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Weight-Bearing Joint Position Sense in Females with Pelvic Asymmetry

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Abstract : Malposition within the pelvic area may result in a cause and effect chain that is realized by changes in lower extremity kinematics. Yet, there is lack of knowledge that supports the functional chain effect of different pelvic alignment on the lower extremities. The purpose of the study was to compare the lower limb's weight-bearing joint position sense bilaterally and between groups of different pelvic alignment. Fifty females with different pelvic alignment in the sagittal plane participated in the study. They were assigned into two groups, group (1) with anterior innominate rotation and group (2) control. Data were collected using the digital Goniometer. Mixed design ANOVA revealed a non-significant difference in the mean values of the active reposition error between groups ($p>0.05$). Also, there was a non-significant difference between the two tested sides in the anterior innominate rotation group ($p>0.05$). However, there was a significant decrease in the active reposition error in the right side compared with the left side in the control group ($p<0.05$).Pelvic asymmetry does not affect the weight-bearing joint position sense. However, bilateral lower extremity symmetry should not always be assumed in adult females.
Keywords : Pelvic asymmetry, Weight-bearing joint position sense.

Introduction

Several articles have been published over the last few years dealing with the increased incidence of knee injuries in females[1].In this population, injury to the anterior cruciate ligament (ACL) is one of the most common and serious injuries. Several factors have been identified as related to the increased incidence, including ligament laxity, femoral notch size, limited muscle strength, muscle activation patterns, muscular fatigue, joint proprioception, hormonal changes, and lower extremity alignment. It is a combination of factors that probably causes these devastating injuries[2]. To predict injury, studies must measure the potential risk factors in subjects before the occurrence of injury[3]. This study investigates two of these factors; sagittal-plane pelvic alignment and joint proprioception.

Pelvic alignment is recognized as the cornerstone of overall skeletal alignment. Proper or neutral pelvic alignment allows for efficient execution of movement and effective muscle recruitment[4]. The influence of proximal stability on lower extremity structure and pathology remains largely unknown. **Bouisset**[5]initially proposed that stabilization of the pelvis and trunk is necessary for all movements of the extremities.

One asymmetry that can be commonly associated with disturbed stress patterns, is unequal innominate bone inclination in the sagittal plane[6].Pelvic asymmetry (PA) is a common phenomenon which is often described in association with various pathological processes affecting the locomotor system. It is not only associated with pathology, but it can also be observed in healthy individuals with no evidence of any dysfunction. Since PA is observed in such a large percentage of healthy subjects, it is probably more appropriate to perceive it as a physiological phenomenon which is associated with, for example, absorption of routine mechanical load exerted on the lumbo-pelvic-hip complex[7].

To prevent faulty standing posture, one must develop a dynamic awareness of neutral joint position and be able to maintain this position in daily living and sporting activities. So, Deficiencies in joint position sense (JPS) can lead to biomechanically unsound limb position. Consequently, individuals will be more prone to injury because of their faulty joint position[8].

Proprioceptive information concerning the status of the joint and muscle receptors is essential for neuromuscular control and maintaining functional joint stability via the sensory motor system. Proprioception is the sensory component of sensorimotor control where sensorimotor control is defined as the control of local joint stability, posture, and whole body movement. As such, before effective motor output can be executed for the purposes of maintaining functional joint stability, accurate sensory input (proprioception) must be received by the central nervous system (CNS). Proprioceptive input to the CNS then modifies motor output[9]**.**

Weight-bearing (WB) tests of the JPS are recommended as they are more functional and involve all of the cutaneous, articular and muscular proprioceptors that act in concert during normal everyday activities. The findings of **Stillman**[10]suggested that standing WB assessment have more clinical relevance when evaluating proprioception in relation to falls and other WB specific pathologies. At present, it seems that WB assessments of proprioception might have greatest relevance in the area of sports medicine. Relatively healthy subjects are more likely to be able to meet the WB assessment requirements. Therefore, the main goal of the current study was to compare the lower limb's WB JPS bilaterally and between groups of females with different pelvic alignment in the sagittal plane.

