Influence of Bilateral Flexible Flat Foot on Weight Bearing and Non-Weight Bearing Knee Proprioception

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ABSTRACT

Background: Proprioceptive information plays an important role in joint stabilization, body coordination and proper function**.** Flatfoot affect the mechanics of lower limb as foot pronation causes tibial internal rotation, which causes knee valgus. Flat foot deformity may alter the proprioception of knee joint and that may predispose to joint injury. **Objective:** Is to investigate the effect of bilateral flexible second degree flatfoot on weight bearing and non-weight bearing knee proprioception. **Methods:** Thirty-two males and females subjects with age ranged from 18-25 years old were assigned into two equal groups, Group A (the normal group) and group B (the flat foot group). Lateral weight bearing radiographs were performed bilaterally for each subject in both groups to determine the degree of flat foot by measuring the talus first metatarsal angle. Active repositioning test of knee flexion was measured in weight bearing and non-weight bearing state by digital goniometer to assess proprioception joint reposition error of knee joint. **Results:** MANOVA revealed that there was no significant difference in reposition error of knee joint in the flatfoot group compared with control group in weight bearing state as $p \geq 0.05$. And there was significant difference in reposition error of knee joint in the flatfoot group compared with control group in non-weight bearing state as $p \leq 0.05$. **Conclusion:** The findings indicate that flatfoot affect knee proprioception in non-weight bearing state only.

Keywords: knee Proprioception; weight-bearing; non-weight-bearing; flexible flatfoot.

INTRODUCTION

Flat foot is one of the frequent orthopedic issues in pediatrics and adult health practice. The development of foot arch start between the age of two and six years, it becomes structurally perfected around the age of twelve to thirteen years There are several causes of flat foot, it can be congenital, adult flexible, posterior tibial tendon dysfunction, tarsal coalition, peroneal spasticity, post traumatic arthritis, charcot foot or due to neuromuscular in-coordination (Riccio, Gimigliano, Gimigliano, Porpora, & Iolascon, 2009).

There are two types of flat foot, flexible and rigid. In flexible flatfoot, medial longitudinal arch of the foot collapses in various degrees during weight-bearing. However, during raising up one's body on tiptoe (tiptoe test) foot arch forms again, while in rigid flat foot the medial longitudinal arch still collapsed in weight-bearing and non- weight bearing. Flexible flatfoot in the adult may present as unilateral or, more commonly, as bilateral. The incidence of flexible flat foot is 23% of the adult population (Atik & Ozyurek, 2014).

The effect of flat foot on the mechanics of human body results from the manifestation of abnormal foot mechanics which include abnormal foot pronation and diminished foot arches (Cote, Brunet, II, & Shultz, 2005). There is a functional relationship between the structure of the arch of the foot and the biomechanics of the lower leg. The arch provides an elastic, springy connection between the forefoot and the hind foot. This association safeguards so that a majority of the forces incurred during weight bearing of the foot can be dissipated before the force reaches the long bones of the leg and thigh(MAHMOUD & KATTABEI, 2017).

Flat foot deformity may resulted in many knee problems as osteoarthritis (Abourazzak et al., 2014), knee valgus (Levangie & Norkin, 2000), patella lateral rotation, Q angle increasing, and knee pain (Letafatkar, Zandi, Khodayi, & Vashmesara, 2013). In the closed kinetic chain (the foot being fixed beneath the base of support) and relies on the integrated feedback and movement strategies among the hip, knee, and ankle. Balance can be disrupted by diminished afferent feedback or deficiencies in the strength and mechanical stability of any joint or structure along the lower extremity kinetic chain (El-Shamy & Ghait, 2014).

The proprioception defined as an individual's ability to integrate the sensory signals from various mechanoreceptors to thereby determine body position and movements in space (Goble, 2010).

For the knee joint, proprioception is assessed in non-weight bearing position [NWB] and weight bearing position [WB]. According to Lonn et al (2000), the NWB knee repositioning procedure has the greatest potential for revealing the proprioceptive status of only the knee joint because it does not involve any movement, resistance or weight bearing of its own or through adjacent joints. In recent years, increasing numbers of authors have recommended weight bearing [WB] test of proprioception, as weight bearing tests are more functional and most our activities come in weight bearing position in every day (Lokhande, Shetye, Mehta, & Deo, 2013).

