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The Relationship of Dynamic Balance with Foot Posture Index and Q Angle in Premenopausal Nursing Population

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ABSTRACT

Background: Nursing is a healthcare profession involving prolonged standing and heavy lifting of patients. Working in awkward positions for longer durations may lead to musculoskeletal problems in weight bearing joints like knee and ankle/foot. Abnormal knee or ankle/foot biomechanics can affect balance by changing somatosensory afferents which can affect their job and quality of life. This study aims to understand the relationship of dynamic balance with foot posture index and Q angle in premenopausal nursing population.
Materials and Methods: Materials required for this study included pen and paper, a measuring tape, a weighing machine, a marker, adhesive tape, and a full-circle goniometer. The study design employed a cross-sectional analytical approach, and convenience sampling was utilized as the sampling method. The study included 175 premenopausal nursing professionals aged between 25 to 45 years with a minimum of 5 years of work experience. Foot posture was evaluated using the Foot Posture Index, and the Q angle wasmeasured using a full-scale goniometer. Dynamic balance was assessed through the Star Excursion Balance Test (Y balance test). Data collection was done, and appropriate statistical analyses were conducted for theobtained data.
Results: Correlation analyses were performed, but no significant (p value > 0.05) correlations were foundbetween foot posture (FPI), Q angle, and dynamic balance (CRDS) for both the right and left sides.
Conclusion: Our study concluded that there is no significant correlation of dynamic balance with foot posture index and Q angle in premenopausal nursing population.

Key Words: Foot Posture Index, Composite Reach Distance Score, Star Excursion Balance Test

INTRODUCTON

Work related musculoskeletal disorders are defined as disorders that result because of occupation, which are very common in health care workers,(1) significantly impact quality of life, transfer to another job or disability with a considerable economic toll on the individual, organization and the society.(2) Nurses routinely perform activities like lifting heavy loads, lifting and transferring patients out of the bed.(3) Nursing population that constitutes about 33 % of hospital workforce are at high risk of musculoskeletal problems accounting for

60% of occupational injuries.[4] The most common biomechanical risk factor for musculoskeletal disorders that include labor- intensive tasks, manual patient handling, repetitive movements, static work postures and dynamic work posture.[5] The prevalence of knee and ankle/foot pain is found to be around 26.4% and 27 % respectively in Indian nursing population in the last 12 months.[1] "Balance" is defined as the ability of the body to maintain its center of gravity within the base of support. Static balance is the ability to maintain posture when the body is at rest and dynamic balance is the ability to maintain posture while the parts of body are in motion.[6] Ankle is the most distal segment of the kinetic chain with relatively small base of support and therefore, excessively supinated or pronated foot postures may influence peripheral somatosensory input via changes in joint mobility, surface contact area or muscle strategies.[7]The star excursion balance test (SEBT) is used to measure dynamic balance. This test has Intra- rater reliability (ICC= 0.84–0.87) and test–retest reliability (ICC = 0.89–0.93).[8] Foot posture index (FPI) is a scale to examine the ankle and foot posture. FPI can be used for quantitative measurements of the abnormal deviations of foot posture. It is sensitive enough to detect any structural dysfunction in the forefoot, midfoot and hindfoot in the frontal, sagittal and transverse planes. FPI-6, a revised version of FPI, was derived from the original eight components scale because two components were lacking unidimensionality. FPI-6 has 64% instrument validity and moderate to good inter– rater (0.62 to 0.91) and intra-rater (0.81 to 0.91) reliability in measuring foot posture.[9]

