Influence Of Pronated Foot On Lumbar Lordosis And Thoracic Kyphosis And Q Angle In Young Adults

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Abstract- Foot is the most distal part of lower extremity kinetic chain and has an important role in standing, walking. The alignment of foot has an effect on the lower extremity, pelvic girdle and spine in the closed kinematic chain. The disturbances in foot posture alignment could result in structural and functional deficits in lower extremity. Young adults leading an active life are prone to injuries of the lower extremity if the alignment is altered.

Method: 58 young healthy adults within age group of 18-35 yrs categorized into 2 groups, pronated feet and normal feet based on Brody's Navicular drop test. The Q angle, LLI and TKI were assessed using goniometer and flexi curve respectively.

Conclusion: The result showed that pronated feet affect the lower extremity and spinal alignment. The Q angle, LLI and TKI was found to be increased in pronated feet than normal feet.

***Index Terms*:** Hyperpronation, Lumbar lordosis index (LLI), Navicular drop test, Quadriceps angle, Thoracic kyphosis index(TKI)

I. INTRODUCTION

In human body, combination of several joints connecting successive segments constitutes a kinetic chain. Understanding the biomechanical structure of each part of the body is important for preventing and treating the musculoskeletal system. The foot forms the important part of the kinetic chain to move the body forward and maintain balance by supporting body weight.[1] Normal biomechanical link of the lower extremity can be disturbed as a result of abnormal position of the foot. In closed kinematic chain, subtalar joint pronation is associated with adduction and plantarflexion of the talus as well as calcaneal eversion.[2] these changes in the foot posture may lead to alterations in knee alignment and spinal alignment.
The knee complex is the next important part of the closed kinematic chain as it is a link between the ankle and pelvis. In the knee joint quadriceps angle is the most important factor and it is defined as, the angle formed by the line from anterior superior iliac spine (ASIS) to the patella center and a line from patella center to the tibial tuberosity. Q angle of 10-15 degree considered as normal.[3] Foot pronation causes internal rotation of tibia which results in valgus at knee joint. This valgus at the knee joint may predispose individuals to injuries caused by abnormal quadriceps forces acting on the knee joint. Excessive angulation may predisposes the individuals to injuries to the knee joint caused by the abnormal quadriceps forces acting at the knee and patellofemoral joints.[4]

Pelvis is an important component of postural alignment. It acts as a key segment between lower extremities and spine. Spine is responsible for anatomic connection and transmission of forces between lower limbs and upper body.[5] The bilateral presence of excessive calcaneal eversion generates internal rotation of the hips, and consequently, may lead to increased pelvic anteversion and to the presence of lumbar hyperlordosis. Thus, the presence of excessive calcaneal eversion may be related to the occurrence of pathological conditions of the lumbar spine.[2]Thoracic kyphosis is the sagittal plane curvature between the T1 and T12 vertebral bodies. Excessive thoracic kyphosis has been linked with range of musculoskeletal problems including shoulder pain and cervical pain.[3]

Many studies have described the relationship between correlating components on the lower extremity factors such as tibial torsion, femoral anteversion, pelvic inclinication in normal individuals but not many have taken into account the effect of foot pronation on spine and lower extremity alignment in standing position. Hence the purpose of this study is to find out the effect of foot pronation on lumbar lordosis, thoracic kyphosis and Q angle.

II. RATIONALE OF STUDY

Foot has an important role in standing, walking and providing support to maintain balance of the body. The alignment of foot has an effect on the lower extremity, pelvic girdle and spine in the closed kinematic chain. The disturbances in foot posture alignment could result in structural and functional deficits in lower extremity. Pronated foot may disturb the normal foot structure and function. It is characterized by decreased medial arch, talus adduction, medial rotation, calcaneal eversion and forefoot adduction. These changes in the foot posture may lead to alterations in spinal alignment and knee alignment.

In closed kinematic chain, foot pronation causes internal rotation of tibia which results in valgus at the knee. Tibial internal rotation causes femoral internal rotation consequently increased pelvic anteversion. This valgus at the knee joint may predispose individuals to injuries caused by abnormal quadriceps forces acting on the knee joint. These postural changes of lower extremity may lead to changes in pelvis and enhance the risk of low back pain. Therefore understanding the biomechanical structure of each part is important. Thus the objective of this study is to compare the effect of foot hyperpronation on lumbar lordosis and thoracic kyphosis and Q angle.

Young adults leading an active life are prone to injuries of the lower extremity if the alignment is altered. Thus it is important to create a awareness about the pronated foot posture and its effect on spine and lower extremity to prevent injuries.

