Correlation between Flexible Flat Foot and Lumbar Lordotic Angle

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Abstract

Objective: To investigate the effect of flexible flatfoot on lumbar lordotic angle.

Material and Methods: This study was conducted at the Faculty of Physical Therapy, Modern University for Technology and Information, Cairo, Egypt, on 40 participants (14 female & 26 male) for each subject using lateral weight-bearing radiography (X-ray) for foot and lumbar. Assessments were performed to measure the lateral talocalcaneal angle, the talar first metatarsal angle (Meary's angle), calcaneal inclination (calcaneal pitch) angle, the calcaneal first metatarsal and lumbar lordotic angle “LLA”. Measurement of these angles was accomplished by using surgimap spine software (valid and reliable).

Results: There was a positive weak significant correlation between lumbar lordotic angle and lateral talocalcaneal (r = 0.421, p = 0.007) and between lumbar lordotic angle and talar first metatarsal angle (Meary's angle) (r = 0.420, p = 0.007). While, there were no significant correlation between lumbar lordotic angle and calcaneal-first metatarsal angle (r = 0.265, p = 0.098) and lumbar lordotic angle and calcaneal inclination angle (r = 0.098, p = 0.548).

Conclusion: Subjects with flexible flatfoot demonstrated increased lumbar lordotic angle than normal subjects. So, foot assessments are recommended as an essential part of the evaluation of patients with spine problems.

Key Words: Flatfoot – Foot deformities – Lateral talocalcaneal angle – Talar first metatarsal angle – Calcaneal inclination – Calcaneal first metatarsal – Lumbar lordotic angle.

Introduction

FOOT posture is continuously changes from children to adult and even older people. Also, some variations in foot posture are strongly associated by some systemic conditions, such as neurological and rheumatological diseases and others associated with changes occur in lower limb motion and muscle activity “which lead to fatigue and injuries” [1].

In approximately 15% of cases, the deformity does not disappear and remains throughout adulthood, all over the world the prevalence of flat foot” pes planus is "increasing. Ninety percent of clinical cases are complaining from foot problems are due to Flatfoot (FF) [3].

A wide varity of techniques used in assessment of foot types are: Visual observation, foot print parameters, navicular tuberosity position and measurement of frontal plane heel position [4]. As the using of clinical methods of assessment are defective by soft tissues the best method of assessment of skeletal structure of foot is by using radiographic techniques "which is regarded as the gold standard for assessment of bone deformities and alignment of foot in weight bearing position” [5]. Physiological spinal curvatures are adaptations that allow standing and walking. These are influenced by hereditary factors, pathological conditions, mental state of the individual and the forces to which the spine is subjected on a daily basis [6].

Lumbar lordosis is determined by two main factors: The shape of the vertebral bodies and the shape of the intervertebral discs. Each of the five lumbar segments, (vertebral body and the adjacent disc), contributes to the lordosis. The last lumbar segment (L5) contributes almost 40% to overall lordosis. The first segment (L1) contributes only 5% [7,8]. Also, body segment connected by each other and any change on segment affect the other one, so in the treatment programs we must deal with the correlation between FF and any other disorder not focused on disorder only and reverse [6].
In flatfoot there are excessive subtalar hyper-pronation which in turn lead to internal rotation of the tibia which lead to internal rotation femur and that will lead to anterior inclination of pelvis finally that may affect lumbar vertebrae by increase muscle tension and rotation [9]. Also flatfoot accompanied by calcaneal eversion which affect the hip angles and in turn lumbar curvature may change [10]. Therefore the changes in foot alignment may affect the pelvic inclination and spine curvature [11].

Also, foot pronation significantly alters onset of muscle activity in the low back and pelvis during the gait cycle, so foot position affect the boney and muscular structures [12]. Therefore, the present study’s objective was to investigate the effects of flexible flatfoot on lumbar lordotic angle.

**Subjects and Methods**

This study took place at Faculty of Physical Therapy, Modern University for Technology and Information, Cairo, Egypt and during the period between November 2015 to February 2016.

Out of 150 student’s volunteers, 40 were recruited for this study. Inclusive criteria for participants were age ranging between 18-21 years old, and flexible flatfoot (male and female) (unilateral). Exclusive criteria were subjects with a previous back or foot surgery, neurologic or traumatic or systemic diseases that could affect back.

**Instrumentation:**

1- X-ray apparatus: This study used a TXR 525SFQ X-ray device to confirm the results of the physical examination and assess foot and lumbar anatomy through lateral weight-bearing; foot and lumbar, radiographs of each participant’s feet.