A planus foot alters patellar movements and increases knee joint stress while a cavus foot may add excessive stress at the ankle due to limited ankle eversion range of motion.[10] Pronated foot can lead to internal rotation of tibia, which causes knee valgus and hip internal rotation.[11]Q angle (Quadriceps angle) is an important indicator of knee biomechanics. Normal Q angle for males and females is 13 degrees and 18 degrees respectively. Q angle below 13 degrees and above 18 degrees is considered abnormal. Q angle is reliable, specific and sensitive (Inter rater ICC: 0.20 (full extension), Intra rater ICC: 0.22 (full extension), correlation with radiographs ICC: 0.32 (full extension)).[12] The Q angle is an indicator of the quadriceps strength. An increase in Q angle reduces the mechanical effect of the power produced by the quadriceps femoris. It results in impaired proprioception which may affect the neuromuscular response and the quadriceps reflex response time. These peripheral inputs are united in the central nervous system and appropriate muscular responses are created to maintain posture. Inadequate proprioceptive inputs by the Quadriceps, affects the muscular responses generated, leading to an increased risk of falls.[13]

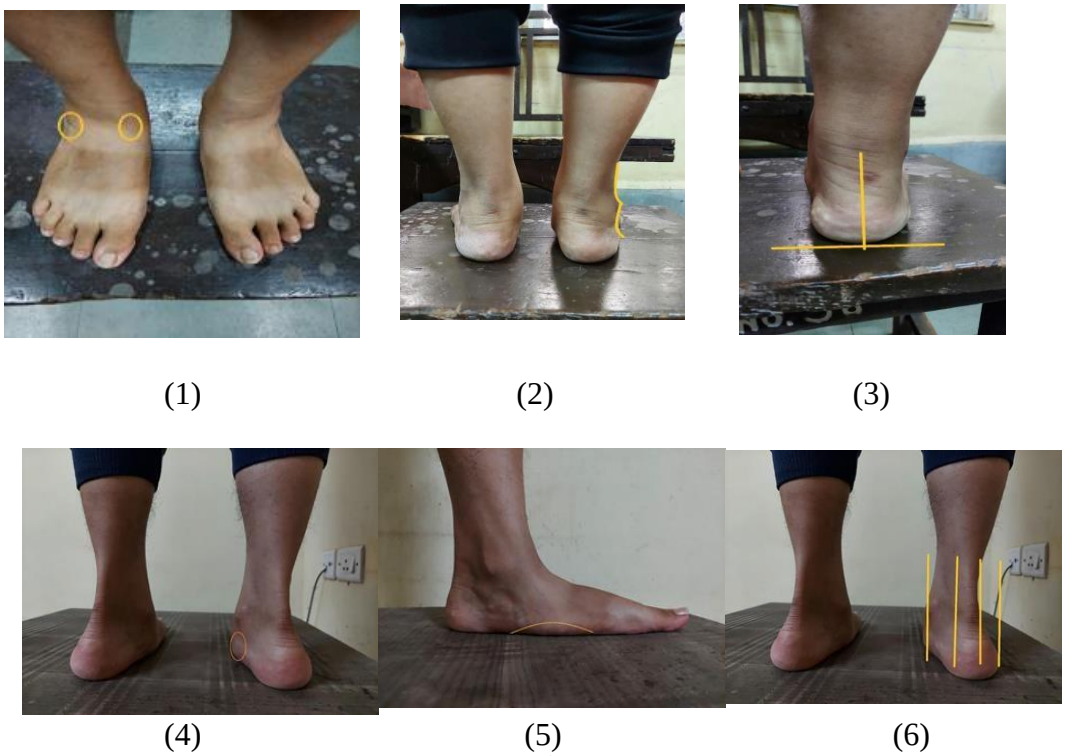
MATERIALS AND METHODS

Materials required for this study included pen and paper, a measuring tape, a weighing machine, a marker,adhesive tape, and a full-circle goniometer. The study design employed a cross-sectional analytical approach, and convenience sampling was utilized as the sampling method. The study included 175 premenopausal nursing professionals aged between 25 to 45 years with a minimum of 5 years of work experience. Subjects with recent vertebral, pelvis or lower limb fractures, recent ligament or meniscus injury, stroke, cerebellar disorders, spinal cord injuries, known case of diabetic neuropathy and vestibular disorder were excluded from the study. The permission from the Dean and Matron attached to tertiary healthcare hospital was taken. Approval from the Ethics Committee for Academic Research Projects (ECARP) was sought. A written informed consent was taken from the participants. A copy of the written informed consent document and the assent document was retained bythe investigator and a copy of it was given to the participant. Subjects

were then assessed for foot posture using the Foot Posture Index, and the Q angle was measured using a full-scale goniometer. Dynamic balance was assessed through the Star Excursion Balance Test (Y balance test).