III. METHODOLOGY AND DATA COLLECTION

Approval was obtained from the ethics committee prior to commencement of the study. The study was explained to all participants and Informed consent taken from all subjects. The research was carried out at Research lab of K.J Somaiya College of physiotherapy. It was a Cross-sectional, analytical study with the duration of 6 months. 58 healthy young adults both male and female were tested for Brody's Navicular drop test for both the feet and were divided into two groups based on the values of navicular drop i.e. if navicular drop was 2mm to 6mm then in Group A- the normal feet group and if the value is more than 6mm then in Group B- pronated feet group. . The sample size was calculated based on a parent article and power fixed at 80% and confidence interval at 95%.

Inclusion criteria – (i) Healthy young adults in the 18 to 35 age group. (ii) Subjects giving written consent.

Exclusion criteria – (i) Recent musculoskeletal injuries of lower limb and spine (within 1 year of participation in study). (ii) Neuromuscular impairment or congenital musculoskeletal anomalies. (iii) Athletic or regular physical exercise.

The quadriceps angle was measured using goniometer in standing position. Thoracic kyphosis index and Lumbar lordosis index were calculated using flexicurve in standing position.

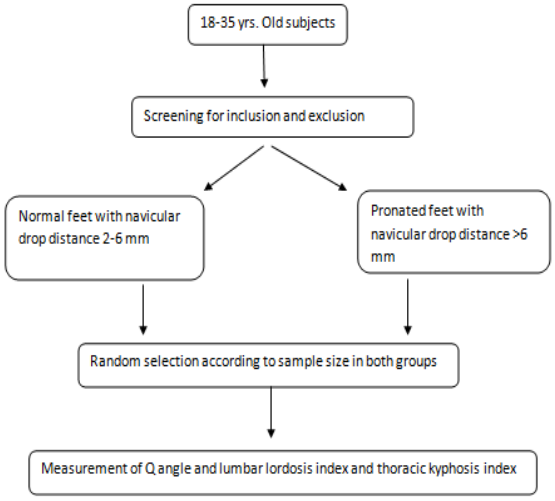

Figure No. 1: flow chart of a study

TEST PROCEDURE:

a. **Q angle measurement:** Q angle was measure in standing position. It is measured in standing so that normal weight bearing stresses were included. The angle was obtained by ensuring that the lower limbs are at a right angle to the line joining to the ASIS. The foot is placed in neutral position. The q angle has the ASIS, midpoint of patella and the tibial tubercle as standard anatomical landmarks. The anatomical landmarks was located through palpation and then marked by the marker. With the pivot of the goniometer place on the midpoint of patella, the stationary arm on the line joining the ASIS to the midpoint of patella, and movable arm is place over line joining tibial tubercle to the midpoint of patella. The angle thus form between two arms of goniometer was measured as the Q angle. Angle was measured in right and left feet. It was measured in degrees.[6]

Figure No.3: Q angle measurement

Figure No.4: Measurement of TKI & LLI

b.Assessment of LLI and TKI: The subject was in the relaxed standing position. First the anatomical bony landmarks was mark as C7, T12, L1, S1, and S2 by the examiner. A flexicurve of 60cm is used for the assessment of lumbar spine. This flexicurve was place on the dorsal aspect of the spine i.e. on the spinous process of Thoracic and lumbar spine and shape to fit the contours of these spinal curves. The instrument was carefully remove and trace onto a graph paper. A vertical line drawn to join the C7 and S1 landmarks. Calculation was perform for the kyphois and lordosis index as

Index = width/ length*100.

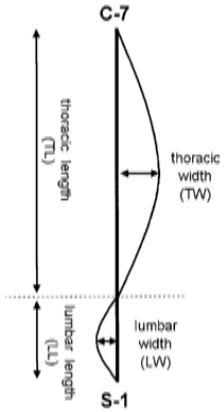

Figure no.5 - Flexicurve Measures

A rular with 1/10th cm markings was used to measure the length and width of each segment.[7,8]

IV. RESULTS AND ANALYSIS

Data was entered using MS Excel 2010 and analyzed using Graph pad instat software version 3.1. The Kolmogorov and Smirnov test was used to test for normal distribution of the data. The unpaired t test and Mann Whitney U was used for normally and not normally distributed data respectively. P value of <0.05 was taken as statistically significant.