It was proved that flat foot and knee problems are closely linked, as flat foot causes tibial internal rotation and knee valgus. Flat foot is significantly associated with medial compartment knee osteoarthritis(OA) as During walking, which submits the knee to repetitive mechanical loads, most of the force is exerted through the medial compartment. This coincides with the timing of subtalar over pronation (Abourazzak et al., 2014).

Since there is lack in research concerning the effect of flat foot on knee proprioception, so the current study was conducted to investigate the effect of flat foot deformity on knee proprioception in weight bearing and non-weight bearing state.

MATERIALS AND METHODS

Study design

Observational cross sectional study.

Participants

32 volunteers with age between 18-25 years old (13 male and 19 female) were included in this study from faculty of physical therapy cairo university students, screening examination was done to determine flatfoot and normal subjects, then digital x-ray was used to confirm bilateral flexible second degree flatfoot and normal subjects. G power test was used to determine our sample size, they were divided into two equal groups, group (A) 16 normal subjects (7 male and 9 female), and group (B) 16 patients (6 male and 10 female) with bilateral flexible flatfoot. The inclusive criteria of subjects included body mass indexes (BMI) ranged from 18-25 kg/m2 and the age between 18-25 years and inclusive criteria of subjects with flexible second degree flat foot included body mass indexes (BMI) ranged from 18-25 kg/m2 and the age between 18-25 years , and The subjects were excluded if they had traumatic condition of the lower limbs, history of Fracture of the lower limbs, previous orthopedic disorders or neurologic deficit of the lower limbs, any sensory problems, leg length discrepancy, neuromuscular disease like multiple sclerosis, and any knee problems as OA, pain and previous surgery. All subjects read and signed data in the informed consent form (Appendix).

Sample size determination:

Calculations to determine Sample-size were performed for non weight bearing knee proprioception as a primary outcome measure using G power 3.1 software. The calculations were based on 1.0574 effect size (an alpha level of .05, a desired power of 80%, numerator degree of freedom of 1 and 2 experimental groups. The estimated desired total sample size for the study was 32 patients.

Instrumentation

X-ray apparatus was used to assess the degree of flatfoot and Digital goniometer was used to assess the knee proprioception by measuring reposition error. Weight and height scales were used to determine BMI for each subjects.

Procedures

X-Ray assessment of flat foot:

Standing lateral view of the foot was obtained for all subjects. All radiographs were obtained in a weight-bearing position with a standardized technique using the same digital radiography system. The digital x-ray detector (film) and the x-ray tube (source) are 35–40 inches apart in lateral views of the foot.

The degree of flatfoot was determined through measuring the talus–first metatarsal angle on a lateral weight-bearing radiograph. It is the angle between line drawn from the centers of longitudinal axes of the talus and the first metatarsal. An angle that is greater than 4° convex downward is considered pes planus (flat foot) with an angle of 15° - 30° considered moderate, and greater than 30° severe.

Assessment of proprioception:

Joint position sense was assessed using digital goniometer in non-weight bearing position and weight bearing position.

Weight bearing proprioception assessment

Participants were asked to wear shorts for ease of attachment of the electro-goniometer to the lateral side of the knee joint. First for the right knee, the electro-goniometer was attached to the knee joint in the neutral knee position. The fixed arm was placed in parallel to an imaginary line between the head of the fibula and the lateral malleolus. The movable arm was placed in parallel to an imaginary line between the greater trochanter and the lateral condyle of the femur. The electro-goniometer was zeroed when the subject was standing motionless in the anatomic position. To prevent slippage during knee joint motion, the end blocks was adhered to the tested leg with double-sided adhesive tape and further secured in place with adhesive tape. Electro-goniometer readings records knee joint angular displacements relative to zero.

The test procedure was active reproduction of the angles, with the feet slightly wider than shoulder-width apart and the toes pointed slightly outward. The foot of the untested limb was lifted from the floor. The knee was straight in the starting position (0 degrees). The subject stood with eyes open, and was instructed to 1) lift the unexamined foot from the floor on a step; 2) slowly flex the WB limb until 15 degrees, 3) identify (sense) the knee position while isometrically holding the test position for approximately 5 seconds, 4) return to the erect bilateral WB stance (for 7 seconds), 5) with eyes close reproduced the previous unilateral flexed position while concentrating on the knee. The test and replicated angles will be measured using the electro-goniometer, 6) Then repeat the test procedure at 45 degrees. Measurement of knee joint position sense was repeated three times, and the average was taken for the limb. By subtracting the test angle (TA) from the reproduced angle (RA), the absolute angular error (AAE) was calculated as a dependent variable. Then the same procedure was done for the left knee Figure (1).