Foot Posture Index:

Foot type was measured by Foot posture index with the participant in bilateral weight bearingstanding position on the basis of following six anatomical observations: [14] 1) Talar head palpation, 2) Supra and infra lateral malleolar curvature, 3) Calcaneal frontal plane position, 4) Prominence in the region of the Talo-navicular joint, 5) Height and Congruence of the medial longitudinal arch, 6) Abduction/adduction of forefoot on the rearfoot. Each item was scored on a scale of -2, -1, 0, +1, +2 (0 for neutral, -2 for clear signs of supination, and +2 for clear signs of pronation). [15]



(1) (2) (3)

(4) (5) (6)

Figure 1: The six items of the Foot Posture Index

	-2	-1	0	1	2
Talar head palpation	Talar head palpable on lateral side/but not on medial side	Talar head palpable on lateral side/ slightly palpable on medial side	Talar head equally palpable on lateral and medial side	Talar head slightly palpable on lateral side/palpable on medial side	Talar head not palpable on lateral side/but palpable on medial side
Supra and infra lateral malleolar curvature	Curve below the malleolus either straight or convex	Curve below the malleolus concave, but flatter/more than the curve above the malleolus	Both infra and supra malleolar curves roughly equal	Curve below the malleolus more concave than curve above malleolus	Curve below the malleolus markedly more concave than curve above malleolus
Calcaneal frontal plane position	More than an estimated 5° inverted (varus)	Between vertical and an estimated 5° inverted (varus)	Vertical	Between vertical and an estimated 5° everted (valgus)	More than an estimated 5° everted (valgus)
Prominence in the region of the talonavicular joint (TNJ)	Area of TNJ markedly concave	Area of TNJ slightly, but definitely concave	Area of TNJ flat	Area of TNJ bulging slightly	Area of TNJ bulging markedly
Congruence of the medial longitudinal arch	Arch high and acutely angled towards the posterior end of the medial arch	Arch moderately high and slightly acute posteriorly	Arch height normal and concentrically curved	Arch lowered with some flattening in the central portion	Arch very low with severe flattening in the central portion – arch making ground contact
Abduction/adduction of the forefoot on the rarefoot	No lateral toes visible. Medial toes clearly visible	Medial toes clearly more visible than lateral	Medial and lateral toes equally visible	Lateral toes clearly more visible than medial	No medial toes visible. Lateral toes clearly visible

Figure 2: Foot Posture Index Scoring

Q angle:

