J. Phys. Ther. Sci. 31: 776–779, 2019

The Journal of Physical Therapy Science

Original Article

Effect of lateral-wedge insole on the center of foot pressure and lower extremity muscle activity at gait initiation in patients with medial knee osteoarthritis

Hiroshi Katoh, RPT, PhD[1)]

[1)] *Department of Rehabilitation, Kyushu University of Nursing and Social Welfare: 888 Tominoo, Tamana-shi, Kumamoto 865-0062, Japan*

Abstract. [Purpose] In clinical settings, patients with knee osteoarthritis often complain of pain at gait initiation. In the present study, we aimed to determine the differences in the center of foot pressure and lower extremity muscle activity at gait initiation in healthy volunteers compared to patients with medial knee osteoarthritis. [Participants and Methods] The study comprised of 10 females without medial knee osteoarthritis (healthy group) and 10 females with medial knee osteoarthritis (medial knee osteoarthritis group). We measured the center of foot pressure trajectory and muscle activity onset times of the tibialis anterior and internal gastrocnemius at gait initiation. Moreover, we examined the effects of insole use in the medial knee osteoarthritis group. [Results] The posterior center of foot pressure displacement was significantly smaller in the medial knee osteoarthritis group (barefoot and insole) than in the healthy group. The anterior center of foot pressure displacement significantly improved with insole use. The muscle activity onset time of the tibialis anterior was significantly delayed in the medial knee osteoarthritis group (barefoot) than in the healthy group. [Conclusion] Postural control decreased at gait initiation in the medial knee osteoarthritis group.

Key words: Knee osteoarthritis, Gait initiation, Insole

(This article was submitted Apr. 24, 2019, and was accepted Jul. 4, 2019)

INTRODUCTION

Medial knee osteoarthritis (me-OA) is characterized by varus knee deformity, and the use of a lateral-wedge insole (insole) is one of the treatment strategies[1)]. According to the Osteoarthritis Research Society International guidelines, the strength of recommendation for insole use in the osteoarthritis treatment is 77%, and the level of evidence is high[2)]. Several studies have been conducted on the effects of insole use during walking; however, only few studies have focused on gait initiation[3, 4)]. Therefore, the present study aimed to investigate the effects of insole use by measuring center of foot pressure (COP) and obtaining a surface electromyogram (EMG) of the lower extremities to determine the cause of pain at gait initiation in patients with me-OA.

PARTICIPANTS AND METHODS

This study comprised 10 healthy females (healthy group) and 10 female patients diagnosed with me-OA (me-OA group). Physical characteristics of the participants are presented in Table 1. The research protocol was reviewed and approved by the ethics committees of Kawasaki Hospital (No. 2005). In addition, all participants were informed of the relevance and purpose

Corresponding author. Hiroshi Katoh (E-mail: hkatosbjpt@gmail.com)

of the research, and they provided consent prior to participation.

The COP trajectory was measured using the center of gravity balance system JK-101 II (Unimec Inc., Tokyo, Japan). The participants were required to stand still on the measuring device. Foot progression angle at gait initiation was set at 10°, and the distance between the foot malleolus was 5 cm. Furthermore, the participants were instructed to gaze at a target placed 2 m ahead. The distance of step length at gait initiation was 40% of the height. The me-OA group performed barefoot gait and gait using insole five times each, whereas the healthy group performed only barefoot gait five times. An insole was made, considering the pain, using low-resilience material with 10-mm lateral elevation, 65-mm width, and approximately 7-degree inclination. The first step of gait initiation was on the right side for both groups. On the basis of resting COP data, we considered that walking was initiated when the value exceeded ± 3 standard deviation (SD). The COP data were calculated as relative distances based on coordinates at gait initiation[5] (Fig. 1).

EMG was obtained using Telemyo DTS (Noraxon Inc., Arizona, USA), and EMG signals from the left tibialis anterior and left internal gastrocnemius muscles, which become the agonist and antagonist muscles at gait initiation, respectively, were obtained using Blue Sensor (P-00-S; Ambu Inc., Copenhagen, Denmark). After appropriate skin preparation, the electrodes were placed 30 mm apart (measured from their centers) on the muscle belly to reduce impedance. According to a previous study[6], muscle activity onset time is defined as the time when an amplitude exceeding ± 3 SD of the EMG amplitude during 1 s at rest is obtained. EMG and COP were sampled at 3 kHz and 100 Hz, respectively, and both measuring instruments were synchronized using the DTS pressure sensor probe.

Statistical analyses were performed using R version 2.8.1. The COP displacement and muscle activity onset time in the healthy group and me-OA group were examined using Tukey's test for multiple comparisons. A p value of <0.05 was considered statistically significant.