Figure (1): Weight bearing proprioception assessment

Non-weight bearing proprioception assessment

Joint position sense was assessed using digital goniometer in high sitting position with eyes blindfolded. Joint position sense for both knees was assessed at 15° and 45°. First for the right knee, Individuals were seated in high sitting and knee was taken into full extension. Then passively the knee flexion was taken at the target angle e.g. 15° and kept there for 5 seconds and returned to starting position for 7 seconds. Then the individual was asked to actively flex the knee to target angle and the error (difference between target angle and angle reproduced) was noted. Mean of 3 readings at each angle was considered for analysis. Then the same procedure was done for the left knee Figure (2).

Figure (2): Non-weight bearing proprioception assessment

Data analysis

Data analysis was performed using the SPSS 25 for Windows statistical software. The appropriate sample size was determined using the pre-post comparison between the subject's responses, the appropriate sample was 32 subjects. The normality of data distribution was tested through the Shapiro-Wilk test and it was normally distributed. Descriptive data for participants, characteristics and dependent variables was calculated as mean ± SD. Multivariate analysis of variance (MANOVA) was used to assess the statistically significant effect of flatfoot on weight bearing and non-weight bearing knee proprioception. The alpha level of significance was adopted at 0.05.

RESULTS

The purpose of this study was to investigate the effect of bilateral flexible second degree flatfoot on weight bearing and non-weight bearing knee proprioception. sixteen subjects with bilateral flexible second degree flatfoot were compared with sixteen normal subjects.

Data obtained from both groups regarding weight bearing and non-weight bearing knee proprioception in form of repositioning error were statistically analyzed and compared.

General characteristics of the subjects:

Control group (group A):

Sixteen normal subjects were included in this group. Their mean ± SD age, weight, height, and BMI were 22.43 ± 1.75 years, 63.62 ± 9.54 kg, 173.21 ± 9.81 cm, and 22.75 ± 1.47 kg/m² respectively as shown in table (1) and figure (1-4).

Flatfoot group (group B):

Sixteen subjects with bilateral flexible second degree flatfoot were included in this group. Their mean ± SD age, weight, height, and BMI were 22.56 ± 2.06 years, 70.06 ± 9.65 kg, 168.82 ± 9.52 cm, and 23.25 ± 1.58 kg/m² respectively as shown in table (1) and figure (1-4).

Comparing the general characteristics of the subjects of both groups revealed that there was no significance difference between both groups in the mean age, weight, height, or BMI ($p > 0.05$).

Table 1. ***Descriptive statistics and t-test for comparing the mean age, weight, height and BMI of the control and flatfoot groups.***

	flatfoot group	**Control group**	**MD**	**t-value**	**p-value**
	$\overline{X}$ **±SD**	$\overline{X}$ **±SD**			

Age (years)	22.56 ± 2.06	22.43 ± 1.75	-.12	-.18	.85*
Weight (kg)	70.06 ± 9.65	63.62 ± 9.54	-6.43	-1.89	.06*
Height (cm)	168.82 ± 9.52	173.21 ± 9.81	-4.39	-1.51	.11*
BMI (kg/m²)	23.25 ± 1.58	22.75 ± 1.47	-.5	-.93	.35*

x̄: mean   SD: Standard deviation   MD: mean difference

t value: Unpaired t value   p value: Probability value   *: Non significant

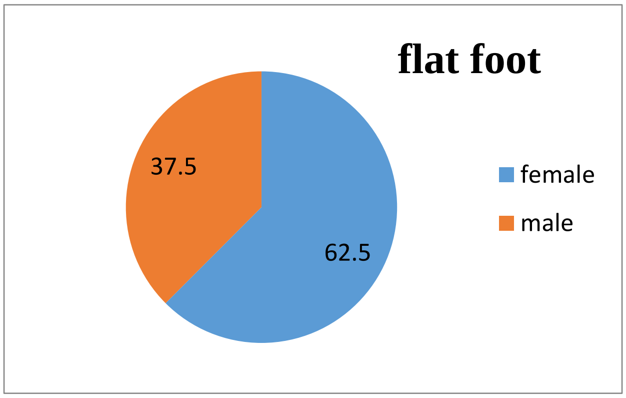
Sex distribution:

The sex distribution of the flatfoot group revealed that there were 10 females with reported percentage of 62.5% while the number of males was 6 with reported percentage of 37.5%. The sex distribution of the control group revealed that there were 9 females with reported percentage of 56.25% and the number of males was 7 with reported percentage of 43.75% as shown in table (2) and demonstrated in figure (5). There was no significant difference between both groups in sex distribution (p = 0.46).