COMPARISON OF Q ANGLE (RIGHT SIDE) BETWEEN THE TWO GROUPS:

TABLE NO.1:

N=58	MIN	MAX	MEDIAN	MEAN	SD	TEST	P- value
NORMAL FOOT	10	18	14	13.41	2.163	Mann-Whitney	<0.0001 **Significant**
FLAT FOOT	12	20	18	17.06	2.329		

COMPARISON OF Q ANGLE (LEFT SIDE) BETWEEN THE TWO GROUPS:

TABLE NO.2:

N=58	MIN	MAX	MEDIAN	MEAN	SD	TEST	P- valve
NORMAL FOOT	10	18	14	13.41	2.163	Mann-Whitney	<0.0001 **Significant**
FLAT FOOT	12	20	18	17.06	2.329		

COMPARISON OF THORACIC KYPHOSIS INDEX BETWEEN THE TWO GROUPS:

TABLE NO.3:

N=28	MIN	MAX	MEDIAN	MEAN	SD	TEST	P- value
Normal foot	4.68	7.95	7.56	7.95	2.31	Unpaired t-test	<0.0001 Significant
Flat foot	7.14	10.65	10.7	10.65	1.52		

COMPARISON OF LUMBAR LORDOSIS INDEX BETWEEN THE TWO GROUPS:

TABLE NO.5:

N=28	MIN	MAX	MEDIAN	MEAN	SD	TEST	P- value
Normal foot	10	33.3	21.4	22.2	5.269	Unpaired t-test	<0.0001 Significant
Flat foot	16.1	38.4	28.8	28.9	5.688		

V. DISSCUTION AND CONCLUSION

The present study was undertaken to assess the effect of pronated foot on the lower extremity and spinal alignment. Quadriceps angle, thoracic kyphosis index and lumbar lordosis index was assessed in healthy young adults. The quadriceps angle (on the right side and left side) was increased in the pronated feet group and the results were statistically significant. These findings are supported by the study carried out by **Sam Khami, Gali Dar et al.** They studied in standing, induced foot pronation was coupled with internal rotation of the tibia, femur and anterior pelvic tilt. Foot hyperpronation initiates kinetic chain reaction and tibia and femur acts as a mediator producing anterior pelvic tilt while standing. [10] The alteration in Q angle leads to imbalance between vastus medialis and vastus lateralis causing various abnormalities. **MOHSEN MAKHSOUs et al** in their study on patello femoral pain syndrome(PFPS) reported that net force on the patella directed too laterally in PFPS patients causing patellar maltracking in the femoral groove. Imbalanced torque contribution from VMO, VML AND VL in PFPS is related to tightness of the lateral structures and changes in Q angle.[11] Knee malalignment i.e. lower or higher Q angle has an effect on anatomical cross sectional area (CSA) of total quadriceps muscle and its individual components. Studies show that higher Q angle (>15) has low CSA of the entire quadriceps. (VM, VL and VI).[12]As a consequence of these changes in the Q angle the femur rotates internally at the hip joint compressing posterior aspect of pelvis. In order to regain the postural balance the trunk moves anteriorly and shifts the center of mass anteriorly. This changes force the pelvis to tilt anteriorly in the sagittal plane.[13] Study done by **Ju-Eun LEE, Ga-Hyeon Park**, noted that rarefoot varus in the flat foot causes abnormal kinetic sequence between tibia and femur leading to increases the Q angle. Flat feet alter the tension in the muscles around foot and fascia and increase the internal rotation at hip joint and lumbar lordosis. EMG activity showed that flat feet had lower activation of VM,AH while higher activation of VL muscle suggesting increase lateral forces at the knee.[14]

The posture of the feet has an influence on spinal alignment too i.e on lumbar lordosis and thoracic kyphosis. The result of the present study showed that subjects with pronated feet have statistically significant increase in lumbar lordosis index. The change in thoracic kyphosis index was less significant in pronated feet subjects. Greater mean difference was observed in lumbar lordosis index as compare to thoracic kyphosis index. **Mohammad Sadegh Ghasemi et al** reported that pronation of the subtalar joint causes medial downward movement of the talus and internal rotation of tibia affecting knee joint function. Internal rotation of hip joint lead to anterior pelvic tilt. As the pelvis is connected to the spine at sacroiliac joint, anterior tilt increases the lumbar lordosis. These changes shift line of gravity at a greater distance from optimal position. Extension movement in lumbar spine increases to maintain the lumbar lordotic curve. Further to maintain the head over sacrum the posterior convexity of thoracic curve increases and becomes kyphotic.[15]

The alterations in the spinal curvatures have effects on the trunk area either internally or externally. **Mattox et al** studied the Variations in spinal curvature which may alter these vector forces and possibly potentiate the development of pelvic organ prolapse. These observations underline the importance of taking into account the abnormal changes in spine curvature in subjects with pronated foot.[16]

In the present study statistical significant difference was observed in all of the three outcome measures (Q angle, lumbar lordosis index and thoracic kyphosis index) which showed that pronated foot posture alter the kinetic chain. This may predispose the individuals to lower extremity injuries and spine injuries. Considering these findings of the study in subjects with pronated feet alignment of lower extremity and spine assessment is very crucial.

VI. CONCLUSION

The present study concluded that, pronated feet affect lower extremity and spinal alignment. The quadriceps angle, lumbar lordosis index and thoracic kyphosis index was was found to be increased in subjects with pronated foot.

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