

Plantar Pressure Distribution Pattern during Mid-Stance Phase of the Gait in Patients with Chronic Non-Specific Low Back Pain

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Objective: To examine the characteristics of the plantar pressure distribution patterns during mid-stance phase of the gait cycle in subjects with chronic non-specific low back pain and asymptomatic subjects.

Material and Method: Twenty-three males and 17 females with chronic non-specific low back pain and age- and gender-matched asymptomatic subjects walked barefoot along a gait mat at comfortable speed for three trials. The left and right plantar pressure distributions were recorded during mid-stance phase and divided into 12 areas. Descriptive statistics including mean and standard deviation of demographic data and plantar pressure were calculated, and plantar pressure distribution patterns were described.

Results: Mean and standard deviation of numeric pain rating scale of chronic non-specific low back pain group were 4.04 ± 1.58 . The average mean peak pressure of both chronic non-specific low back pain and asymptomatic subjects located at the fifth area (lateral aspect of forefoot) in both feet. However, the modes of the peak pressure of subjects with chronic non-specific low back pain were in the different areas in the left and right feet. The distribution patterns of the average mean peak pressure were not the same in chronic non-specific low back pain and asymptomatic subjects. This altered foot contact in the subjects with chronic non-specific low back pain may be used to avoid pain or to compensate for limited mobility of the lower limbs at pre-swing phase.

Conclusion: At mid-stance phase of walking, the pressures on the plantar surface were unequally distributed in subjects with chronic non-specific low back pain.

Keywords: Plantar pressure, Foot pressure, Low back pain

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Low back pain is a complex condition with an incredibly high rate of recurrence⁽¹⁾. The most common type of low back pain is a non-specific low back pain describing as back pain in which a specific cause i.e., nerve root compression, cauda equina syndrome, etc. or unknown underlying pathology, cannot be identified. Between 60 and 70% of people with low back pain get better within six weeks, and 80 to 90% by twelve weeks⁽¹⁻³⁾. However, a large percentage of people still have some pain or disability after twelve months and progress to chronic non-specific low back pain⁽⁴⁾. In Thailand, there were also reportedly high prevalence rates of low back pain among different occupation groups. The 12 months prevalence was found to be as high as 77% in rice

farmers⁽⁵⁾ and 61.5% in nurse⁽⁶⁾. Interestingly, 95% of rice farmers also had chronic symptom of low back pain⁽⁵⁾. Possible reasons for persistence of low back pain include inadequate rehabilitation, re-injury, clinical complication, undiagnosed pathology, or referral from remote body structure. To manage the patients with chronic low back symptom, those causes have to be assessed.

In terms of biomechanical perspective, impairments that contribute to chronic non-specific low back pain include inadequate shock absorption during walking or excessive foot pronation and sagittal plane blockage that alters spinal loading^(7,8). Plantar pressure measurement is a biomechanical measure of foot pressure distribution. This measurement is used to diagnose and manage conditions related to the foot, gait pathologies and other musculoskeletal disorders such as lower extremity pain and low back pain⁽⁸⁾. Plantar pressure measurement assesses the effects of structural changes resulting from abnormal biomechanics in lower extremity kinetic chain. Plantar

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pressure has been widely used to assess patients in various conditions⁽⁹⁻¹²⁾. A few studies of plantar pressure distribution have been reported in patients with low back pain^(13,14). The findings have demonstrated plantar pressure distribution only in specific low back pain. However, plantar pressure distribution in chronic non-specific low back pain has not been fully investigated.

The objective of this study was to investigate the characteristics of the plantar pressure distribution patterns in subjects with chronic non-specific low back pain and asymptomatic subjects during mid-stance of gait.