Table 2. ***The frequency distribution and chi squared test for comparison of sex distribution between flat foot and* normal *groups.***

	Flatfoot group	**Control group**	χ^2	**p-value**	**Sig**
Females	10(62.5%)	9 (56.25%)	0.129	0.718	**NS**
Males	6 (37.5%)	7(43.75%)			

χ^2 : Chi squared value   **p value: Probability value**   **NS: Non significant**



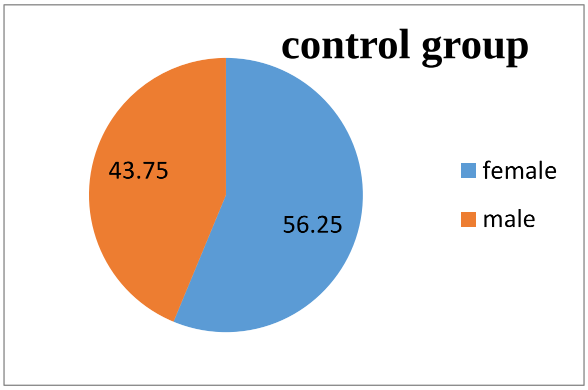


Figure (5). **Sex distribution of flatfoot and control groups.**

Effect of flexible flatfoot on knee joint proprioception:

Multivariate analysis of variance (MANOVA) was carried out to investigate the effect of bilateral flexible second degree flatfoot on weight bearing and non-weight bearing knee proprioception.

- Overall effect of flexible flatfoot on knee joint proprioception:

Mixed MANOVA was conducted to investigate the effect of flat foot on weight bearing and non-weight bearing knee proprioception. There was a significant effect of time (p = 0.0001). There was a significant main effect time (p = 0.0001). (Table 1).

Table 1. Mixed MANOVA for the effect of flat foot on weight bearing and non-weight bearing knee proprioception:

Mixed MANOVA	
Interaction effect (flat foot * wight)	
F = 11.915	p = 0.0001**
Effect of flat foot (group effect)	
F = 14.926	p = 0.0001**
Effect of wight	
F = 5.488	p = 0.٠٠2**

F value: Mixed MANOVA F value p value: Probability value **: Significant

1- Comparison between flatfoot and control groups in weight bearing knee reposition error

RT knee reposition error at angle 15°

The mean ± SD Weight bearing RT knee reposition error at angle 15° of flat foot group was 1.96 ± 0.87 while that of control group was 1.73 ± 1.44. The mean difference between both groups was 0.22. There was no significant difference in reposition error in the flatfoot group compared with control group (p=0.59). (Table 3, figure 6).

RT knee reposition error at angle 45°

The mean ± SD Weight bearing RT knee reposition error at angle 45° of flat foot group was 3.33 ± 1.17 while that of control group was 2.75 ± 1.32. The mean difference between both groups was 0.58. There was no significant difference in reposition error in the flatfoot group compared with control group (p=0.19). (Table 3, figure 6).

LT knee reposition error at angle 15°

The mean ± SD Weight bearing LT knee reposition error at angle 15° of flat foot group was 1.8 ± 1.12 while that of control group was 1.19 ± 1.05. The mean difference between both groups was 0.61. There was no significant difference in reposition error in the flatfoot group compared with control group (p=0.12). (Table 3, figure 6).

LT knee reposition error at angle 45°

The mean ± SD Weight bearing RT knee reposition error at angle 45° of flat foot group was 2.82 ± 1.47 while that of control group was 2.08 ± 1.13. The mean difference between both groups was 0.74. There was no significant difference in reposition error in the flatfoot group compared with control group (p=0.12). (Table 3, figure 6).