2- Surgimap spine software (measurement program on the computer): This is (valid and reliable). [13].

**Testing procedures:**

**A- Assessment of foot:**

1- Physical examination of the subjects which include:
   - Observation of feet: Included observing the participant foot normally no calcaneal valgus or varus (calcaneal valgus, low medial arches) while standing and ambulating [24].
   - Single-heel-raise test. Each participant was asked to stand on their tiptoes on one foot then repeat the same procedure for the other foot. Participants were noted as having flexible flat foot if their arch reappeared and their calcaneus demonstrated normal inversion when viewed from behind.

2- Radiographic evaluation: Following the physical examination, each participant’s submitted to lateral weight-bearing X-ray radiographs of foot. The degree of flatfoot was determined through using surgimap spine software program to analysis and drawing these angles:
   - Calcaneal pitch is angle, Fig. (1): Drawn between calcaneal inclination axis and supporting surface, normally equal 20 decreased in a flatfoot deformity [1].
   - Calcaneal-first metatarsal angle, Fig. (1): Is the angle formed by the inferior surface of the calcaneal and a line parallel to the dorsum of the mid-shaft of the first metatarsal. Normally up to 137, increased in a flatfoot deformity [1,23].
   - Lateral talocalcaneal angle, Fig. (1): Is formed by the intersection of the line bisecting the talus with the line of inclination of calcaneal. Normally between 35 up to 50 increased in a flatfoot deformity [14].
   - Talar first metatarsal angle (Meary’s angle), Fig. (1): This is an angle formed between the long axis of the talus and first metatarsal normally equal zero, increased in a flatfoot deformity [14].

![Fig. (1): A: Calcaneal inclination angle, B: Calcaneal-first metatarsal angle, C: Lateral talocalcaneal angle, D: Talar first metatarsal angle (Meary’s angle).](image)
B- Assessment of lumbar curvature by:
Radiographic evaluation: Each participant’s submitted to lateral weight-bearing X-ray radiographs of lumbar region and analysis by same way of the foot and measure Lumbar Lordotic Angle (LLA), Fig. (2): Which is the angle between the cranial end plate of L 1 and cranial end of sacral border [7,8].

Statistical analysis:
Statistical analysis was conducted using SPSS for windows, version 18 (SPSS, Inc., Chicago, IL). Pearson product moment correlation coefficient was used to determine the correlations among: Lumbar lordotic angle and lateral talocalcaneal, calcaneal-first metatarsal, talo first metatarsal angle (Meary's angle)* and calcaneal inclination angles:

As presented at (Table 1) the correlations between lumbar lordotic angle and lateral talocalcaneal, calcaneal-first metatarsal, talo first metatarsal “Meary’s angle”, and calcaneal inclination angles were studied through the Pearson product moment correlation coefficient. It revealed that there was positive weak significant correlation between lumbar lordotic angle and lateral talocalcaneal angle, Fig. (4) ($r=0.421, p=0.007$). Also, there was positive weak significant correlation between lumbar lordotic angle and talo first metatarsal “Meary’s angle”, Fig. (6) ($r=0.420, p=0.007$). While, there were no significant correlation between lumbar lordotic angle and calcaneal-first metatarsal angle, Fig. (3) ($r=0.265, p=0.098$). Additionally, there were no significant correlation between lumbar lordotic angle and Calcaneal inclination angle, Fig. (5) ($r=0.098, p=0.548$) (as shown in figure from 55 to 58).

Results
Table (1): Bivariate correlations lumbar lordotic angle and lateral talocalcaneal, calcaneal-first metatarsal, talo first metatarsal “Meary’s angle”, and calcaneal inclination angles.

<table>
<thead>
<tr>
<th>Lateral talocalcaneal angle</th>
<th>Calcaneal-first metatarsal angle</th>
<th>Talo first metatarsal “Meary’s angle”</th>
<th>Calcaneal inclination angle</th>
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<tbody>
<tr>
<td>Lumbar lordotic angle</td>
<td>$r=0.421$</td>
<td>$r=0.420$</td>
<td>$r=-0.098$</td>
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<tr>
<td></td>
<td>$p=0.007^*$</td>
<td>$p=0.098$</td>
<td>$p=0.548$</td>
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</table>

Fig. (3): Scatter plot for the bivariate correlation between lumbar lordotic angle and lateral talocalcaneal angle.