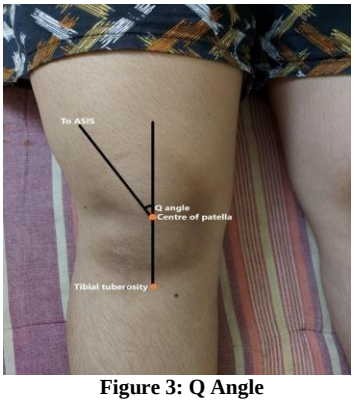


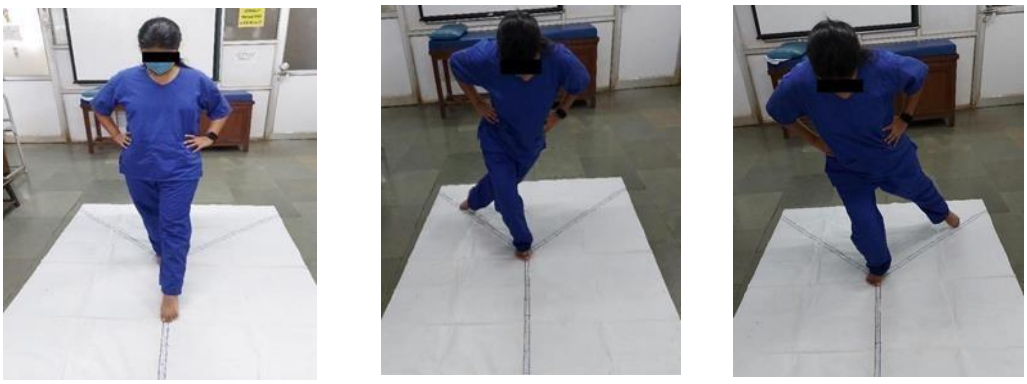
Figure 3: Q Angle

The Q angle was measured using a goniometer while the subject lay supine with knees extended and relaxed quadriceps. To prevent hip rotation, the foot was positioned with the heel-middle to the second metatarsal line perpendicular to the ground. Three landmarks were marked: anterior superior iliac spine, center of thepatella, and tibial tuberosity. The long arm of the goniometer was placed along the direction the line connecting the anterior superior iliac spine with the center of the patella while the short arm along the direction of line connecting the center of the patella with the tibial tuberosity with fulcrum of goniometer at centre of patella. [16]

Star excursion balance test (Y balance test):

The shortened version of Star Excursion Balance Test (Y balance test) involves assessment of reaches in the Anterior, Posteromedial and Posterolateral direction. Limb length of the subjects was measured from ASIS to medial malleolus for each limb. The starting position was bilateral standing with socks keeping hands on the hips. Maintaining single leg stance (weight bearing leg), instructions were given to reach out as far as possible with the non-stance limb (non-weight bearing leg) along the marked tape. Subjects were asked to point to the farthest point with their great toe and return the limb back to the original position. Subjects were asked to practice each direction 4 times before the test to minimize learning effect. Three successful trials were assessed in each direction with both legs with 10 sec rest is given between the attempts. [8]

Composite reach distance [17-18] = Sum of mean of 3 reach distances in 3 directions (anterior, Posteromedial and Posterolateral) /3 times limb length × 100.



(a) (b) (c)

Figure 4: Y balance test of right weight bearing (a)anterior, (b)posteromedial and(c)posterolateraldirections respectively.

DATA ANALYSIS:

Data was analyzed using GraphPad Prism (Version 9.2.0). The data was tested for normality by using Kolmogorov Smirnov test. Right and left foot posture index and Q angle did not pass the normality test while right and left CRDS passed the normality test. Therefore, correlation was measured using non-parametric test, i.e., spearman's correlation coefficient to find the relationship of right FPI with right CRDS, right Q angle with right CRDS, left FPI with

left CRDS, left Q angle with left CRDS.

Test for normality Distribution	Kolmogorov-Smirnov test					
	Right FPI	Left FPI	Right QAngle	Left Q Angle	Right CRDS	Left CRDS
KS distance	0.2591	0.2767	0.1014	0.1181	0.04068	0.05654
P value	<0.0001	<0.0001	0.0001	<0.0001	>0.1000	>0.1000
Passed normality test(alpha=0.05)?	No	No	No	No	Yes	Yes
P value summary	****	****	***	****	Ns	ns
Number of values	176	176	176	176	176	176

Table 1: Test for normality

CORRELATION ANALYSIS:

Spearman r	
R	0.01467
95% confidence interval	-0.1379 to 0.1665
P value	
P (two-tailed)	0.8467
P value summary	Ns
Exact or approximate P value?	Approximate
Significant? (alpha = 0.05)	No
Number of XY Pairs	176

Table 2: Correlation Right FPI with Right CRDS

Spearman r	
R	0.0264
95% confidence interval	-0.1263 to 0.1779
P value	
P (two-tailed)	0.728
P value summary	Ns
Exact or approximate P value?	Approximate
Significant? (alpha = 0.05)	No
Number of XY Pairs	176