Table 3. ***Comparison of mean value of knee reposition error of flatfoot and control groups in weight bearing state:***

	Flatfoot group	**Control group**	**MD**	**p-value**
	$\overline{X}$ ±SD	**$\overline{X}$ ±SD**		
weight bearing RT knee reposition error at angle 15°	1.96 ± 0.87	1.73 ± 1.44	0.22	0.59*
weight bearing RT knee reposition error at angle 45°	3.33 ± 1.17	2.75 ± 1.32	0.58	0.19*
weight bearing LT knee reposition error at angle 15°	1.8 ± 1.12	1.19 ± 1.05	0.61	0.12*
weight bearing LT knee reposition error at angle 45	2.82 ± 1.47	2.08 ± 1.13	0.74	0.12*

x̄: mean SD: Standard deviation MD: mean difference

t value: Unpaired t value p value: Probability value *: Non significant

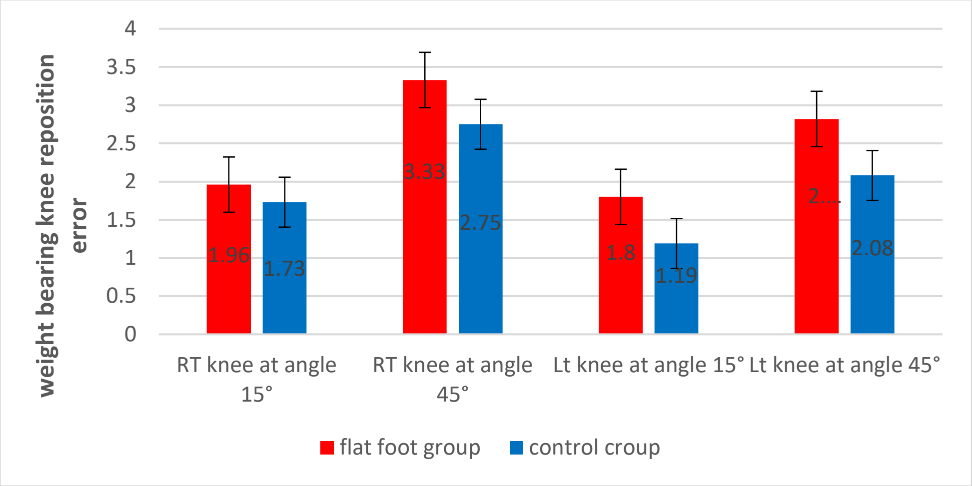


Figure (6): **mean value of knee reposition error of flatfoot and control groups in weight bearing state**

1- Comparison between flatfoot and control groups in non-weight bearing knee reposition error

RT knee reposition error at angle 15°

The mean ± SD Non-weight bearing RT knee reposition error at angle 15° of flat foot group was 3.59 ± 1.66 while that of control group was 1.2 ± 0.87. The mean difference between both groups was 2.38. There was a significant increase in reposition error in the flatfoot group compared with control group (p = 0.0001). (Table 4, figure 7).

RT knee reposition error at angle 45°

The mean ± SD Non-weight bearing RT knee reposition error at angle 45° of flat foot group was 7.37 ± 4.26 while that of control group was 1.96 ± 1.24. The mean difference between both groups was 5.41. There was a significant increase in reposition error in the flatfoot group compared with control group (p = 0.0001). (Table 4, figure 7).

LT knee reposition error at angle 15°

The mean ± SD Non-weight bearing LT knee reposition error at angle 15° of flat foot group was 3.66 ± 2.25 while that of control group was 1.05 ± 0.57. The mean difference between both groups was 2.61. There was a significant increase in reposition error in the flatfoot group compared with control group (p = 0.0001). (Table 4, figure 7).

LT knee reposition error at angle 45°

The mean ± SD Non-weight bearing LT knee reposition error at angle 45° of flat foot group was 7.18 ± 4.96 while that of control group was 1.41 ± 0.88. The mean difference between both groups was 5.76. There was a significant increase in reposition error in the flatfoot group compared with control group (p = 0.0001). (Table 4, figure 7).