Material and Method

This study is a cross-sectional study designed to investigate the plantar pressure distribution of subjects with chronic non-specific low back pain and asymptomatic subjects. Eighty subjects, 40 subjects with chronic non-specific low back pain and 40 asymptomatic between 20 and 45 years of age, were recruited. Subjects in both groups were matched by age and gender. The subjects with chronic non-specific low back pain were diagnosed by a physician or a physical therapist if they had low back pain with constant, intermittent or recurrence symptoms longer than three months. The age and gender matched asymptomatic subjects did not have low back pain for six months prior to participating to this study. The range of ± 5 years of age was considered as matched range. Subjects with the following criteria were excluded, specific low back pain, observable foot abnormalities or deformities, pregnancy, implantation of artificial joints or other biomedical devices of the lower extremity, any condition resulting in neurological deficits, history of fracture or surgery of lower extremity or spine, red flag disorders (cancer, infection, inflammatory joint disorders such as rheumatoid arthritis and gout, and severe systematic disease), or lack of physical or mental ability to complete the study procedure. All procedures and methods were approved by Mahidol University Institutional Review Board (MU-IRB COA. NO.2011/131.1710). A clinical examination was conducted by a qualified physical therapist to screen the subjects according to the inclusion and exclusion criteria.

The subjects who passed the screening process gave their consent. The body weight and height of each subject were measured. Leg length was measured from the tip of the greater trochanter to the

ground through the lateral malleolus in upright standing position⁽¹⁴⁾. The subjects with chronic non-specific low back pain had recorded the pain duration, pain intensity on a numerical rating scale (NRS) and their function using Thai Modified Oswestry Low Back Pain Disability Questionnaire (TMODQ)⁽¹⁶⁾. The TMODQ is a common self-reported disability questionnaire. It has been used as a treatment outcome measurement for low back pain patients. The questionnaire comprises 10 items questioning pain intensity associated with the impact of activity daily living. Each item scored from 0 to 5 with higher values indicating more severe impact. The test-retest reliability of this scale was reported to be good⁽¹⁶⁾.

Average mean peak pressure showed the average mean of the highest pressure in any areas of the planar surface.

The mode of the average mean peak pressure showed the most frequency of highest pressure in any areas of the planar surface.

Procedure

All subjects were then asked to walk barefoot along the gait mat system (The GAITRite system CIR Systems Inc., Peekskill, NY), at their comfortable walking speed for three trials with a 1-minute rest between trials⁽¹⁵⁾ to measure plantar pressure distribution. During mid-stance phase, using data when the foot fully contacted with the walking surface, the plantar pressure on gait mat system was divided into twelve areas as shown in Fig. 1.

Statistical analysis

Mean and standard deviation (SD) of demographic data were calculated, and independent sample t-test was used to determine comparability between chronic non-specific low back pain and asymptomatic groups. Descriptive statistics of plantar pressure data were also calculated, and plantar pressure distribution patterns were described.

Results

Each group of subjects composed of 23 males (57.5%) and 17 females (42.5%). The characteristics of the subjects were shown in Table 1. The age, height, weight, and leg length were not statistically different between subjects with chronic non-specific low back pain and asymptomatic subjects. In the chronic non-specific low back pain group, the patients reported pain intensity from 1 to 7 out of 10 with the duration of pain from three months to seven years. The TMODQ scores

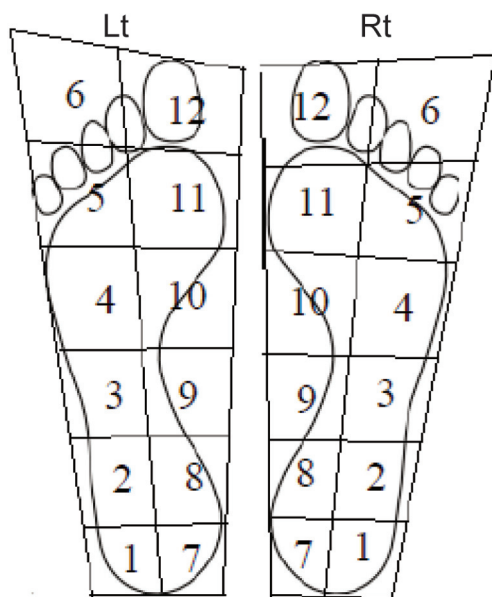


Fig. 1 The area of plantar surface of the left and right foot

were reported at 12.15 ± 7.12 points that indicated the subjects with chronic non-specific low back pain had mild functional limitation in activities of daily life. The plantar pressure distribution patterns in chronic non-specific low back pain group were not differed from those in asymptomatic group (Fig. 2). The average mean peak pressure was highest in the fifth area in both groups for both feet.