Table 3: Correlation of Left FPI and Left CRDS

Spearman r	
R	0.008512
95% confidence interval	-0.1439 to 0.1605
P value	
P (two-tailed)	0.9107
P value summary	Ns
Exact or approximate P value?	Approximate
Significant? (alpha = 0.05)	No
Number of XY Pairs	176

Table 4: Correlation Right Q Angle with Right CRDS

Spearman r	
R	0.09466
95% confidence interval	-0.05841 to 0.2434
P value	
P (two-tailed)	0.2114
P value summary	Ns
Exact or approximate P value?	Approximate
Significant? (alpha = 0.05)	No
Number of XY Pairs	176

Table 5: Correlation of Left Q Angle with Left CRDS

RESULT

Table 1, shows, Kolmogorov-Smirnov test for the normality of data with results.

Table 2: Correlation of Right FPI with Right CRDS showing Spearman's correlation coefficient on the data, (r=0.01467, N=176) the results were found to be not significant (p value > 0.05). This indicates that there was no correlation between right FPI with right CRDS.

Table 3: Correlation of Left FPI and Left CRDS showing Spearman's correlation coefficient on the data, (r=0.0264,N=176) the results were found to benot significant (p

value > 0.05).This indicates that there wasno correlation between left FPI with left CRDS.

Table 4: Correlation Right Q Angle with Right CRDS showing Spearman's correlation coefficient on the data, (r=0.008512, N=176) the results werefound to be not significant (p value > 0.05).This indicates that there was no correlation between right Q angle with right CRDS.

Table 5: Correlation of Left Q Angle with Left CRDS showing Spearman's correlation coefficient on the data, (r=0.09466,N=176) the results were found to be not significant (p value > 0.05).This indicates that there was no correlation between right Q angle with right CRDS.

DISCUSSION

This study was conducted on 176 premenopausal nurses in tertiary care hospital between the age of 25 to 45 years with a mean age of 36.88±6.58 years. Mean clinical experience14.93±6.57 years while Mean BMI was 25.21±4.079 kg/m^2.

FOOT POSTURE INDEX:

Mean Right foot posture score was 2.068 ±4.148 while mean left foot posture score was 1.972±4.213. In our study we found that out of 176 population, 5.68% participants had highly supinated, 1.13% had supinated, 68.75% had normal, 17.04% had pronated and 7.38% had highly pronated foot posture in the right leg while 5.68% participants had highly supinated, 0.56% had supinated, 71.59% had normal,14.20%had pronated and 7.95% had highly pronated foot posture in left leg.

Q ANGLE:

Right Q anglescore was 22.57±6.203, left Q angle score was 22.51±6.566. Out of 176 population, 4.54% participants had less than normal Q angle, 22.72% had normal Q angle, 72.72% had more than normal Q angle in their right leg while 6.81% participants had less than normal Q angle, 16.47% had normal Q angle, 76.70% had more than normal Q angle in their left leg. In our study mean Q angle was more than normal range. This is more than the range given by Veeramani Raveendranath et al in Indian females which was 14.48° ± 2.02.The lateral placement of the tibial tuberosity with respect to the centre of patella was 1.8 ± 0.65 cm in Indian women. A more laterally placed Tibial Tuberosity in females could be due to an increase in the valgus angle or tibial torsion along with wider pelvis in Indian females.[19]

Ved Prakash et al (2017) found significant positive correlation between BMI and Q angle in Indian population.[20] In our study, the mean BMI was 25.21±4.079 kg/m^2 which was slightly more than the normalBMI range. A prolonged standing job, which increases the stress on knee joint, combined with a high BMI may be a possible reason behind higher values of Q angle in nursing population.

S.M.Madugwu et al (2019) found the osteoarthritis to be prevalent in Nigerian nursing population with mean age 39.92±10.97 similar to our study. They found bilateral osteoarthritisto be prevalent in 32.3% of their population, while 62.9% participants presented with unilateral osteoarthritis.[21]

So, we can conclude the high prevalence of OA knees in nursing population can be due to underlying increased Q angle.

