A total of 100 individuals, 50 PP patients (25 female and 25 male) and 50 healthy individuals (25 female and 25 male), between the ages of 11 and 14 were included. Circumference of waist, hip, thigh, leg, bimalleolar and foot; tarsal and MLA height; bimalleolar and foot breadth were measured. Leg index, foot index and foot types were calculated with various anthropometric rates.

Results: Significant differences were found in female circumference measurements of the waist, hip, both thighs and right foot bimalleolar ($P < .05$). Significant differences were found in right and left foot bimalleolar circumferences measurements and leg indexes in men ($P < .05$). Significant differences were found in both genders in right and left foot MLA and tarsal heights ($P < .05$).

Conclusion: It was found that PP affects not only the foot anthropometric measurements but also the hip, thigh and leg measurements. Early treatment for PP can provide irreversible lower extremity problems that cause lower quality of life.

Keywords: Anthropometry; foot types; lower extremity index; pes planus

INTRODUCTION

Anatomical structure and normal boundaries of the human body have been researched since the old times. Studies which were originally conducted to find out the human body with ideal beauty in terms of art gained a scientific dimension with the development of anthropology and medical sciences (1).

Different foot problems occur in the society since foot plantar arc measurements differ from person to person. While PP can be defined as the decrease or total loss of longitudinal arches of the foot, it can also be defined as side sole contact foot (2,3). The deterioration in the mechanical balance of the foot with PP changes the localization and severity of the stresses on especially lower extremity joints and lumbar vertebrae. Angular deviations in the lower extremity influence the foot biomechanics and cause static deformation (4). The changes in the distribution of the body weight when standing influence the shape of the foot (5).

Anthropometry is a method which classifies the subjective characteristics of the human body into sizes and structural features according to specific measurement methods and principles and which gives information about the body type and size (6).

Factors such as human beings' biological profiles, their ages, genders, heights and ethnic structures help in defining their anthropometric description (7). Body sizes and differences in the rates of these measurements create standards specific for societies. At the same time, these differences help in assessing the health and socioeconomic state of the society and designing and producing all kinds of devices, machines, clothes, accessories suitable for the characteristics of the population (8,9).

The aim of the present study is to find out whether PP causes any anthropometric changes in individuals and to determine the relationship between PP and foot type.

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MATERIALS and METHODS

A total of 100 individuals, 50 PP patients (25 female and 25 male) and 50 healthy individuals (25 female and 25 male), between the ages of 11 and 14 were included in our study. Permission was taken from Inonu University Health Sciences Non-Interventional Clinical Research Ethics Committee with the code of 2020/36 protocol and those who agreed to participate in the study signed voluntary consent forms. The study was carried out in accordance with the Helsinki Declaration. Exclusion criteria of the study were a history of surgery and trauma of the lower extremity, any neurological problems and having a congenital developmental disorder except for PP.

Anthropometric measurements were taken to compare the physical fitness levels of the individuals. After the measurements were taken, lower extremity indexes and foot type analyses were performed. Tape measurement was used for measurements of length, circumference and height, while NIQUA make digital compass was used for measurements of breadth. Arithmetic mean, standard deviation and significance values of the measurements were found. PP diagnosis was made according to Staheli Index. The diameters of the widest point of the heel of the foot and the diameter of the narrowest point of the foot arch were found and their ratios were measured. PP diagnosis was made if this rate was higher than 0.7 (10) (Figure 1).

Figure 1. Pes Planus

The following measurements were made for assessment

Body Mass Index (BMI): It is found by dividing body weight in kilogram with the square of height (kg/m2) (8). Measurements of the height, length, breadth and circumferences of the lower extremity were made in anatomical position and based on literature (11).

Thigh length: The distance between the upper end of the femur's trochanter major and the midpoint of the patella is measured (11).

Leg length: The distance between midline of the patella and foot sole is measured (11).

Foot length: The distance between the posterior point of the heel and the end point of the big toe or second toe (if the second toe is longer than the big toe) is measured (12).

Waist circumference measurement: It is the circumference measurement based on umbilicus (13).

Hip circumference measurement: It is the circumference measurement parallel to the floor by taking care for not compressing the tissues when the tape is at the widest area of the hip (6).

Thigh circumference measurement: It is the circumference measurement taken from the midpoint of the thigh (14).

Leg circumference measurement: It is the circumference measurement taken from midpoint of the leg (14).

Bimalleolar circumference measurement: It is the circumference measurement taken from the most protrusive points of both malleolus (15).

Foot circumference measurement: It is the circumference measurement taken from the metatarsophalangeal joint (15).

Bimalleolar breadth: It is the breadth between the most protrusive points of both malleolus (15).

Foot breadth: The distance between phalanx proximalis bases of the first and fifth toes and caput ossis metatarsi of the first and fifth toes and the distance between the inner and outer borders of metatarsophalangeal joints were measured (11).

Tarsal height: The distance between the sole and back of the foot was measured 1 cm from the back of half of foot length (15).

MLA height: It was measured by calculating the height of the highest point of medial archus from the floor (15).

Leg index: It is the value obtained by taking the percentage (%) of the ratio of leg length to thigh length (16).

