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PES PLANUS & GENU VALGUM;
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ABSTRACT... Pes planus (flat foot) is a musculoskeletal abnormality of lower limb, often associated with some degree of malalignment at the knee i.e. genu valgum (knock knees). In majority of cases, these deformities resolve by themselves during infancy and childhood, but if they persist in adolescent age, then there is no chance of resolution and might pose serious problems for the individual in the future. **Objectives:** The objective of this study was to determine the factors associated with pes planus and genu valgum in adolescents. The two main factors under investigation were physical activity and dietary habits of adolescents and their effect on these lower limb musculoskeletal conditions. **Material and methods:** A case-control study was conducted on 400 (161 cases and 239 controls) school- going adolescents (11-16 years). After completing the demographic data and recording the height and weight of each participant, the diagnosis of pes planus was made on the basis of physical examination and special tests. The data for genu valgum was collected by the measurement of clinical tibiofemoral angle. A self-report questionnaire was used to collect other relevant data such as the symptoms experienced by the individuals. Data was analyzed on SPSS 21. **Results:** Out of 400 adolescents, there were 171 males and 229 females. The physical activity level of cases was 2.17 ± 0.70, slightly less than that of control group 2.32 ± 0.76. The diet score of cases (11.087 ± 3.75) did not differ much from that of controls (11.214 ± 3.75). Tibiofemoral angle of cases was 15.7 ± 3.42 degrees valgus for controls it was 14.1 ± 3.49 degrees valgus. There was also a greater trend of cases towards overweight (12.8% cases and 7.43% controls) and obesity (5.84% cases and 2.62% controls), whereas the frequency of controls was higher in underweight (19.8% cases and 27.5% controls) and healthy/ normal weight category (55.5% cases and 66.8% controls). Other associated symptoms such as foot pain, knee pain, trauma to foot and knee, difficulty in running and jumping activities etc were also found to be in higher frequency in cases as compared to in controls along with significant gender differences. **Conclusion:** Our study results showed that reduced physical activity can be a factor for causation of flat foot and knock-knees but the difference in diet habits was not very significant between cases and controls. Therefore unhealthy diet is not a very considerable factor in the contribution to musculoskeletal conditions in lower limb. There was a direct link between obesity and pes planus, along with a greater TFA. There was also a higher incidence of knee pain in the flat foot cases who complained of foot pain along with various other associated symptoms.

Key words: Pes planus (flat foot), genu valgum (knock knees), physical activity, diet, adolescents.

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INTRODUCTION

Pes planus (flat foot) is a condition in which the foot has a visibly lowered medial longitudinal arch.[1] Arch is described as a segmental elevation of foot which is made up of multiple ligaments, muscles and bony articulations. Ligaments play the primary role in the support and stabilization of arches whereas secondary support is offered by the foot muscles during dynamic activities.[2,3] There is a functional link between the arches of foot and lower limb biomechanics. The arch acts as a springy, flexible and elastic union between fore-foot and hind-foot. Several risk factors contributing to flat foot have been acknowledged such as tarsal coalition, ligamentous laxity, equinus foot deformity, tibial torsional defect, congenitally vertical talus, posterior tibial tendon dysfunction (PTTD), peroneal spastic flat foot,

post-traumatic flat foot and so on.[4] Obesity on the other hand is found to be rather conflicting risk factor for the development of flat feet.[5]

As mentioned earlier another musculoskeletal deformity which is often seen to be associated with pes plaunus is genu valgum. Genu Valgum is a deformity in which the axial alignment of the lower limb is disturbed and an exaggeration of the tibiofemoral angle (formed by the intersection of mechanical axis of femur with mechanical axis of tibia) occurs.[6] Genu valgum is classified into two basic types: physiologic and pathologic knock knees. The physiologic variations are considered normal as a part of growth and development and they resolve spontaneously with age as the contracture stretches. This physiological form of knock knees begins appearing from 2 years onwards and reaches maximum level at 3-4 years of age. The severity of genu valgum can further be increased if it is accompanied by thigh fat, ligamentous laxity, pes planus and torsional malformations such as femoral neck anteversion with compensatory external tibial torsion.[7-9]

Although there is a lack of literature regarding the relationship between body weight and knee angle in children and adolescents. A recent study found greater prevalence of valgus malalignments in overweight children as compared to normal weighted. They hypothesized that in the presence of a lower limb deformity, excess weight load across the joints leads to increased incidence of musculoskeletal discomfort and pain. As a result, such individuals are not keen to participate in any physical activity, thus gaining more weight and leading a sedentary lifestyle. It has been found that less time spent in moderate to vigorous physical activity has a direct relationship with body fat and BMI in 8-10 years old kids.[10,11]