Y balance test and CRDS:

Right CRDS was 66.99±9.31, left CRDS was 66.11±8.519. Mean CRDS of right leg in anterior direction was 58.64±8.60, posteromedial was 52.85±10.89, posterolateral direction was 58.41±9.06. Mean CRDS ofleft leg in anterior direction was 57.65±8.07, posteromedial direction was 52.70±9.70 and posterolateral direction was 57.28±8.71.

There was not much difference between the right and left Y balance composite reach distancescores. The posteromedial direction score of both the legs was less than the anterior and posterolateral direction. The possible reason for this may be little to no visual feedback in posteromedial direction.

Correlation of Foot posture and dynamic balance:

The objective of our study was to find the relationship between dynamic balance with foot posture index in premenopausal nursing population. The results showed no significant correlation between foot posture with dynamic balance in both right and left leg.

Nurses walk an estimated distance of 4 to 5 miles in a 12 hour shift, thus spending most of their working time on their feet. [22] In a study done by Songlin Xiao et al(2020), the authors compared the changes in foot morphology in sitting and standing position in 26 healthy males. Their findings showed that foot length and foot width remarkably increased in standing, whereas navicular height Arch Height Index considerably decreased in standing as compared to sitting position. In the standing position, there is flattening of the medial longitudinal arch. The decreased in transverse arch of foot is responsible for increased foot width. There is a possibility that these morphological changes result in greater surface area of foot in nursing population due to their prolonged standing job.[23]

Changes in foot morphology due to body weight in standing may also affect the length–tensionrelationship of foot muscles and the increased vertical load on the foot increases the activities of its intrinsic muscles. Plantar foot intrinsic muscle activation was strongly correlated mediolateral postural sway in single leg stance, with increased activity observed in abductor hallucis, flexor digitorum brevis and quadratus plantae during medial lateral sway. [24] These compensatory changes in the foot intrinsic muscles with respect to pronated and supinated foot can be the possible reason that our study failed to find significant correlation of supinated, neutral and pronated foot postures with dynamic balance.

Correlation between Q angle and CRDS:

Our study found no significant correlation between Q angle with dynamic balance in both right and left leg. In a study done by Aikaterini E. et al (2008), the authors compared anatomical cross sectional area of quadriceps muscle of low Q angle group (less than 15 degrees) with high Q angle group (more than 15 degrees) . They found a reduction of 9.1 to 13.4% in the area of cross section (muscle atrophy) of entire quadriceps as well as Vastus Medialis, Vastus Lateralis and Vastus Intermedius in individuals with high Q angle. The cross sectional area of rectus femoris was unaffected between low Q angle and high Q angle group.[25] Hiroshi akima et 2013 concluded that though Rectus Femoris is a two joint muscle and Vastus intermedius a one joint muscle, their line of action is similar in the activation of quadriceps tendon.[26] This can be the reason that dynamic balance is not significantly affected in both high and low Q angle. Fiber composition can also affect the activation in the quadriceps muscle group. .In a study conducted by Robert S. Staron et al (2020) the authors studied the composition of vastus lateralis muscle fibers in 55 women and95 men by taking muscle biopsies. They found that the hierarchy of percentage fiber type area from largest to smallest was I>IIA>IIB for women.[27] The large percentage of type I fibers in women can be yet anotherpossible reason for lateral pulling of patella and increased Q angle.

Authors Yildiz Erdoganoglu et al (2020) found similar results when they assessed dynamic balance by star excursion balance test in patients with unilateral patellofemoral pain syndrome. Dynamic balance did not show a difference as compared to the unaffected side limb, even if the affected painful limb showed a lower limb malalignment (knee valgus).[28]

CONCLUSION:

Our study concluded that there is no significant correlation of dynamic balance with foot posture index and Q angle in premenopausal nursing population.

Declaration by Authors
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