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Research Article

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Unstable structure impact on external knee adduction moment

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ABSTRACT

Osteoarthritis (OA) of the knee is one of the most common diseases. For this chronic disease, modified sole structure can effectively prevent and relieve disease of the knee. The aim of this study is to explore the influence of unstable shoe with different stiffness on ground reaction force and external knee adduction moment. 17 healthy female volunteers were recruited, and every subject performed five walking trials in three shoes condition. The results showed that external knee adduction moment was decrease in all stance phase using soft unstable sole. The ground reaction force has no obvious changing between two shoes condition. The unstable shoes of this study mainly create instability in the medial-lateral direction and lead to external knee adduction moment increase.

Keywords: Unstable shoes, stiffness, knee joint, adduction moment

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INTRODUCTION

Osteoarthritis (OA) of the knee is one of the most common diseases. Cause of knee OA is that the medial of knee under the high load (60-80%) in the process of walking in our daily life. Previous studies said that patients with knee OA often accompanied by high angle of knee adduction, eventually lead to the knee medial surface stress increased accordingly. More studies have shown that excessive knee abduction moment would also lead to the produce of the medial knee osteoarthritis. The increase of knee adduction moment and abduction moment will affect the medial of the knee joint, The increase of the loading on knee medial will leads to excessive load on the surface of the knee joint cartilage unbearable degradation and irreversible loss of articular cartilage, eventually led to the decrease of the range of motion, pain or stiffness. Therefore, effective control and relieve knee lesions can mitigate the effects of knee OA in walking and daily activities. Total knee replacement or high tibial osteotomy has been shown to be effective in subjects with severe knee OA, However, it takes a very expensive surgery even the invasive damage. Therefore, conservative treatments are becoming popular. Current conservative treatments can be divided into lateral wedge insoles, subtalar strapping of those 7 methods. These conservative treatment methods are by means of assistive devices to improve walking or running gait. By a modification of the shoes can effectively reduce the knee adduction moment. Prior studies have summarized 348 such documents, and the results show that it will be effectively reduced the first peak of adduction moment by adding a lateral wedge insole during walking

With the development of research on footwear, it was discovered that in unstable shoes also can alleviate the pain. NIGG et al indicated that wearing MBT can relieve mild golfers back pain slightly [14], and it can effectively reduce the pain of patients with knee OA after a period of wear. Therefore, some researchers began to study the effects on knee while wearing MBT shoes. Nigg et al [16] and Buchecker[17] reported that wearing unstable shoes can reduce knee moment. Instrumented knee implants with telemetric data transmission were used to measure the tibiofemoral contact forces and moment during walking with four different shoes compared to those during barefoot walking, The results showed that Significant reductions of the resultant force were solely observed for the advanced running shoe and the MBT shoe at late stance. Such studies described above shows that wearing unstable shoes can reduce knee moment.

The foot is an integral component of the lower limb closed kinetic chain and its position and motion influence knee load. Because of this, shoes can increase or decrease knee load depending on their design features[20]. Because the effect of the benefits brought by this instability, Amir Haim et al. [21] added two removable unstable elements in Forefoot and rear foot area to modify the center of pressure during gait in order to reduced knee adduction moment, but the unstable elements used in the experiments is the same material, Whether different hardness of unstable elements can also reduce the knee adduction moment is still unknown. The aim of this study is to explore the influence of unstable shoe which add different stiffness unstable element on forefoot and rear foot with on external knee adduction moment changing.

EXPERIMENTAL SECTION

Seventeen subjects participated in this study, with the mean age, height and mass being 22.4 ±3.2 years, 161.2±5.8 cm and 60.6±7.2kg, respectively. Each of the 17 subjects had no previous experience wearing unstable shoes, no lower extremity injury or major pain duration of test, no previous major surgery to lower extremity or back and no evidence of arthritis, diabetes or neuromuscular condition.

A comprehensive three-dimensional gait analysis was performed on all subjects, for two footwear conditions. For all testing visits, subjects had their gait measured while walking in a soft unstable shoe and a hard unstable shoe. The unstable shoe was adjunction unstable element on forefoot and rear-foot of control shoe (figure 1).

Figure 1.Unstable shoe and position of unstable element

The materials of unstable element was rubber and Elastic modulus was measured by the elastic modulus test system (INSTRON AG Grove USA), height was 15mm[21,22]. Unstable element was hemispheric and induced medial-lateral direction instability on single-support phase.