Since adolescent years mark a transition towards adulthood, it constitutes the dynamic stage of puberty during which there is acceleration of all physiological changes in the body. This time of transitioning is very crucial for attaining healthy bone mineral density. If this bone gain process is not supported by healthy lifestyle including diet and physical activity, then there is a high risk for low bone mass during adulthood.[12] According to one study, the adolescent period constitutes the crucial years between childhood and adulthood i.e. from 13-19 years. The persistence of obesity and other co-morbidities into later adult life has also been attributed to the lifestyle during adolescent stage. Thus, to determine the degree of overweight and obese adolescents, an index was formulated known as BMI- Body mass index or Quetelet index which was calculated as weight (kg)/ height (m^2) percentiles.[13]

Various studies have investigated the effects of nutrition and diet on bone mineral density and the acquisition of peak bone mass during adolescence phase. For the weight which is in a healthy range, the body mass index correlates directly with the bone mineral density. Therefore healthy diet intake is essential for the attainment of peak bone mass.[14] Since balanced diet and proper nutrition plays a vital role in the normal growth and development of human skeleton,[15] hence, we have taken it as one of the risk factors in our study.

The significant role of physical activity for the growth, development and healthy lifestyle of children and adolescents is undeniable.[16] According to a ranking by the World Health Report in 2002, physically inactive lifestyle is among the 10 major factors contributing to morbidity, mortality and disability in the developed world.[17,18] During the transition from childhood to adolescence, there is a marked decline in physical activity levels. There is a high risk of weight gain and energy imbalance in adolescents due to reduced physical activity during this period.[13] As regularly performed exercises induce various adaptations in the skeleton, especially the physical activity performed during the time of maturity has a direct effect on bone mass and skeletal growth,[19] therefore we have chosen 'physical activity' as one of the risk factors under investigation in our study along with diet and nutrition.

OBJECTIVES

The objective of this study was to establish the

factors associated with pes planus and genu valgum in adolescents. The factors under consideration were physical activity and dietary habits of adolescents and their impact on these musculoskeletal deformities.

MATERIALS & METHODS

We conducted a retrospective case-control study on almost 400 school-going adolescents aged 11-16 years, comprising of 161 cases and 239 controls. Non-probability convenient sampling technique was used for sampling of all data. This study was carried out in 8 schools in Rawalpindi (Pak) and its premises.

We obtained approval from the higher authorities of each school and took informed consent from the participants and their parents. After completing the demographic data and recording the height and weight of each participant for the calculation of BMI, the participants were categorized into cases and controls on the basis of presence or absence of flat feet, respectively. The diagnosis of pes planus was made on the basis of visual observation, clinical examination and special tests. After visual observation and clinical exam of feet, tiptoes standing test was performed to distinguish between flexible and rigid flat foot.

Genu valgum was measured by tibiofemoral angle using standard, plastic goniometers. To augment the findings of degree of genu valgum in a few ambiguous cases, the intercondylar distance (cm) i.e. the distance between medial femoral condyles with the medial malleoli in contact and intermalleolar distance i.e. the distance between both medial malleoli with medial femoral condyles in contact, was measured by a standard tape measure.

Physical activity was assessed by a 7-day recall tool PAQ-A (Physical Activity Questionnaire for Adolescents) whereas diet was evaluated by a 23-item diet tool (Adolescent food habits checklist). Data was analyzed on SPSS 21.

RESULTS

Total participants of study were 400 adolescents (14.15 ± 1.44 years) and were divided into cases, flat footed individuals (161) and controls, normal footed subjects (239).

According to the applied tool for physical activity (PAQ-A), the mean score of cases was 2.17 ± 0.70 (SD), whereas for controls, it was 2.32 ± 0.76 (SD). The results in this study showed significant gender differences. The mean activity level of female cases, 1.96 ± 0.52 was quite less than male cases 2.56 ± 0.83. The comparison of diet between both groups didn't reveal any statistically significant differences. It was found that the mean diet score of cases 11.087 ± 3.75 (SD) was also only slightly less than the diet score of controls 11.214 ± 3.75 (SD). Mean tibifemoral angle was found to be higher in cases i.e. 15.7 ± 3.42 degrees valgus and for controls it was 14.1 ± 3.49 degrees valgus.

Comparing cases and controls for BMI percentile, it was found that there was a trend of cases towards overweight and obesity whereas there was greater frequency of controls in underweight and healthy/ normal weight category.

It was observed that foot pain was more frequent in cases and less common in controls. Among the subjects complaining of foot pain, unilateral pain was more frequent in cases whereas bilateral was more common in controls. Similar findings were obtained for knee pain, which was distinctly associated with flat foot subjects. Among those experiencing knee pains, unilateral pain was more frequent in cases whereas bilateral pain frequency was almost similar in both groups. Among gender, knee pain was found to be in higher frequency in female cases than in male cases.