The highest frequency of subjects who had greatest pressure in different areas of the planar surface was shown in Fig. 3. In chronic non-specific low back pain group, the left foot had the mode of the average

mean peak pressure in the seventh area (37.5%), while the right foot had mode in the fifth area (35%). The second most frequent areas of average mean peak pressure were the fifth area (32.5%) in the left foot and the seventh area (22.5%) in the right foot. In contrary, asymptomatic group had the mode of the average mean peak pressure in the fifth area in the left (25%) and right (62.5%) feet. The second most frequent were the seventh area (22.5%) in the left and the second (10%), and eleventh areas (10%) in the right foot.

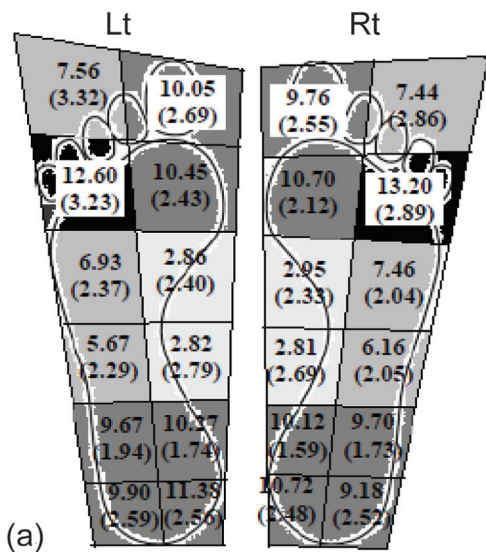
Discussion

This study investigated the plantar pressure distribution patterns in subjects with chronic non-specific low back pain during mid-stance of gait. The average mean peak plantar pressure was in the lateral aspect of the forefoot in both groups (Fig. 2). This finding is similar to the results of Lee et al⁽¹⁴⁾ who reported the plantar pressure distribution in subjects with specific low back pain. The results also showed the mode of average mean peak pressure at the fifth area in mid-stance phase for both feet in the asymptomatic group and the right foot of the subjects with chronic non-specific low back pain groups while the left foot appeared to be the area of second most frequent distributed (Fig. 3). Subjects in chronic non-specific low back pain group had an altered foot pressure distribution possibly to avoid pain or discomfort during mid-stance phase⁽¹⁷⁾. Another possible explanation for these distribution pattern changes may be related to limited range of motion in the lower limb impeding the pre-swing phase⁽⁴⁾. In that situation, the plantar pressure would be transferred to the lateral aspect of forefoot. In contrast, during the

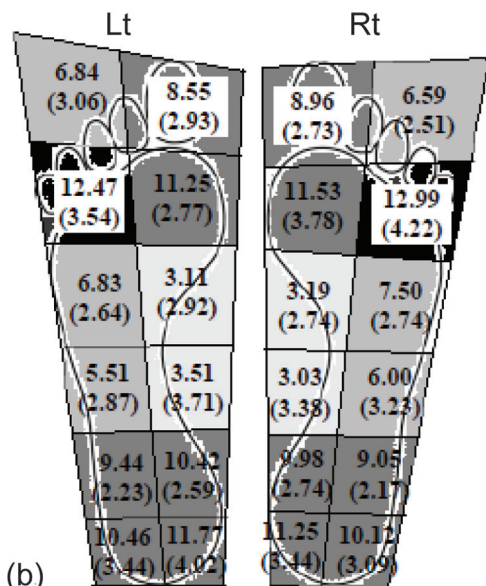
Table 1. The subjects' characteristics

Characteristic	CNLBP		Asymptomatic		p-value
	Mean \pm SD	Min, Max	Mean \pm SD	Min, Max	
Age	29.08 \pm 6.77	21.0, 44.0	28.43 \pm 5.99	21.0, 44.0	0.65
Height (cm)	166.10 \pm 9.45	150.0, 183.0	166.05 \pm 3.40	150.0, 186.0	0.98
Weight (kg)	63.35 \pm 15.06	31.0, 103.0	61.34 \pm 13.51	40.0, 95.0	0.53
Lt. leg length (cm)	84.13 \pm 4.86	73.0, 94.0	84.40 \pm 4.43	76.0, 95.0	0.79
Rt. leg length (cm)	84.13 \pm 4.86	73.0, 94.0	84.40 \pm 4.43	76.0, 95.0	0.79
Pain duration (years)	1.61 \pm 1.58	0.3, 7.0	-	-	-
Pain intensity (NRS)	4.04 \pm 1.58	1.0, 7.0	-	-	-
TMODQ Score	12.15 \pm 7.12	0, 28.0	-	-	-

