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Original Research Article

CORRELATION BETWEEN PES PLANUS AND TIBIOFEMORAL ANGLE MEASUREMENT IN NORMAL, HEALTHY YOUNG ADULTS

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ABSTRACT

Background: Pes planus deformity of the feet is primarily an asymptomatic condition that alters the lower limb biomechanics. It is associated with changes in knee alignment among older adults and subjects with osteoarthritis. No data are available on the correlation between pes planus and knee alignment among young adults.

Purpose: The purpose of this study was to determine if a correlation exists between the presence of pes planus and tibiofemoral angle measurement in normal, healthy young adults.

Methods: Thirty subjects had their flat footedness assessed by using Feiss' line test. The tibiofemoral angle was assessed through a photograph of their lower limbs, and the data from the photograph were processed using the SCODIAC program.

Results: No significant differences were found between pes planus and tibiofemoral angle among healthy, young adults. Seven subjects had bilateral structural flat feet, while most of the participants had 1st degree flat foot. Knee genu varum was observed in most of the participants.

Conclusions: Although there was no significant correlation between pes planus and tibiofemoral angle measurement among young healthy adults, the findings of this study agreed with the previous studies that was done on older adults and subjects with knee osteoarthritis in the fact that most of the pes planus feet had genu varum knee alignment.

KEY WORDS: Pes planus, Feiss' line test, tibiofemoral angle, valgus knee, varus knee, genu varum, genu valgum.

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INTRODUCTION

Pes planus foot deformity is a lowering of the medial longitudinal arch of the foot causing flattening of the foot arch and is most commonly known as flat foot [1]. Lowering of the arch is primarily asymptomatic, however it changes the lower limb biomechanics and alters the muscle activity therefore leading to pain and injury [2, 3]. The main two categories of pes planus are flexible and rigid. A flexible pes planus demonstrates a normal arch in the non-weight bearing condition of the foot and demonstrates a lowered arch in the weight bearing condition [2]. Rigid pes planus is a fixed lowering of the arch, which is also known as structural pes planus [2]. Flexible pes planus is very common in infants and young children due to the laxity of their ligaments and the lack of neuromuscular control. However, the arch normally develops around five to six years of age [2]. Flexible pes planus may also be found in individuals with: dysfunction of the posterior tibial tendon; fractures to the hindfoot area; plantar fascial injury; spring ligament injury; degenerative or inflammatory

arthropathies; obesity; tight Achilles tendon; tight calf muscles; and congenital ligamentous laxity.[2][3][4] Most cases of pes planus are flexible [2].

Changes in foot posture leads to changes in body biomechanics [5-7]. Studies have shown that the presence of pes planus foot deformity is associated with medial compartment knee osteoarthritis [5-7]. A significant difference was observed in the incidence of pes planus in healthy subjects and subjects with osteoarthritis with 22% and 42% respectively [5]. Furthermore, 38.3% of females studied had both knee medial and lateral compartment osteoarthritis in the presence of pes planus [7].

Knee osteoarthritis has rapidly increased in the United States [8,9]. In 2007-2008, 14 million individuals had symptomatic knee osteoarthritis [8]. Some important systematic risk factors for knee osteoarthritis are direct damage to the joint and not allowing the joint to heal properly [9]. While biomechanical factors are considered to be local risk factors for the development of knee osteoarthritis by altering the forces applied to the joint, other risk factors exist such as obesity, the presence of metabolic disease, age, sex, bone density, and muscle function [9]. Knee joint malalignment was considered to be an independent risk factor for the progression of radiographic knee osteoarthritis in a systematic review done in 2009 [10]. Pes planus is not always symptomatic because the foot adapts to the biomechanical changes placed upon it, and over time changes occur in the structure of the ligaments [1].