It was also observed that history of trauma to foot was found to be overall more in cases. Rapid wearing out of shoes on inner side was greater in male cases as compared to female cases and male controls. It was also found that cases experienced significant difficulty in fast running and playful jumping activities, especially females.

Characteristics	Cases (n=161)		Controls (n=239)	
	Mean (n)	Standard Deviation (±)	Mean (n)	Standard Deviation (±)
1. Age of subjects (years)	14.04	1.497	14.22	1.415
2. Tibiofemoral angle (degrees)	15.7	3.42	14.1	3.49
3. Physical activity	2.17	0.70	2.32	0.76
4. Diet levels	11.087	3.75	11.214	3.75

Table-I. Mean and standard deviation of age, tibiofemoral angle, physical activity and diet scores of all cases and controls (n=400)

Variables	Male cases (%)		Male controls (%)		Female cases (%)		Female controls (%)	
	Yes	Sometimes	Yes	Sometimes	Yes	Sometimes	Yes	Sometimes
1. **Foot pain**	8.9	46.4	6.9	42.6	18	47.6	10.4	53.2
2. **Difficulty in fast running**	17.8	26.7	8.7	31.3	19	37	16	51
3. **Difficulty in jumping activities**	10.7	19.6	6.9	12	14.2	38	5.6	28.2
4. **Knee pain**	17.8	28.5	12.1	24.3	17.1	41.9	11.2	31.4

Table-II. Presence of associated symptoms in male and female cases and controls (n=400)

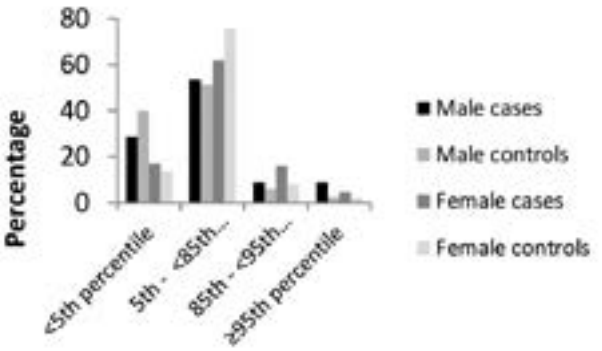

Fig-1. Bar-chart showing frequency of BMI for age percentile in male and female cases and controls

DISCUSSIONS

As our study focused on the comparison between two study groups i.e. cases (flat-footed individuals) and controls (those without flat feet) to investigate the factors or causative agents contributing to the development of this condition and associated changes in knee valgus angle, therefore we got multiple findings.

The two major investigations in this study included the level of physical activity and dietary habits of adolescents and whether or not these factors have any role in the development or contribution to musculoskeletal conditions in lower limb. It has already been established that physical activity and nutritional intake are the most important factors affecting the growth and development of various body tissues such as bones, ligaments, skeletal muscles and body fat.[16]

Using a standard physical activity tool (physical activity questionnaire for adolescents PAQ-A), we found out the mean physical activity score of both study groups (cases and controls). The findings indicated slightly decreased physical activity levels in cases as compared to control group. Although there wasn't a major significant difference in physical activity patterns of cases and controls, but that slight difference in activity in combination with other factors, may become a major causative agent in the persistence of lower limb mal-alignments. A study done on 6-10 year old school children also revealed that a direct proportional relationship existed between physical activity and the development of medial longitudinal arch i.e. flat foot prevalence was higher in the children who were physically inactive.[3] As per the evidence, adolescents usually have low activity levels and although there are variations among different ethnicities, but the overall trend shows higher inactivity levels in this age group.[20]

There was significant difference in activity levels between males and females, with females being even more inactive in daily life than males. This finding holds true for various ethnicities such as the decline in physical activity in both black and white adolescent girls, which may be due to the

fact that mostly girls do not engage in any form of physical activity such as sports, after the school hours.[21]

This low physical activity level of adolescent girls is in direct correlation with higher frequency of overweight girls in our sample as compared to overweight boys i.e. a proportional relationship exists between reduced physical activity and increased BMI. According to the results of our study, the number of overweight female cases was higher than overweight female controls, i.e. obesity was directly linked with the occurrence of pes planus. The degree of inactivity of the overweight girls as compared to non-over weight girls is already established.[22] It is also found that a significant association exists between physical activity and weight status among children and adolescents.[23]

Foot arches are influenced by increased body weight which might be the reason behind the higher incidence of flat feet in overweight/ obese individuals.[24,25] Even in elder population too, overweight/obese people have a higher tendency of foot and ankle problems.[26] In our study, there was found to be a significant tendency towards flat foot in obese subjects compared with normal subjects. Hence we can say that obesity can be one major cause of flat foot which is directly associated with decreased physical activity levels as per our hypothesis. There is also a positive correlation between incidence of genu valgum and overweight/ obese children, thus leading to reduced physical activity levels.[27]

The second factor which was investigated in our study was the dietary habits of adolescents and whether it has any association with the causation of flat foot. The diet tool "adolescent food habits checklist" was used to determine if there is any association between dietary habits of adolescents and causation of flat-foot. Contrary to our hypothesis, there was no significant difference between the diet scores of cases and controls i.e. both of these groups had almost similar dietary habits which comprised of rather unhealthy food choices.