CNLBP = Chronic non-specific low back pain; SD = standard deviation; Min = minimum; Max = maximum; Lt. = left; Rt. = right; NRS = numeric rating scale; TMODQ Score = Thai Modified Oswestry Low Back Pain Disability Questionnaire Score



(a)

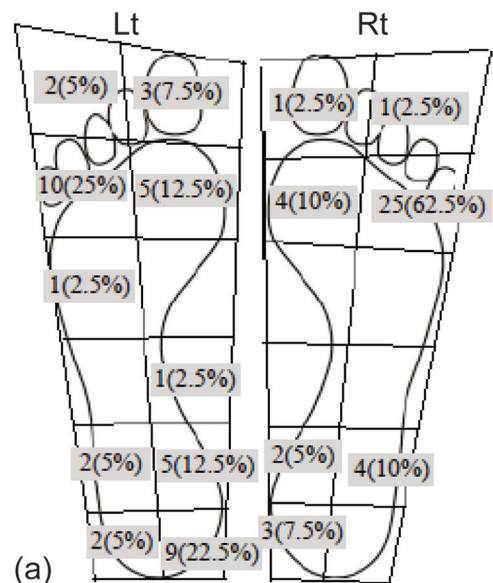


(b)

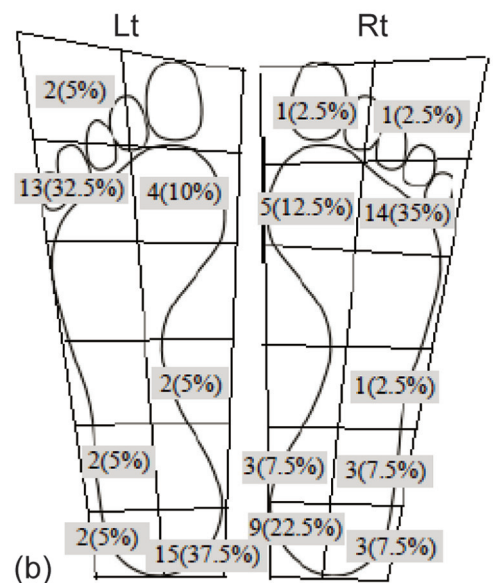
Fig. 2 The average mean peak pressure (kPa) of each area of the foot of (a) asymptomatic subjects and (b) subjects with chronic non-specific low back pain.

mid-stance phase in asymptomatic group, the forefoot pressure was observed under the second or third metatarsal head.

Understanding plantar pressure distribution patterns during mid-stance phase will be beneficial in the evaluation of mechanical changes in patients with chronic non-specific low back pain. Examining plantar pressure distribution during mid-stance phase could provide better understanding of abnormal lower limb



(a)



(b)

Fig. 3 The frequency of average mean peak pressure of each area (a) asymptomatic subjects and (b) subjects with chronic non-specific low back pain.

mechanics that alter loading pattern in the spine. However, patients with chronic non-specific low back pain might be treated without considering the cause outside the area of back. This might result in unresponsiveness and causing the pain to become chronic. The results of this study imply that the abnormal plantar pressure distribution would need to be adjusted to manage the abnormal lower limb mechanics, which could transfer into the spine by gait

training. Consequently, gait analysis and gait training are considered one of the choices of assessment and treatment for patients with chronic non-specific low back pain.

There were some limitations of this study. First, the gait characteristics of some subjects were not the nature of them, although they had a practice trial until they walked naturally before actual data collection. Another was that some subjects with chronic non-specific low back pain have history of lower limb injuries or deformities, especially foot deformities although we tried to monitor these during screening. These limitations could influence on the interpretation of our results. Therefore, replication of this study is needed.