Materials and Methods

Participants

Fifty females volunteered to participate in this study. Their mean ± SD age, body mass, and height were 21.8 ± 4.3 years, 55.7 ± 10.2 kg and 1.62 ± 0.04 m respectively. They were assigned into two equal groups of 25 (experimental and control). The experimental group included participants with anterior innominate rotation while the control group involved participants with neutral symmetrical pelvis. The WB JPS were measured for all participants in both groups by the same examiner.

All participants in the experimental group had asymmetrical pelvis with bilateral difference greater than one degree. In the control group, all participants had neutral pelvis (pelvic tilt less than or equal six degrees) and symmetrical pelvis (bilateral difference less than or equal one). Participants were excluded from the study if they had any previous history that would affect the alignment or the motion of lower extremity joints such as fractures, surgery, significant knee joint laxity or instability, genurecurvatum (knee hyper extension exceeding 5^0),fixed deformity or low back / sacroiliac joint pain. Participants were also excluded if they suffered from any medical condition affecting peripheral nerves as diabetes mellitus, any neuromuscular dysfunction and vestibular disorder.

Instrumentations

The PALM inclinometer (Performance Attainment Associates, Saint Paul, MN, USA) was used for measuring the pelvic angle and static innominate rotation of the ipsilateral anterior superior iliac spine (ASIS) and posterior superior iliac spine (PSIS). The digital goniometer was used for assessing the WB JPS.

Procedure

Before starting the procedures, a pilot study was conducted to determine the appropriate sample size. Power analysis was done at a significance level of 5% and a test power of 80%. It was revealed that a minimum of 18 participants for each group were required and the total required sample size was 36. In the current study, the total assessed number of participants was 75. Then, 25 participants, who didn't meet the inclusion criteria, were excluded from the study. Only fifty participants met the inclusion criteria and completed the study. This sample size achieved 93% power of significance. Prior to the clinical assessment, the nature of the study, aims, and procedures were explained to each participant to be familiar with the study. All participants provided written consent prior to the participation in our study.

Pelvic angle was measured from a bilateral stance while the participant was standing and bearing equal weight on both lower limbs using a modified technique described by **Gilliam et al.**[11]The participant's anterior thigh was snug against a table and she was looking at a fixed point at the wall to reduce postural sway. The inferior prominence of the ASIS and the most prominent portion of the PSIS were palpated, and the tips of the inclinometer were placed on these landmarks. The angle formed by a line from the ASIS to the PSIS relative to the horizontal plane was measured with the PALM inclinometer on both sides. PALM was also used to measure static innominate rotation of the ipsilateral ASIS and PSIS. The difference in innominate rotation between the right and left sides was calculated by subtracting the left side mean from the right side mean. This method of measurements has a high intra-tester reliability (ICC = 0.77 -0.99) [12].

Weight-bearing joint position sense assessment

During the unilateral WB assessment, each participant maintained balance by leaning backward against the wall while standing 10–20 cm from the wall. Each participant was instructed to slowly squat with eyes closed until told to stop (when the target angle of 30 degrees of knee flexion was reached). The hip was close to 45 degrees, whilst the foot, under the influence of body weight, occupied 20.7 degrees dorsiflexion. Then, the participant was instructed to hold the knee in this position for 15 seconds and concentrate on sensing the knee position. Next, the subject returned to a standing position and waited for 15 seconds. Then, the subject was instructed to reproduce the target angle for that trial as accurately as possible. Each participant's dominant leg (defined as the leg with which the subject preferred to kick a ball) and non-dominant leg, were tested. Between trials, each subject walked 20 steps to eliminate any proprioceptive memory of the test.

Statistical analysis

All statistical measures were performed through the Statistical Package for Social Science (SPSS) version 20.Data exploration was done to assess normality. This was conducted through assessing the presence of significant Kolmogorov-Smirnov and Shapiro-Wilks normality tests in addition to the presence of skewness and kurtosis and extreme scores. Once data were found not to violate the normality assumption, parametric analysis was used. Two-way mixed design univariate analysis of variance (ANOVA) was used to differentiate between the tested groups and the tested sides for the dependent variable. The family wise alpha level was set at 0.05.