Table 4. ***Comparison of mean value of knee reposition error of flatfoot and control groups in non-weight bearing state:***

	Flatfoot group	**Control group**	**MD**	**p-value**	**Sig**
	$\overline{X}$ ±SD	**$\overline{X}$ ±SD**			
non-weight bearing RT knee reposition error at angle 15°	3.59 ± 1.66	1.2 ± 0.87	2.38	0.0001	**S**
non-weight bearing RT knee reposition error at angle 45°	7.37 ± 4.26	1.96 ± 1.24	5.41	0.0001	**S**
non-weight bearing LT knee reposition error at angle 15°	3.66 ± 2.25	1.05 ± 0.57	2.61	0.0001	**S**
non-weight bearing LT knee reposition error at angle 45	7.18 ± 4.96	1.41 ± 0.88	5.76	0.0001	**S**

$\bar{x}$: mean

SD: Standard deviation

MD: mean difference

p value: Probability value

s: significant

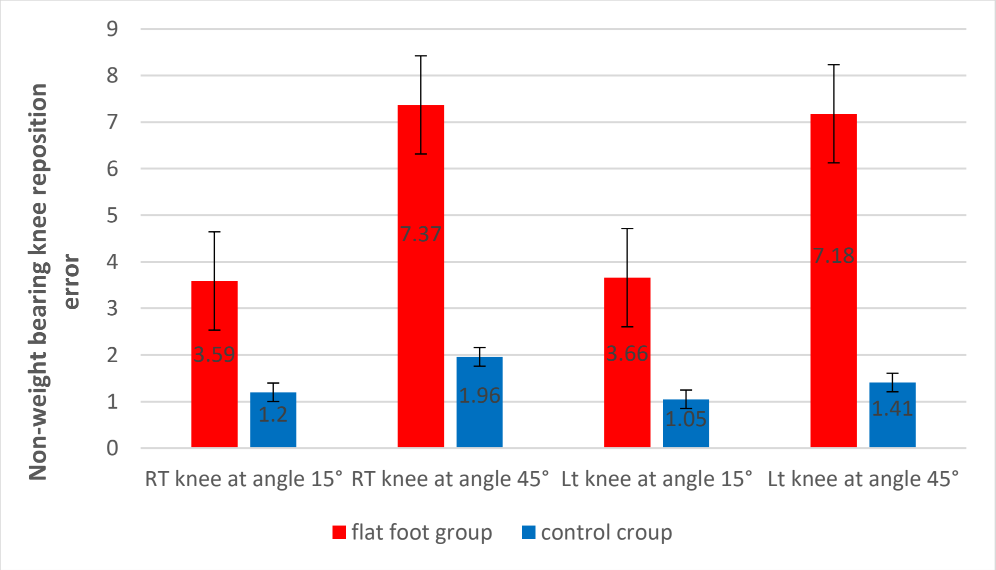


Figure (7): **mean value of knee reposition error of flatfoot and control groups in non-weight bearing state**

2- Comparison between Weight bearing and non-weight bearing knee reposition error in flat foot group

RT knee reposition error at angle 15°

The mean ± SD weight bearing RT knee reposition error at angle 15° was 1.96 ± 0.87 while that of Non-weight bearing was 3.59 ± 1.66. The mean difference between weight bearing and Non-weight bearing was 1.63. There was a significant increase in reposition error in Non-weight bearing state compared with weight bearing state (p = 0.002). (Table 5, figure 8).

RT knee reposition error at angle 45°

The mean ± SD weight bearing RT knee reposition error at angle 45° was 3.33 ± 1.17 while that of Non-weight bearing was 7.37 ± 4.26. The mean difference between weight bearing and Non-weight bearing was 4.03. There was a significant increase in reposition error in Non-weight bearing state compared with weight bearing state (p = 0.0001). (Table 5, figure 8).

LT knee reposition error at angle 15°

The mean ± SD weight bearing LT knee reposition error at angle 15° was 1.8 ± 1.12 while that of Non-weight bearing was 3.66 ± 2.25. The mean difference between weight bearing and Non-weight bearing was 1.86. There was a significant increase in reposition error in Non-weight bearing state compared with weight bearing state (p = 0.0001). (Table 5, figure 8).

LT knee reposition error at angle 45°

The mean ± SD weight bearing LT knee reposition error at angle 45° was 2.82 ± 1.47 while that of Non-weight bearing was 7.18 ± 4.96. The mean difference between weight bearing and Non-weight bearing was 4.35. There was a significant increase in reposition error in Non-weight bearing state compared with weight bearing state (p = 0.0001). (Table 5, figure 8).