Conclusion

The pressures on the plantar surface were unequally distributed in subjects with chronic non-specific low back pain among areas in the same foot. Gait analysis and gait training might be considered for assessing and treating patients with chronic non-specific low back pain.

What is already known on this topic?

Plantar pressure distribution is already known in specific pathology and deformity such as Diabetes Mellitus, Rheumatoid Arthritis of foot, obese, or specific low back pain.

What this study adds?

This study adds the knowledge about plantar pressure distribution patterns in patients with chronic non-specific low back pain.

Acknowledgements

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Potential conflicts of interest

None.

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แรงกดเท้าระหว่างช่วงมิดสแตนด์ของการเดินในคนปวดหลังเรื้อรังแบบไม่จำเพาะ

เกียรติพร อนุกุลการย์, มัชฌานา วงศ์ศิริวินรัตน์, สุนีย์ บวรสุนทรชัย, รุ่งทิพา วัจฉละจิตติ

วัตถุประสงค์: การกระจายของแรงกดเท้าระหว่างช่วงมิดสแตนด์ของการเดินในผู้ที่มีอาการปวดหลังเรื้อรังแบบไม่จำเพาะเมื่อเปรียบเทียบกับผู้ที่ไม่มีอาการปวดหลังอาจเกิดไม่เหมือนกัน การศึกษาในครั้งนี้ทำเพื่อศึกษาลักษณะการกระจายของแรงกดเท้าระหว่างช่วงมิดสแตนด์ของการเดินในผู้ที่มีอาการปวดหลังเรื้อรังแบบไม่จำเพาะและในผู้ที่ไม่มีอาการปวดหลัง

วัสดุและวิธีการ: ผู้เข้าร่วมการศึกษาคู่ละกลุ่มประกอบด้วยชาย 23 คน หญิง 17 คน ผู้เข้าร่วมการศึกษามีอาการปวดหลังเรื้อรังแบบไม่จำเพาะ และที่ไม่มีอาการปวดหลังที่มีอายุเท่ากันและเพศเดียวกันเดินเท้าเปล่าบนเครื่องวิเคราะห์การเดินด้วยความเร็วที่ผู้เข้าร่วมการศึกษารู้สึกสบาย 3 รอบ ระหว่างการเดินแรงกดเท้าซ้ายและขวาจะถูกบันทึก และแบ่งเป็น 12 ส่วน จากนั้นนำไปคำนวณหาค่าเฉลี่ยเลขคณิต ส่วนเบี่ยงเบนมาตรฐาน และอัตราร้อยละ

ผลการศึกษา: ระดับความเจ็บปวดของกลุ่มผู้เข้าร่วมการศึกษามีอาการปวดหลังแบบไม่จำเพาะเท่ากับ 4.04 ± 1.58 แรงกดเท้าที่สูงสุดของทั้งสองกลุ่มอยู่ในบริเวณที่ 5 (ด้านนอกของเท้าส่วนหน้า) ของเท้าทั้งสองข้าง อย่างไรก็ตามฐานนิยามของแรงกดเท้าสูงสุดในกลุ่มผู้เข้าร่วมการศึกษามีอาการปวดหลังแบบไม่จำเพาะอยู่ต่างบริเวณกันในเท้าซ้ายและขวา การกระจายของแรงกดเท้าสูงสุดแตกต่างกันในผู้ที่มีอาการปวดหลังเรื้อรังแบบไม่จำเพาะและในผู้ที่ไม่มีอาการปวดหลัง อาจเป็นกลไกของร่างกายที่ผู้ที่มีอาการปวดหลังเรื้อรังแบบไม่จำเพาะใช้เพื่อหลีกเลี่ยงอาการปวดหรือเพื่อชดเชยช่วงการเคลื่อนไหวที่จำกัดระหว่างช่วง *preswing*

สรุป: ระหว่างมิดสแตนด์ของการเดิน แรงกดเท้ามีการกระจายที่ไม่เท่ากันในผู้ที่มีอาการปวดหลังเรื้อรังแบบไม่จำเพาะ