There was found to be a link between history of trauma and flat feet. Flat foot and trauma seems to be closely related. Various studies revealed that flat foot can also result from rupture of the tibialis posterior tendon.[28,29] There is a positive correlation between pes planus predisposing the people to lower extremity athletic injuries.[30]

Foot pain, especially heel pain is a very prominent feature in the clinical presentation of pes planus along with various other conditions in foot and ankle complex.[31] According to the results of our study, foot pain was more prevalent among the cases as expected, and less prevalent in controls. It is found that pes planus is a chief cause of foot pain leading to disability.[29] Contrary to that no relation between flat foot and foot pain was found in a study done on classification of flat feet in a Nigerian population.[32]

In accordance with our results, there is observed to be a familial trend of flat foot i.e. it runs in families so we can assume that it is an inherited foot disorder. The same findings are reported by various other studies.[33,34] Majority of the cases in our study faced difficulty in running and jumping activities. It is already established that injury during landing in jump sports is very much associated with biomechanical factors.[35] Since the biomechanics of foot is greatly disturbed in flat foot subjects, hence they face trouble while running, especially fast running and jumping.

Flat foot is closely linked to frequent knee pain in adults.[36] According to the result of our study, in the flat feet subjects reporting knee pain, there was a greater incidence of knee pain in adolescent females as compared to same age group males which may also be related to the increased valgus angulation of tibiofemoral joint in both limbs. This could be explained by the fact that the disturbance of biomechanics in foot may lead to excessive stresses at knee resulting in pain and the development of some degree of knee deformities such as genu valgum.[33]

Another relation observed was between flat feet and the type of footwear. According to our finding,

there was a significantly higher association between pes planus and flat boots, especially in female cases and also in female controls. Controversial to our results, there is found to be a higher prevalence of flat foot in children who wore closed–toe shoes as compared to those who wore slippers or sandals.[37] The significance of footwear is its effect on soft-tissues of the body. It is also established already that those who wore shoes during early childhood were twice as prone to develop flat feet as compared to those who spent majority of the time barefoot in early childhood years.[33]

Sunlight exposure in female cases was found to be less than that of the controls and since flat foot was found to be more prevelant in females, therefore it is possible that vitamin D deficiency due to less sunlight exposure may have a role in the contribution of flat foot to be more prevelant in females. Vitamin D deficiency causes weakening of bones, thus resulting in structural malalignments. In veiled Arab women,vitamin D deficincey was the result of limitation in exposure to sunlight (because of socioethnic reasons) plus a low oral intake of Vitamin D supplements.[33] In another study vitamin D supplementation was found to be the reason behind improved gait speed and improved muscle stenght training in adults.[39] Thus, a direct correlation is observed between sunlight exposure and lower limb musculoskeletal conditions.

We can conclude by stating that physical activity levels in association with other factors such as family history, H/O trauma, low vitamin D levels etc, can play a vital role in the development of pes planus. Pes planus then contributes to the increased valgus anglation at knee resulting in mild degrees of knocking knees.

CONCLUSIONS

This study focused on investigating whether phyiscal inactivity and unhealthy dietary habits in adolescents play any role in the causation of pes planus and its associated condition genu valgum. Based on the results of statistical data analysis, it is concluded that reduced physical activity can be a factor for flat foot and knock-knees development as physical activity was found to be slighty less in cases as compared to controls, when assesed by a physical activity tool (PAQ-A). Dietary scores were also slighty less in cases than in controls on assessment by a diet tool (adolescent food-habits checklist) but this difference was not very considerable according to our findings, therefore we can conclude that unhealthy diet is not a very significant risk factor for the development and contribution to musculoskeletal conditions in lower limb. Also, a direct relation was observed between obesity (as determined by BMI) and flat foot/ knock-knees.

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"The best way to predict the future is to create it."

Abraham Lincoln

AUTHORSHIP AND CONTRIBUTION DECLARATION

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2	Mishal Ali Rai	Concept and design, Data collection & analysis	
3	Imran Amjad	Concept & design, Critical expertise & writing, Statistical expertise	
4	Bushra Mobeen	Data collection, Data analysis	