The tibiofemoral angle is defined as the angle formed between the line of anatomical axis of the femur and anatomical axis of the tibia in the frontal plane [11-15]. The tibiofemoral angle normally develops with age. Infants have varus knees until the ages of 1 to 1.5 years, and then they progress to valgus around the ages of 2 to 3 years. The angle decreases to varus by 6 to 7 years of age and continues in slight varus throughout adulthood [12,16,17]. In the literature, measurement in adults of the tibiofemoral angle by using the anatomical axis as a reference resulted in mean values of valgus alignment, while studies that measured the tibiofemoral angle as a reference by using the mechanical axis resulted in mean values of varus alignment. This discrepancy maybe due to the fact that the anatomical axis of the femur has a 5° to 7° normal valgus angulation relative to the mechanical axis [12,15]. Therefore, measuring tibiofemoral angle in reference to the anatomical axis would be considered normal if it is between 5° and 7° of valgus alignment (approximately 6° valgus) [15,18,19]. Valgus deformity would be >7° and varus deformity would be <5°.

Early intervention for management of pes planus by prescribing the proper orthotics can serve to potentially correct the distribution of forces on the foot and therefore decrease the incidence of knee osteoarthritis [1]. To date, some studies have shown the correlation between pes planus and knee angle in pediatric populations and in populations with knee osteoarthritis [5,7,20]. However, no correlation studies have been found that studied healthy young adults. Thus, the purpose of this present study was to determine if a correlation exists between the presence of pes planus and tibiofemoral angle measurement in normal, healthy young adults.

SUBJECTS AND METHODS

Subjects: A sample of convenience of 30 (10 males and 20 females) young adults was recruited from New York University Physical Therapy Department [(mean ± SD) age = 26.60 ±3.00 years weight = 66.97 ±11.09 kg, height = 1.64 ±0.07 m, and BMI = 24.70 ±2.64] (see Table1). Participants ages ranged between 21 and 33 years. All participants had functional range of motion and strength and normal sensation in their lower extremities. All participants were healthy and free of cardiopulmonary or neuromuscular conditions. Prior to participation, all participants signed the consent form. New York University's Committee on Activities Involving Human Subjects approved the study.

Protocol: All participants signed a consent form and then completed a questionnaire about their background. Age, sex, height, and weight were recorded. Lower extremity functional muscle strength and joint range of motion were assessed by performing a full squat. Superficial sensation of the lower extremity was assessed

by using a cotton swap. Pes planus was determined by using Feiss' line test, which is clinically used to "estimate the amount of pronation via transcutaneous measurement of the inferior displacement of the tarsal navicular"[21]. Participants removed their shoes and socks and sat on the table in a long sitting position with the foot to be tested off the table. The medial malleolus of the tibia, navicular tubercle, and head of the first metatarsal phalangeal joint were marked. Using a ruler, a line was drawn connecting the medial malleolus of the tibia and the head of first metatarsal phalangeal joint, and then the location of the navicular tubercle was noted in the non-weight bearing position to determine if the subject has a structural pes planus. The participant then stood in a full weight bearing position with the feet 8-15 cm apart. The navicular tubercle was marked again, and its inferior displacement was measured relative to Feiss' line with a ruler.[21] If the navicular tubercle falls 1/3 of the distance to the floor, it is considered 1st degree flat foot; if the navicular tubercle falls 2/3 of the distance to the floor, it is considered 2nd degree flat foot; and if the navicular tubercle falls and rests on the floor, it is considered 3rd degree flat foot (Figures 1, 2, and 3) [22].

Fig. 1: The three anatomical landmarks used to measure Fiess' line.

Fig. 2: The drawing of Feiss' line in the non-weight bearing position.

Fig. 3: Location of the navicular tubercle in relation to Feiss' line in the weight bearing position.

The tibiofemoral angle was measured by using the SCODIAC program which uses photographs of the lower limb by placing the subjects in a standardized weight bearing position and then measuring the tibiofemoral angle on a computer program [23,24]. This method is similar to measuring the tibiofemoral angle with a goniometer [12,13,25,26]. However, the SCODIAC program is more accurate because there is no sway or movement of the goniometer while reading the angle [24]. The goniometer clinical placement in measuring the tibiofemoral angle is: the fulcrum is placed over the knee center "midpoint between the medial and lateral joint line in the frontal plane" [12,13,25,26]. The movable arm is placed over the knee center to a midpoint between the medial and lateral malleoli [12,13,25,26]. The stationary arm is placed over the knee center to the anterior superior iliac spine [25]. Choosing the anterior superior iliac spine instead of the greater trochanter has been determined to be more accurate due to the increased thickness of the soft tissue over the greater trochanter as opposed to the minor soft tissue over the anterior superior iliac spine. Thus, the anterior superior iliac spine can be easily located, and the axis going from the anterior superior iliac spine to the knee center will simulate the axis of the femur [24].