Table 5. ***Comparison of mean value of knee reposition error of flatfoot group in weight bearing and non-weight bearing state:***

	weight bearing	**Non-weight bearing**	**MD**	**p-value**	**Sig**
	$\bar{X}$ **±SD**	$\bar{X}$ **±SD**			
RT knee reposition error at angle 15°	1.96 ± 0.87	3.59 ± 1.66	1.63	0.002	**S**
RT knee reposition error at angle 45°	3.33 ± 1.17	7.37 ± 4.26	4.03	0.0001	**S**
LT knee reposition error at angle 15°	1.8 ± 1.12	3.66 ± 2.25	1.86	0.0001	**S**
LT knee reposition error	2.82 ± 1.47	7.18 ± 4.96	4.35	0.0001	**S**

at angle 45°					

x̄: mean SD: Standard deviation MD: mean difference

p value: Probability value s: significant

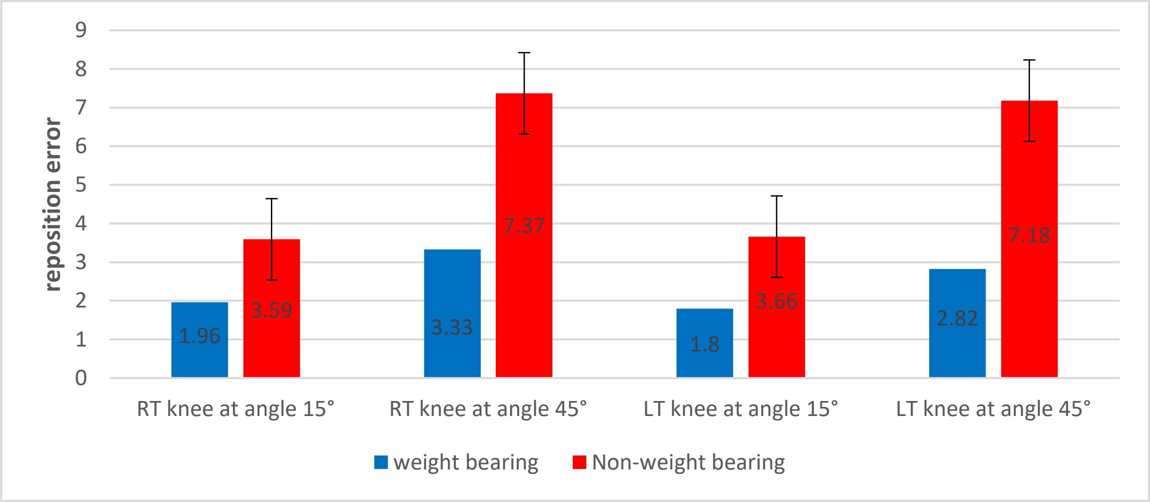


Figure (8): **mean value of knee reposition error of flatfoot group in weight bearing and non-weight bearing state**

DISCUSSION

The current study was conducted to investigate the effect of bilateral flexible flat foot deformity on knee joint proprioception in weight bearing and non-weight bearing state.

Thirty-two subjects participated in the study with age ranged from 18 to 25 years old. Subjects were assigned into two equal groups; each group consists of 16 subjects. Group (A) (the control group) normal subjects and group (B) (the study group) with bilateral flexible flat foot.

Concerning weight bearing knee reposition sense in flatfoot group and control group as there was no significant difference between them, it is suggested that the NWB knee repositioning procedure had the greatest potential for assessing the proprioception of the tested joint only, while whole limb WB provides the chance for proprioceptive feedback from adjacent joints as hip and ankle joints. Possibly, the sensory areas of the brain may use this information in detecting the location of the knee. (Hanafy, 2017)

A similar explanation to locating the knee joint position during WB joint reposition sense testing may arise from the receptors of the tested foot skin. WB may enhance the afferent signals from compressed mechanoreceptors in the connective tissue structures of the WB joints. (Viseux et al., 2019)

Another possible explanation is that foot dorsiflexion and the resulting calf muscle lengthening which occurs during

WB assessment procedures may also play an important rule. As it was concluded by Refshauge and Fitzpatrick that the foot and knee postures, including calf stretch, were the major determinants of the WB and NWB test results.(Refshauge K, 1995). It was previously documented that even a minimum resistance increases the afferent output from muscle spindles, So the greater resistance applied to muscles through WB position may affect the magnitude of muscle contractions that may affect the proprioceptive acuity (Wilson LR, 1997).