Fig. (4): Scatter plot for the bivariate correlation between lumbar lordotic angle and calcaneal-first metatarsal angle.
Discussion

The aim of this study was to study the effect of flexible flatfoot on lumbar lordotic curvature. The result of the study show significant change in lumbar curvature observed in the flexible flatfoot group which can be attributed to the presence of foot pronation and calcaneal eversion.

Flatfoot generates an internal rotation of the tibia and femur and consequently at the hip joint [10]. This internal rotation may make the head of femur move posteriorly, which consequently shifts the pelvis posteriorly. In order to regain postural balance, the trunk moves anteriorly to shift the centre of mass anteriorly and this forces the pelvis to tilt anteriorly in the sagittal plane. In addition, tension in the iliopsoas muscle and hip joint capsule as a result of hip internal rotation produced anterior pelvic tilt [11].

As Khamis and Yizhar reported that the alteration in foot mechanics will cause alteration in whole body mechanics, including in the pelvis. These body alterations can occur even when foot alteration is temporary [10].

Abdel-Raooof et al., and Eldesoky et al., investigated the effects of increase in calcaneal eversion, unilaterally and bilaterally, on pelvic alignment during standing and found that bilateral and unilateral increases of calcaneal eversion led to significant changes in pelvic alignment which in turn led to pelvic tilting and finally, changing of lumbar curvature angle [11,15,16].

Roussouly et al., and Been et al., proved that a high correlation between the lumbar lordosis curvature and pelvic and thoracic orientation in space. Greater lordosis angles correlate with a more horizontally inclined sacrum (increased sacral slope, more vertical sacral endplate), increased pelvic incidence, and increased pelvic tilt [8,17,18].

Pinto et al., reported that bilaterally increased foot pronation did not generate any change in pelvic alignment in the frontal plane, while only unilateral-increased foot pronation would significantly increase pelvic tilt in the frontal plane [11].

Duval et al., reported that foot pronation (artificially induced) did not have a relationship with pelvic tilt which is in disagreement with the results of current study this may attributed to participant not complaining from flat foot. Or may be due to compensatory mechanisms preventing a change in pelvic and lumbar posture; the degree of pelvic tilt at which low-back posture is affected wasn’t reached with the manipulations (wedges) [19].

Conclusion:

The results of this study support the existence of a kinematic chain in healthy subjects, where hyperpronation can lead to leg and thigh internal rotation and change in pelvic position which causes an increase in the lumbar lordotic angle. This study provided evidence for the effects of flexible flatfoot on lumbar lordosis curvature mechanics. In physical therapy management we must investigate all body segments and not to be localized on the affected segment only. Also we recommend further research to assess foot biomechanics changes that affect different body segments.

References


الملخص العربي

الهدف: للتأكد من تأثير القدم المقلقة المرنة على زوايا الامام الأقصى للفقرات القطنية.

الطريقة: أجريت الدراسة في كلية العلاج الطبيعي، الجامعة الحديثة للتكنولوجيا والمعلومات، القاهرة، مصر، على مدار المشاركين في الدراسة 40 شخص (16 إم و 24 ذكر)، تم عمل اشعة عادية من وضعية ال الوقوف من منظر جانبي، باستخدام أجهزة منخفضة الطاقة. تم القيام باستخدام برنامج لحساب الزوايا بالنسبة للزاوية المقياسية التي تم قياسها، وكانت الزوايا المقياسية كالتالي: الزاوية الجانبية بين القدم والصدر، وزاوية القدم ومشطية القدم الأولى، وزاوية الانحناء عضلة الركبة، وزاوية القدم ومشطية القدم الأولى، وزاوية الامام القصعي للفقرات القطنية.

النتائج: وجد ان هناك علاقة إيجابية ضعيفة بين الامام القصعي للفقرات القطنية وكلا من: الزاوية الجانبية بين القدم والصدر (p=0.01)، وزاوية القدم ومشطية القدم الأولى (p=0.01). بينما لا يوجد علاقة بين الامام القصعي للفقرات القطنية وكلا من زاوية القدم ومشطية القدم الأولى (p=0.08) وزاوية الانحناء عضلة الركبة (p=0.04).

النتيجة: الأشخاص الذين لديهم تقلصات القدم المرنة لديهم زيادة في الامام القصعي للفقرات القطنية أكثر من الأشخاص العاديين (الذكور). يتضح الكتاب بالإجراء تقييم للقدم كجزء أساسي لدى المرضى الذين يعانون من مشاكل بالعمود الفقري.)