Subjects were instructed to remain barefooted and stand on a fixed marked place with both knees in extension and touching each other [25]. A camera was placed in front of them, the anterior superior iliac spine was marked, and a photograph was taken from the waist to the feet. On the computer program, the placement of the

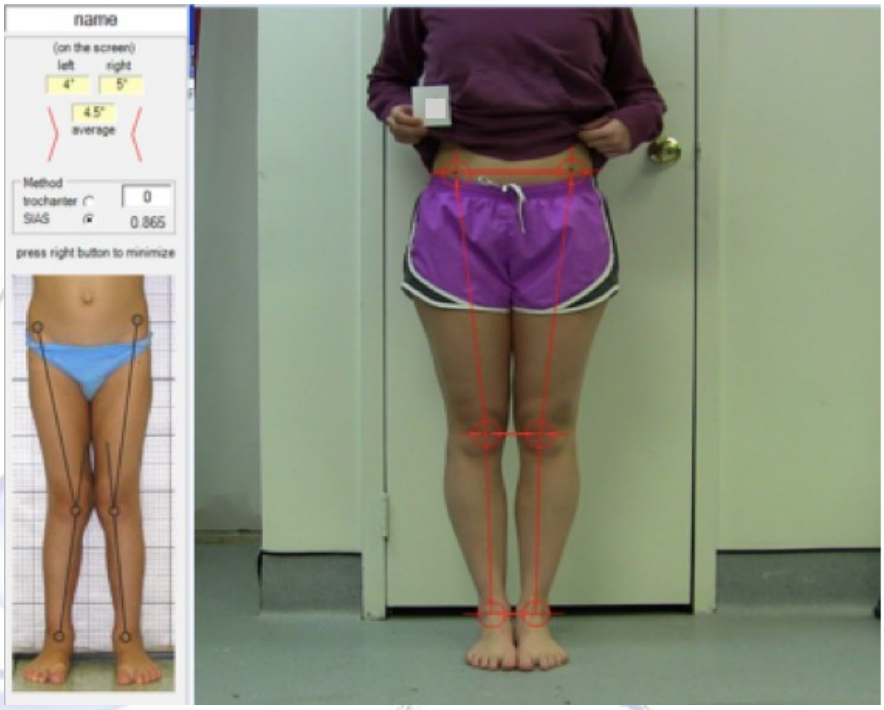

Fig. 4: SCODIAC program output.

axis simulated the placement of the fulcrum, stationary arm, and movable arm of the goniometer (Figure 4) [24]. The knee was determined to be in valgus alignment if its angle was >7°,and in varus alignment if its angle was < 5°[27].

Data Processing: Pes planus was classified into four categories: normal, 1st degree flat foot, 2nd degree flat foot, and 3rd degree flat foot. The knee alignment was obtained by measuring the tibiofemoral angle on the SCODIAC program. The angle was determined to be in valgus alignment if it was >7°, in varus alignment if it was < 5°, and normal if it was between 5° and 7° [27].

Data Analysis: Demographic data were analyzed by descriptive statistical analyses. A Chi-square test of independence using the SPSS software (version 25) was used to determine the correlation between pes planus and tibiofemoral angle. An adjusted p-value at 0.05 was used to indicate any significant differences.

RESULTS

Table 1 describes the characteristics of the participants. No differences were noted between genders in terms of the characteristics of the participants. Twenty subjects had right flat foot, 23 subjects had left flat foot, and 7 subjects had bilateral structural flat feet. All subjects had either normal knee alignment or varus knee alignment except for one subject who presented with valgus knee alignment and 2nd degree flat foot. Only one subject had 3rd degree flat foot with varus knee alignment.