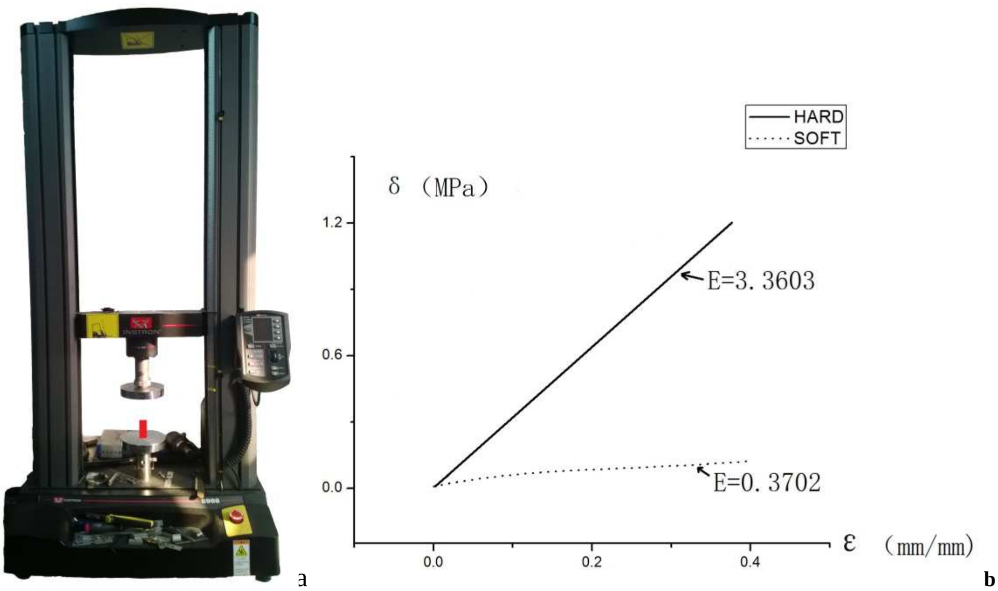

Figure 2.Material test system. B: condense elasticity modulus of two unstable elements

During the subjects visit to the laboratory and before making any measurements, subjects were instructed on how to properly stand and walk in the unstable shoe and were then given approximately 10 min to get accustomed to the unstable nature of the shoes. Every subject perform five walking trails in two shoes condition, two kinds of experiment shoes were unstable shoe (soft) and unstable shoe (hard), the experimental shoes was random selection. Subjects performed five walking trials in the soft unstable shoe and hard unstable shoe, with the order being randomized between the two footwear conditions for both visits. Infrared timing gates were used to guide the subjects to walk at 1.5±0.5 m/s and only the stance phase for the right foot landing of each trial was used for the analyses. Kinematic data were obtained with eight high-speed cameras at 250 Hz (Vicon Oxford Metrics Limited UK) system was calibrated allowing a three-dimensional residual error 0.5mm. Before testing, three retro-reflective markers were attached each segment of lower limbs. The markers attached with a divided into two groups. A group of makers attached with pelvis (four)：lift and right anterior superior spine, lift and right posterior superior iliac spine；another group of markers attached with lower limb (twelve): lift and right knee, lift and right thigh, lift and right shank, lift and right ankle, lift and right toe, lift and right heel. In order to distinguish between left and right sides, the markers of right thigh was slightly lower than lift thigh. Kinetic data were collected at 2400 Hz with a Kistler force platform (Kistler Instrumente AG, Winterthur, Switzerland). During the experiment two experimental apparatus was synchronous collected data. The collected data were exported into Vicon nexus 1.8.1 (Oxford Metrics Limited UK), with the kinematic and kinetic data being filtered low-pass Butterworth filter with cut-off frequencies of 12 and 50 Hz, respectively. The internal joint moments were calculated with inverse dynamics using the anthropometric, ground reaction force and motion data.

Statistical analysis use spss17.0 software, paired sample t-test was used to analysis significance of peak knee adduction moment. The level of significance was set at $\alpha=0.05$ to identify statistically significant differences between the two shoe conditions.

RESULTS

For the stance phase of the gait cycle, joint adduction moment and resultant ground reaction force mean ensemble average waveforms are shown for the right knee (Figure 4,5) for two footwear conditions (unstable shoe with soft element and unstable shoe with hard element).