RESULTS

The posterior COP displacement was significantly higher in the healthy group than in me-OA group (barefoot and insole) ($p<0.05$; Table 2). The anterior COP displacement at gait initiation was significantly higher in the healthy group than in the me-OA group (barefoot and insole); moreover, this displacement was significantly higher in the me-OA group (insole) than in the me-OA group (barefoot) ($p<0.05$; Table 2).

Table 1. Comparison of basic data of the participants

	Healthy group (n=10)	Knee OA group (n=10)
Height (cm)	153.8 ± 3.0	155.8 ± 3.0
Age (years)	65.4 ± 3.8	68.7 ± 3.2
Weight (kg)	56.7 ± 2.9	63.9 ± 6.3
BMI (kg/m^2)	24.0 ± 0.9	26.3 ± 2.8
K/L grade		III:6, IV:4

Mean ± SD. BMI: body mass index; K/L grade: Kellgren-Lawrence grade.

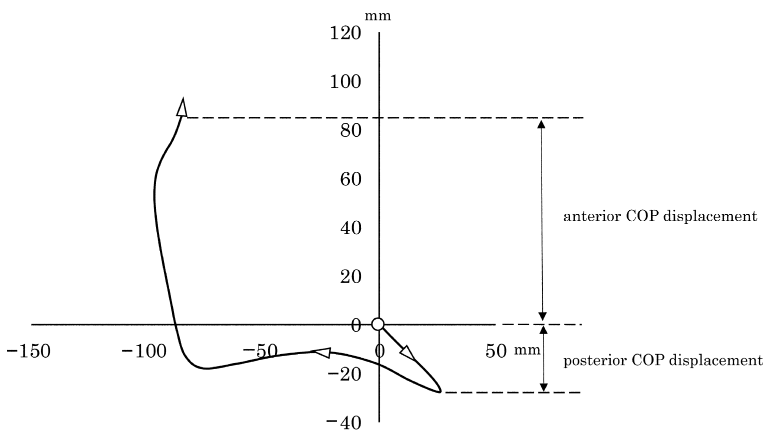

Fig. 1. Definition of COP displacement.
Circle: Starting point of COP trajectory; Triangle: Direction of COP movement; Dashed line: Maximum distance of movement in the posterior and anterior directions from the starting point of COP trajectory.

Table 2. Changes of center of pressure (COP) at gait initiation

	Healthy group	Knee OA group	
		Barefoot	Insole
Posterior COP displacement (mm)	28.7 ± 8.1	19.2 ± 6.2*	17.9 ± 6.3*
Anterior COP displacement (mm)	95.5 ± 12.3	74.2 ± 17.6*	87.2 ± 19.9*†

Mean ± SD. *$p<0.05$ Healty group vs. Knee OA group (barefoot, insole). †$p<0.05$ Knee OA group (barefoot) vs. Knee OA group (insole).

Table 3. Characteristics of muscle activity onset time at gait initiation

	Healthy group	Knee OA group	
		Barefoot	Insole
Tibialis anterior muscle (s)	0.26 ± 0.08	0.42 ± 0.10*	0.37 ± 0.09*
Internal gastroconemius muscle (s)	0.79 ± 0.14	0.81 ± 0.13	0.75 ± 0.14

Mean ± SD. *$p<0.05$ Healthy group vs. Knee OA group (barefoot, insole).

The muscle activity onset time of the tibialis anterior muscle at gait initiation was significantly higher in the me-OA group (barefoot and insole) than in the healthy group ($p<0.05$; Table 3).

The muscle activity onset time of the internal gastrocnemius muscle was not significantly different between the two groups.

DISCUSSION

At gait initiation, COP showed posterior displacement in both the healthy group and the me-OA group. This is one of the posture control functions called reverse reaction[7]. In a previous study, it has been reported that the posterior COP displacement at gait initiation is smaller in elderly people than in young people[8]. In the present study, the posterior COP displacement was smaller in the me-OA group than in the healthy group; moreover, in the me-OA group, only the anterior COP displacement showed increase with insole use. Posterior COP displacement is related to the silent period of the triceps surae muscle, which occurs just before gait initiation[9]. The insole is less effective for the appearance of the silent period. These findings suggest that the postural control function decreased in the me-OA group. The other factors affecting static standing balance include toe muscle strength[10] and plantar sensation[11]. In addition, the insoles reportedly improve body sway[12]. A previous report has shown that a textured insole is more effective in stabilizing the posture than a flat insole suggesting that insole surface shape affects static balance[13]. Considering these reports, the postural control function at gait initiation in the me-OA group reduced because of the decrease in toe muscle strength and plantar sensation. Moreover, insole use may improve dynamic stability in the anterior direction.