When comparing right foot with right tibiofemoral angle, 26 knees were in varus alignment; 9 were normal, 14 had 1st degree flat foot, 2 had 2nd degree flat foot, and 1 had 3rd degree flat foot. However, only one knee was in valgus alignment with 2nd degree flat foot. Three participants had normal knees: one of which had normal foot alignment; one had 1st degree flat foot; and one had 2nd degree flat foot. In addition, when comparing left foot with left tibiofemoral angle, 24 knees where in varus alignment; 5 had normal feet, 12 had 1st degree flat foot, 6 had 2nd degree flat foot, and 1 had 3rd degree flat foot. Only one knee had valgus alignment with 2nd degree flat foot. Five participants had normal knees and 2 of which had normal feet and 3 had 1st degree flat foot. The right and left pes planus foot and knee angle cross tabs are shown in Tables 2 and 3. In addition, the right and left structural pes planus and knee angle cross tabs are shown in Tables 4 and 5.

A Chi-square test of independence found no statistically significant correlation between pes planus and tibiofibular angle. In addition, no statistically significant correlation was found between structural pes planus and tibiofibular angle.

Table 1: The characteristics of the participants.

Characteristic	Males (N=10) Mean ± SD	Females (N=20) Mean ± SD
Age (years)	26.90 ± 2.80	26.45 ± 3.15
Height (meters)	1.71 ± 0.06	1.60 ± 0.04
Weight (kilograms)	75.93 ± 10.18	62.49 ± 8.67
BMI	25.77 ± 2.09	24.17 ± 2.76

Table 2: Right flat foot and right knee angle crosstab.

Presence of Flat Foot	Normal Knee	Varus Knee	Valgus Knee	Total
No flat foot	1	9	0	10
1st degree flat foot	1	14	0	15
2nd degree flat foot	1	2	1	4
3rd degree flat foot	0	1	0	1
Total	3	26	1	30

Table 3: Left flat foot and left knee angle crosstab.

Presence of Flat Foot	Normal Knee	Varus Knee	Valgus Knee	Total
No flat foot	2	5	0	7
1st degree flat foot	3	12	0	15
2nd degree flat foot	0	6	1	7
3rd degree flat foot	0	1	0	1
Total	5	24	1	30

Table 4: Right structural flat foot and right knee angle crosstab.

	Normal knee	Varus knee	Valgus knee	Total
Positive structural flat foot	1	5	1	7
Negative structural flat foot	2	21	0	23
Total	3	26	1	30

Table 5: Left structural flat foot and left knee angle crosstab.

	Normal knee	Varus knee	Valgus knee	Total
Positive structural flat foot	0	6	1	7
Negative structural flat foot	5	18	0	23
Total	5	24	1	30

DISCUSSION

The purpose of the study was to determine if a correlation existed between the presence of pes planus and tibiofemoral angle measurement in normal, healthy young adults. According to the results of this study, no statistically significant correlation was found between pes planus and tibiofemoral angle measurements among healthy 21 to 33 year old adults. This finding may indicate that this age group is too young to present a measurable correlation, hence the following generation should be screened to investigate if pes planus had an effect on tibiofemoral angle. A study suggested that either pes planus causes genu varum malalignment of the knee, or pes planus occurred as a consequence of the degenerative changes of the medial compartment of the knee that forces the foot to pronate during weight bearing.[5] Prospective studies are needed to further draw a conclusion on any relationship between pes planus and tibiofemoral angle [5].