Results

Results revealed a non-significant statistical difference in the mean values of the active reposition error between groups ($p>0.05$).Also, there was a difference between the two tested sides in the anterior innominate rotation group but this difference was not significant ($p>0.05$). On the other hand, there was a significant reduction in the active reposition error in the dominant side (Right side in most of the cases) compared with the non-dominant side (Left side) in the control group ($p<0.05$) as represented in table 1.

Table 1.Descriptive statistics and multiple pairwise comparison tests of the weight-bearing joint position sense between the two tested sides in both tested groups

Active Reposition Error mean ± SD (in degrees)			
Innominate rotation group		***Control group***	
Right	**Left**	**Right**	**Left**
3.16±1.79	3.63±1.72	2.53±1.42	3.42±1.46
Multiple Pairwise Comparison tests			
Innominate rotation VS control		**Right**	**P=** 0.402
		Left	**P=** 1.000
Right VS Left		**Innominate**	**P** = 0.221
		Control	**P** = 0.023*****

****Significant at alpha level < 0.05***

Discussion

The findings of the current study revealed a non-significant difference in the mean values of active reposition error between groups. It is suggested that proprioceptive afferent information from a wide variety of sources during WB assessments might diminish or fully compensate for disturbed proprioception [13].It was also suggested that knee flexion from WB position involves contribution from the hip and ankle joints as single leg squat is a complex multi joint movement requiring contributions from several muscles and joints. This theory suggests that of the two largest lower limb joints producing most of the work for the squat movement, the hip joint should be more responsible for producing the movement [14].

Findings of the current study are in disagreement with those of **Loudon**[15]who investigated the relationship between sagittal-plane knee alignment and joint proprioception in women with varying degrees of genu recurvatum. The researcher reported a significant difference between the tested groups. These contradictions might be due to different tested population.

Regarding the control group, findings of the current study reported a significant decrease in the active reposition error in the right side compared with the left side. **Schamberger**[16]stated that 70% of us are left and 15% right motor cortex dominant, the other 15% having about an equal representation bilaterally. This asymmetry in motor control at the cortical level result in the asymmetry in muscle strength between the two sides of the body and hence, asymmetry in the amount of afferent output from muscle spindle, afferent feedback, and sensory motor function.

Furthermore, **Hewett**[17] suggested that females have dominant leg dominance. Dominanat leg dominanace is the imbalance between muscular strength and recruitment on opposite limbs, with the nondominant limb often having weaker and less coordinated lower limb musculature. With dominant leg dominance, there is an imbalance between the two lower extremities in strength and coordination. So, females may have a lack of dynamic muscular control of the nondominant knee, which may predispose the knee to injury. The findings of the current study are similar to those reported **Hewett et al**[18] due to the dominant leg dominance which is more prevalent in females.

On the other hand, the findings of the current studyare opposed by those reported by**Bullock-Saxton et al**.[19] who found no side differences between the right and left limbs in the non WB, partial WB, and full WB JPS assessment. The reason for this conflict might be attributed to differences in the assessment procedure (target joint position was passively generated in contrast to the current study).

Concerning the anterior innominate rotation group, the findings of the current study reported a non-significant difference between the two tested sides. To the best of the author's knowledge, this is the first study to assess the WB JPS in females with anterior innominate rotation. The non-significant difference in JPS between the two tested sides in participants with anterior innominate rotation in contrast to the control group might be due to the presence of pelvic malalignment which results in asymmetrical increase in muscles tension and asymmetrical muscle weakness in the hip girdles and legs on both sides.[16] This asymmetrical muscle

weakness may affect the dominant side more than the non-dominant side. As in right anterior innominate rotation, there is an inhibition of gluteal muscles (gluteal muscles are the most responsible muscles for producing squat movement) on the right (dominant) side. This unilateral muscle inhibition decreases the amount of afferent output from muscle spindle, afferent feedback, and sensory motor function.[10]

Conclusion

Pelvic asymmetry does not affect the weight-bearing joint position sense. However, bilateral symmetry should not always be assumed as dominant lower extremities have better WB JPS than non-dominant lower extremities in adult females.

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