The WB position involved use of the main muscle, tendon, and capsular receptors responsible for joint repositioning and proprioception both in and around the knee joint. These receptors are stimulated by muscle contraction, joint movement, and approximation, which were all part of the WB condition so they may augment the afferent signals concerning joint sense.(Andersen, Terwilliger, & Denegar, 1995)

Regarding NWB knee reposition sense in flatfoot group and control group as there was significant difference between them, there was increase in reposition error in flat foot group. A possible explanation is that due to the interactions of the skeletal system, muscular system, and CNS, dysfunction of any joint or muscle is reflected in the quality and function of others, not just locally but also globally. Muscle and fascia are common to several joint segments; therefore, movement and musculoskeletal pathology are never isolated. Because muscles must disperse load among joints and provide proximal stabilization for distal movements, no movement is truly isolated. (Frank, Page, & Lardner, 2009)

The body When viewed as part of a kinetic chain, the distal end of the lower extremity can be an important investigator in the development and maintenance of pathology throughout the body. The foot is a very important area for proprioception as well as for posture and balance. The foot is the most distal segment in the lower extremity chain and represents a relatively small base of support on which the body maintains balance. Although it seems reasonable that even minor biomechanical alterations in the support surface may influence postural-control strategies (Cote et al., 2005)

Another possible explanation is that a pronated foot is an excessive unwinding of the osteo-ligamentous plate. If the foot biomechanically functions in constant pronation as in flatfoot, the entire leg undergoes excessive internal rotation. The internal rotatory stress or position of excessive internal rotation of the leg may result in several possible problems around the knee (knee valgus), including excessive angulation of the patellar tendon and excessive pressure of the lateral patellar facet. Increasing the angle of incidence of the quadriceps muscle relative to the patella (Q angle) will increase the chance of patellar compression problems. The angle of alignment of the quadriceps; a Q angle of ≥ 20º is considered abnormal and creates a lateral stress on the patella. This lead to imbalance between the vastus medialis and lateralis muscles, affect co-contraction pattern between quadriceps and hamstring muscles and may alter afferent signals concerning joint sense (Page, Frank, & Lardner, 2010).

There is limited research on the effectiveness of flat foot on knee proprioception, the results of the current study concerning WB JPS are similar to those reported by Ghiasi and Akbari (Ghiasi & Akbari, 2007), Stillman and McMeeken (Stillman & McMeeken, 2001), Hyouk Bang et al.(Hyouk Bang D, 2015). These authors found significant increase in the JRS errors during NWB testing. The results of the current study are consistent also with those of Andersen et al.(Andersen et al., 1995), who reported that knee joint angles are more accurately repositioned in the closed chain condition. Additionally, this study is also in agreement with the results found by Bunton et al (Bunton, Pitney, Cappaert, & Kane, 1993). Those authors reported that proprioception is improved by WB because of the proprioceptive input produced by Golgi tendon organs, Ruffini endings, Pacinian corpuscles, and muscle spindles. Which may be another explanation for the greater accuracy of WB testing found in this study.

On the other hand, the reported findings are contradicted with those reported by Kramer et al.(Kramer, Handfield, Kiefer, Forwell, & Birmingham, 1997) and Lokhande et al.(Lokhande et al., 2013). These researchers did not find any significant difference between the WB and NWB testing conditions. Additionally, Lokhande et al.(Lokhande et al., 2013) found a significant increase in the JRS testing errors during WB. These contradictions might be attributed to that our study assess knee JPS in flat foot subjects not in normal subjects.

It was concluded from the results of this study that there was no significant difference between persons with flat feet deformity and normal persons concerning reposition sense of knee joint in weight bearing state, but there was significant difference between them in non-weight bearing state.

This study helped to attract the attention to evaluate the patient's whole posture and not to focus on the symptomatic area as foot posture alterations can produce and maintain long term effects on knee joint. When these changes are overlooked, symptoms referred to other parts of the body continue because their cause, being in the feet, has failed to be properly diagnosed and removed. Further studies are required to investigate the effect of bilateral and unilateral flexible and rigid flatfeet on hip proprioception.

CONCLUSION

Weight-bearing proprioception assessment produced more accurate and functionally related results than non-weight bearing assessment in bilateral flexible flatfoot subject when comparing with normal subjects.

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