A 2014 study compared a foot posture index and medial compartment knee osteoarthritis among 180 Moroccan subjects. The authors found statistically significant differences between the healthy group and the group with osteoarthritis in which the latter had more pronated and flat feet. The medial compartment group with osteoarthritis had a flat footed percentage of 42% while the normal group had 22% with a p-value of 0.03 [5]. However, in this same study, no statistically significant differences were found in the navicular height between groups which is similar to our finding of no relationship between flat foot and knee angle measurement when using Feiss' line test since it measures the navicular drop relative to the line. Another study used the Staheli Arch Index to measure the foot morphology and compared it to knee cartilage damage obtained through MRI imaging among 1,903 older subjects. Their findings showed that pes planus feet had 29% ipsilateral medial tibiofemoral cartilage damage on MRI, while there was no association with lateral tibiofemoral cartilage damage [6]. The relationship between pes planus and medial tibiofemoral cartilage damage was a significant finding, however the study did not measure the tibiofemoral angle, therefore the correlation between pes planus and tibiofemoral angle was not determined.

Most of our participants presented with 1st degree flat foot. In fact, side by side comparison showed that there were equal numbers of feet with 1st degree flat foot on both sides. However, left feet showed more 2nd degree flat foot than right feet with a 7:4 ratio. This increased lowering of the medial longitudinal arch causes

an alteration in the force distribution among the lower limbs thus changing their biomechanics [1]. Of note was the one subject who had bilateral structural pes planus with 2nd degree flat footedness and who had genu valgum of the knees. This observation may indicate a possible link between pes planus and valgus knee alignment [28].

Even though no significant correlation was found between pes planus and tibiofemoral angle measurements among our sample, most of the participants who had pes planus did have a genu varum knee alignment, indicative of medial convergence of the knee joint which is in fact consistent with other literature that found a significant correlation between flat foot and medial compartment knee osteoarthritis among older adults [6]. The current study found that 52 knees out of 60 knees presented with abnormal alignment (50 varus, 2 valgus, and 8 normal). This change in the knee alignment has been found to affect the force distribution around the knee joint [10]. Moreover, a slight increase in knee genu varum alignment (4-6%) has been reported to increase the loading in the medial compartment of the knee by 20% which leads to degenerative changes [10].

Limitations: The limitations in this study should be noted for future studies. A sample of connivance of 30 subjects was used in this study thus a more random sample and larger number of subjects are recommended in order to detect a correlation. In addition, a more objective pes planus foot measurement may be used in future studies.

CONCLUSION

There are no known studies that investigated the correlation between pes planus and tibiofemoral angle measurement among healthy young adults. Previous studies have shown a correlation between pes planus and tibiofemoral angle measurement among older adults and individuals with osteoarthritis [5-7].

Healthy young adults had no significant correlation between pes planus and tibiofemoral angle. However, even though there was no significant correlation, the findings of this study agreed with the previous studies in the fact that most of the pes planus feet had genu varum knee alignment [5-7]. Potentially it must be considered that the change in the biomechanical alignment of the feet as a result of pes planus and the early noted incidence of genu varum in these young knees may result in increasing incidence of osteoarthritis at the knee joint over time. Perhaps preventive strategies could be implemented at an early age.

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Conflicts of interest: None

REFERENCES

[1]. Franco AH. Pes cavus and pes planus. Analyses and treatment. Phys Ther. 1987;67(5):688-694.

[2]. Raj MA, Bhimji SS. Pes planus. In: StatPearls [Internet]. https://www.ncbi.nlm.nih.gov/books/NBK430802/. Published June 2017. Updated February 7 2017. Accessed October 1 2017.

[3]. Murley GS, Menz HB, Landorf KB. Foot posture influences the electromyographic activity of selected lower limb muscles during gait. J Foot Ankle Res. 2009;2(1):35-43.

[4]. Erol K, Karahan AY, Kerimoðlu Ü, et al. An important cause of pes planus: the posterior tibial tendon dysfunction. Clin Pract. 2015;5(1): 11-13.

[5]. Abourazzak F.E, Kadi N, Azzouzi H, et al. A positive association between foot posture index and medial compartment knee osteoarthritis in moroccan people. Open Rheumatol J. 2014;8:96-99.

[6]. Gross KD, Felson DT, Niu J, et al. Association of flat feet with knee pain and cartilage damage in older adults. Arthritis Care Res. 2011;63(7):937-944.

[7]. Guler H, Karazincir S, Turhanoglu AD, et al. Effect of coexisting foot deformity on disability in women with knee osteoarthritis. J Am Podiatry Assoc. 2009;99(1):23-27.