Foot index: It is the value found by multiplying foot length ratio with hundred (11).

Foot types analysis: Chiroma et al. (5) stated foot types in terms of foot index as standard, slender and broad type of foot. Foot types is determined by the formuled; Foot Breadth / Foot Length X 100 (11).

RESULTS

There was no statistically significant difference in demographic characteristics of male and female participants. The demographic characteristics of PP and healthy male participants were found to be age (P = .07), height (P = .577), weight (P = .973) and BMI (P = .281). The demographic characteristics of PP and healthy female participants were found to be age (P = .07), height (P = .088), weight (P = .420) and BMI (P = .200). Statistically significant increases were found in right bimalleolar (P = .039) and left bimalleolar (P = .047) circumference measurements of male participants. These differences were in the form of increase in bimalleolar circumference measurements (Table 1).

Statistically significant increases were found in waist (P = .001), hip (P = .012), right thigh (P = .007), left thigh (P = .005) and right bimalleolar (P = .021) circumference measurements of female participants. These differences were in the form of increase in circumference measurements (Table 2).

Table 1. Circumference measurement results of male participants

Circumference measurement results of male participants (cm)	Pes planus (n=25)		Healthy (n=25)		P
	Ave.	SD±	Ave.	SD±	
Waist circumference	66.56	6.850	69.56	8.790	0.185
Hip circumference	76.860	7.4659	74.400	8.3116	0.276
Right thigh circumference	38.200	4.6278	37.760	5.6220	0.764
Left thigh circumference	37.000	3.8188	37.020	5.8247	0.989
Right leg circumference	29.180	2.8682	28.780	3.4098	0.656
Left leg circumference	29.072	3.2448	28.660	3.2330	0.655
Right bimalleolar circumference	24.140	2.1772	22.860	2.0942	**0.039**
Left bimalleolar circumference	24.060	1.8333	22.980	1.9120	**0.047**
Right foot circumference	22.220	1.7858	21.880	1.6475	0.488
Left foot circumference	22.120	1.6538	21.940	2.1081	0.738

cm: Centimetre, n: Number of People, SD: Standard Deviation, Ave: Average

Table 2. Circumference measurement results of female participants

Circumference measurement results of female participants (cm)	Pes planus (n=25)		Healthy (n=25)		P
	Ave.	SD±	Ave.	SD±	
Waist circumference	74.44	7.188	66.76	8.786	**0.001**
Hip circumference	84.840	8.8832	78.540	8.1137	**0.012**
Right thigh circumference	42.600	4.3012	38.980	4.7489	**0.007**
Left thigh circumference	42.620	4.6036	38.900	4.2155	**0.005**
Right leg circumference	29.280	2.7616	28.440	3.3644	0.339
Left leg circumference	29.560	3.2382	28.580	3.4571	0.306
Right bimalleolar circumference	23.160	1.3748	22.020	1.9444	**0.021**
Left bimalleolar circumference	23.460	1.0599	22.800	1.9472	0.143
Right foot circumference	22.292	3.0995	21.260	1.9425	0.165
Left foot circumference	22.312	2.9693	21.420	1.6246	0.194

cm: Centimetre, n: Number of People, SD: Standard Deviation, Ave: Average

Statistically significant differences were found in right MLA (P = .002), left MLA (P < .001), right and left tarsal height (P < .001) values and right leg (P = .009) and left leg (P = .004) indexes of male participants. These differences were in the form of decrease in MLA and tarsal height values and leg indexes of individuals with PP (Table 3).

Table 3. Breadth, height and index measurement results of male participants

Breadth, height and index measurement results of male participants	Pes planus (n=25)		Healthy (n=25)		P
	Ave.	SD±	Ave.	SD±	
Right bimalleolar breadth	65.8840	4.91330	63.7860	5.64810	0.168
Left bimalleolar breadth	66.1272	4.17193	65.8148	6.42578	0.839
Right foot breadth	86.4048	7.06567	84.9424	10.72609	0.572
Left foot breadth	87.9732	6.05944	85.3996	10.86475	0.306
Right MLA height	1.088	0.4682	1.640	0.6984	**0.002**
Left MLA height	0.832	0.5000	1.800	0.5129	**<0.001**
Right tarsal height	4.880	0.8165	6.300	0.6964	**<0.001**
Left tarsal height	4.980	0.9028	6.260	0.6994	**<0.001**
Right leg index	40.7768	3.65492	43.9188	4.43379	**0.009**
Left leg index	41.5412	3.59967	44.6912	3.84274	**0.004**
Right foot index	35.6732	2.11121	34.3108	5.42280	0.248
Left foot index	36.2628	2.39548	34.9740	4.20559	0.189