EMG analysis revealed a delay in the muscle activity onset time of the tibialis anterior muscle in the me-OA group (barefoot). Furthermore, in line with this finding, Polcyn et al.[7] reported that activation of the tibialis anterior muscle and inhibition of the gastrocnemius muscle simultaneously occur at gait initiation, and this remains constant regardless of age. Further, in a study on the co-contraction index (CCI) of agonist and antagonist muscles at gait initiation, Khanmohammadi et al.[14] reported that the CCI of the tibialis anterior and gastrocnemius muscles is higher in young people than in elderly people. This is considered to be in response to the increase in stability of the ankle joint. Therefore, the delay in the muscle activity onset time of the tibialis anterior muscle in the me-OA group (barefoot) may decrease CCI at gait initiation.

The pain-reducing effect of insoles during gait in patients with me-OA has been recognized[15]. Furthermore, the findings of the present study suggest that it contributes to the improvement in the anterior displacement of COP at gait initiation.

Conflict of interest

None.

REFERENCES

1) Toda Y, Tsukimura N: Influence of concomitant heeled footwear when wearing a lateral wedged insole for medial compartment osteoarthritis of the knee. Osteoarthritis Cartilage, 2008, 16: 244–253. [Medline] [CrossRef]

2) Zhang W, Moskowitz RW, Nuki G, et al.: OARSI recommendations for the management of hip and knee osteoarthritis, Part II: OARSI evidence-based, expert consensus guidelines. Osteoarthritis Cartilage, 2008, 16: 137–162. [Medline] [CrossRef]

3) Hinman RS, Payne C, Metcalf BR, et al.: Lateral wedges in knee osteoarthritis: what are their immediate clinical and biomechanical effects and can these predict a three-month clinical outcome? Arthritis Rheum, 2008, 59: 408–415. [Medline] [CrossRef]
4) Shimada S, Kobayashi S, Wada M, et al.: Effects of disease severity on response to lateral wedged shoe insole for medial compartment knee osteoarthritis. Arch Phys Med Rehabil, 2006, 87: 1436–1441. [Medline] [CrossRef]
5) Sousa AS, Silva A, Santos R: Ankle anticipatory postural adjustments during gait initiation in healthy and post-stroke subjects. Clin Biomech (Bristol, Avon), 2015, 30: 960–965. [Medline] [CrossRef]
6) Cowan SM, Bennell KL, Hodges PW, et al.: Delayed onset of electromyographic activity of vastus medialis obliquus relative to vastus lateralis in subjects with patellofemoral pain syndrome. Arch Phys Med Rehabil, 2001, 82: 183–189. [Medline] [CrossRef]
7) Polcyn AF, Lipsitz LA, Kerrigan DC, et al.: Age-related changes in the initiation of gait: degradation of central mechanisms for momentum generation. Arch Phys Med Rehabil, 1998, 79: 1582–1589. [Medline] [CrossRef]
8) Halliday SE, Winter DA, Frank JS, et al.: The initiation of gait in young, elderly, and Parkinson's disease subjects. Gait Posture, 1998, 8: 8–14. [Medline] [CrossRef]
9) Elble RJ, Moody C, Leffler K, et al.: The initiation of normal walking. Mov Disord, 1994, 9: 139–146. [Medline] [CrossRef]
10) Katayama Y, Senda M, Hamada M, et al.: Relationship between postural balance and knee and toe muscle power in young women. Acta Med Okayama, 2004, 58: 189–195. [Medline]
11) Freeman MA: Soft tissues: a question of balance. Orthopedics, 1997, 20: 827–831. [Medline]
12) de Morais Barbosa C, Bértolo MB, Gaino JZ, et al.: The effect of flat and textured insoles on the balance of primary care elderly people: a randomized controlled clinical trial. Clin Interv Aging, 2018, 13: 277–284. [Medline] [CrossRef]
13) Corbin DM, Hart JM, McKeon PO, et al.: The effect of textured insoles on postural control in double and single limb stance. J Sport Rehabil, 2007, 16: 363–372. [Medline] [CrossRef]
14) Khanmohammadi R, Talebian S, Hadian MR, et al.: Characteristic muscle activity patterns during gait initiation in the healthy younger and older adults. Gait Posture, 2016, 43: 148–153. [Medline] [CrossRef]
15) Felson DT, Parkes M, Carter S, et al.: The efficacy of a lateral wedge insole for painful medial knee osteoarthritis after prescreening: a randomized clinical trial. Arthritis Rheumatol, 2019, 71: 908–915. [Medline] [CrossRef]