[8]. Deshpande BR, Katz JN, Solomon DH, et al. Number of persons with symptomatic knee osteoarthritis in the US: impact of race and ethnicity, age, sex, and obesity. Arthritis Care Res. 2016;68(12):1743-1750.

[9]. Litwic A, Edwards MH, Dennison EM, Cooper C. Epidemiology and burden of osteoarthritis. Br Med Bull. 2013;105(1):185-199.

[10]. Tanamas S, Hanna FS, Cicuttini FM, et al. Does knee malalignment increase the risk of development and progression of knee osteoarthritis? A systematic review. Arthritis Rheum. 2009;61(4):459-467.

[11]. Nguyen A-D, Boling MC, Levine B, Shultz SJ. Relationships between lower extremity alignment and the quadriceps angle. Clin J Sport Med. 2009;19(3):201-20.

[12]. Nguyen A-D, Shultz SJ. Sex differences in clinical measures of lower extremity alignment. J Orthop Sports Phys Ther. 2007;37(7):389-398.

[13].Karukunchit U, Puntumetakul R, Swangnetr M, Boucaut R. Prevalence and risk factor analysis of lower extremity abnormal alignment characteristics among rice farmers. Patient Prefer Adherence. 2015;9:785-795.

[14]. Paley D**.** Normal lower limb alignment and joint orientation. In: Paley D, ed. Principles of Deformity Correction. Berlin: Springer-Verlag, 2002:1-18.

[15]. Brunet M. Unique Considerations of the Female Athlete. Florence, KY: Delmar Cengage Learning; 2010.

[16]. Cherian JJ, Kapadia BH, Banerjee S, et al. Mechanical, anatomical, and kinematic axis in TKA: concepts and practical applications. Curr Rev Musculoskeletal Med. 2014;7(2):89-95.

[17]. Sanfridsson J, Ryd L, Svahn G, et al. Radiographic measurement of femorotibial rotation in weight-bearing. The influence of flexion and extension in the knee on the extensor mechanism and angles of the lower extremity in a healthy population. Acta Radiol. 2001;42(2):207-217.

[18]. McRae R. Pocketbook of Orthopaedics and Fractures. Edinburgh: Churchill Livingstone; 2006.

[19]. Gosselin RA, Spiegel DA, Foltz M. Global Orthopedics: Caring for Musculoskeletal Conditions and Injuries in Austere Settings. New York, NY: Springer Science & Business; 2014.

[20]. Khalid Z, Rai MA, Mobeen B, Amjad I. Pes planus & genu valgum; factors associated. Professional Medl J. 2015;22(10):1237-1244.

[21]. Hannigan-Downs K HR, Smith G. Radiographic validation and reliability of selected clinical measures of pronation.[PhD Dissertation]. Oregon: Oregon State University; 2004.

[22]. Hertling D, Kessler RM. Management of Common Musculoskeletal Disorders : Physical Therapy Principles and Methods. 4th ed. Philadelphia, PA : Lippincott Williams & Wilkins; 2006.

[23]. Marik I, Culik J. Monograms for detecting the tibia-femoral angle. Locomotor Syst J. 2002;9:81-89.

[24]. Cerny P. Methods for the measurement of skeletal deformities from the X -ray pictures and photographs. Anglespine. http://www.anglespine.com/. Accessed October 10 2017.

[25]. Mohd-Karim MI, Sulaiman AR, Munajat I, Syurahbil AH. Clinical measurement of the tibio-femoral angle in malay children. Malays Orthop J. 2015;9(2):9-12.

[26]. Shultz SJ, Nguyen A, Windley TC, et al. Intratester and intertester reliability of clinical measures of lower extremity anatomic characteristics: implications for multicenter studies. Clin J Sport Med. 2006;16(2):155-161.

[27]. Brown DE, Neumann RD. Orthopedic Secrets. 3rd ed. Philadelphia: Hanley & Belfus; 2004.

Theofilos K, eds. Total Knee Arthroplasty: Long Term Outcomes. London: Springer-Verlag; 2015.

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