n: Number of People, SD: Standard Deviation, Ave: Average

Table 4. Breadth, height and index measurement results of female participants

Breadth, height and index measurement results of female participants	Pes planus (n=25)		Healthy (n=25)		P
	Ave.	SD±	Ave.	SD±	
Right bimalleolar breadth	60.4372	9.01476	60.4052	4.01945	0.987
Left bimalleolar breadth	61.3128	8.81387	60.5600	4.17115	0.701
Right foot breadth	87.4608	5.75210	84.0996	8.04350	0.096
Left foot breadth	87.5708	5.58462	85.1004	7.73412	0.202
Right MLA height	1.276	0.4327	1.768	0.6200	**0.002**
Left MLA height	1.144	0.5501	1.848	0.7583	**<0.001**
Right tarsal height	5.000	0.7522	6.236	0.4082	**<0.001**
Left tarsal height	5.020	0.8165	6.100	0.6532	<0.001
Right leg index	44.9600	3.78388	45.5032	2.95629	0.574
Left leg index	44.2536	3.54952	45.8312	3.61732	0.126
Right foot index	37.3336	3.35135	36.1172	3.75727	0.233
Left foot index	37.7788	2.57955	36.5216	3.47461	0.153

n: Number of People, SD: Standard Deviation, Ave: Average

Statistically significant differences were found in right MLA (P = .002), left MLA (P < .001), right and left tarsal (P < .001) heights of female participants. These differences were in the form of decrease in MLA and tarsal height values of individuals with PP (Table 4).

Our analyses showed that the majority of the participants had standard foot type. While broad type of foot is more frequent in individuals with PP, slender foot type shows variations.

DISCUSSION

Different foot problems emerge in society since foot plantar arch differs from person to person. While PP can be defined as the decrease or total loss of longitudinal arches of the foot, it can also be defined as side sole contact foot (2,3). The prevalence of PP varies in different populations for instance Çetin et al. (17) found PP prevalence as 35.5% in girls and as 28.5% in boys between 6 and 13 years of age in Anatolia. In a study they conducted on girls and boys between 7 and 12 years of age in Iran, Kachoosangy et al. (18) found PP in 74% of the participants. They found that 23% of these participants had mild PP, while 34% had moderate PP and 17% had severe PP.

In the anthropometry study, Yucel AH et al. (19) reported waist circumference as 69.48±6.49, hip circumference as 96.70±7.44 and thigh circumference as 50.63±6.36. Içten N et al. found bimalleolar circumference as 24.62±0.13, thigh circumference as 51.78±0.40 in Karadeniz girls (20). In our study statistically significant differences were found in right and left bimalleolar circumference measurements of healthy and PP with male participants; while statistically significant differences were found in waist, hip, right and left thigh and bimalleolar circumference measurements of healthy and PP with female participants. We think that the array of bones and joints, the tendency of decrease in muscle strength and looseness in ligaments can have influenced the biointegrity of the body and caused these differences in individuals with PP.

Yucel AH et al. (21) found leg index as 92.10±10.91 in male participants. In our study, statistically significant differences were found in right and left foot MLA, tarsal height and leg indexes of healthy male participants and male participants with PP; and right and left foot MLA and tarsal height values of healthy female participants and female participants with PP. PP occurs as a result of the deterioration in the bone array and biomechanic of the foot, a decrease or loss in the height of arcus longitudinalis medialis. Bone structure of the foot skeleton and the joints in-between are supported by various factors such as muscle strength, ligaments and fascia. We believe that functional problems in various structures supporting MLA can be influential in the occurrence of these differences.

Foot shapes differ according to different weight bearing states. The shape of foot changes genetic, natural and environmental factors (5). In a study conducted in Nigeria, Chiroma et al. (5) reported slender type as 16.9%, standard type as 32.3% and broad type as 50.7% in men, while they reported slender type as 21.5%, standard type as 55.3% and broad type as 23.0% in women.

In our study, while slender type foot, standard type foot and broad type foot rates were 4%, 96% and 0%, respectively in right feet of healthy male participants; they were found as 16%, 84% and 0% in left feet. In male participants with PP, the same parameters were found as 24%, 52%, 24%, respectively in right foot, while they were found as 20%, 56% and %24, respectively in left foot. Slender type foot, standard type foot and broad type foot rates were 12.0%, 84.0% and 4.0%, respectively in right feet of healthy female participants, while they were found as 28.0%, 64.0% and 8.0% in left feet. In female participants with PP, the same parameters were found as 0%, 92% and 8%, respectively in right foot, while they were found as 4%, 72% and 24%, respectively in left foot. Gender, age, genetic differences, geographical conditions, cultural make and diseases can influence the differences in foot types. While the majority of participants had standard type foot in our study, broad type foot is more common in participants with PP. Slender type foot prevalence varies in individuals. We think that the reason why broad type foot is more common in participants with PP is because of the enlargement that occurs in metatarsophalangeal joint as a result of the loss of arcus longitudinalis medialis.

CONCLUSION

With the present study, we found that PP causes many anthropometric problems in the lower extremity. These problems are related with environment, height, breadth, foot type, leg and foot index values being influenced. There are studies in literature reporting that PP influences anthropometric measurements. This influence occurs through affecting the array, biointegrity and biomechanic in lower extremity as a result of the loss of foot medial longitudinal arch. If these problems are not prevented, health problems can become much more serious. For this reason, our priorities in individuals with PP are making sure that individuals are aware of the problem, necessary equipments are used, ergonomic designs are made and treatment is performed.

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