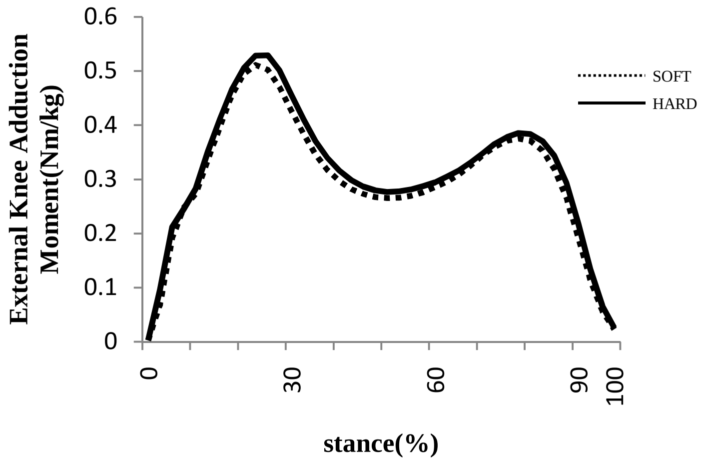

Figure 4.Mean knee joint moment waveforms for the stance phase while walking in a soft unstable shoe and a hard unstable shoe

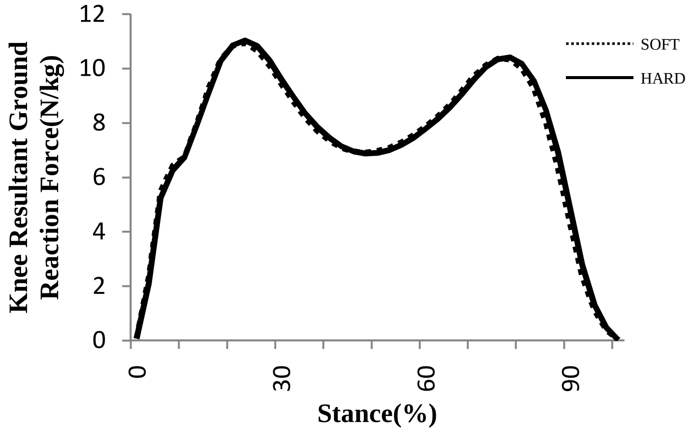

Figure 5.Mean resultant ground reaction force waveforms for the stance phase while walking in a soft unstable shoe and a hard unstable shoe

Table 1. Mean and SD of the analyzed biomechanical variables for the two shoes condition and *p* value

Variable	Soft	Hard	*P* value
First peak knee adduction moment(Nm/kg)	0.51±0.11	0.53±0.12	0.33
Second peak knee adduction moment (Nm/kg)	0.38±0.04	0.39±0.02	0.39
Trough knee adduction moment(Nm/kg)	0.26±0.04	0.27±0.04	0.35
First peak knee Resultant Ground Reaction Force(N/kg)	10.92±0.36	11.08±0.43	0.78
Second peak knee Resultant Ground Reaction Force(N/kg)	10.22±0.60	10.24±0.92	0.89
Trough knee Resultant Ground Reaction Force(N/kg)	6.94±0.95	6.89±0.86	0.63

The comparison of the soft unstable shoe and hard unstable shoe condition indicated that the first peak external knee adduction moment of soft unstable shoe was decrease (Figure 4 and Table 1). During the mid-stance external knee adduction moment of soft unstable shoe was showed slightly decrease and the second external knee adduction moment was also showed slightly decrease (Figure 4 and table 1).The resultant ground reaction force of three shoes condition in all stance phase exhibited no statistically significant differences (Figure 5 and Table 1).

DISCUSSION

The aim of this study was to investigate the differences of knee joint moments and ground reaction force for different hardness sole unstable shoes. Various design factors of footwear such as heel width, arch support, sole shape, flexibility or cushioning might influence joint loading [19]. This study focused on changes in the knee adduction moment and ground reaction forces under the conditions of different hardness soles. The comprehensive three-dimensional gait analysis show that the first and the second peak external knee adduction moment of soft unstable shoe was lower than the hard unstable shoe, While the trough knee adduction moment was decrease when wearing a soft unstable . Scott C. Landry et al. have shown that the decrease of the knee adduction moment mainly appears in the early stance when wearing MBT shoes [18], soft unstable is the closest one with MBT in this study. During the heel-strike external knee adduction moment of soft unstable shoe was showed slightly decrease Compared with the hard unstable shoe, it may be due to the foot heel of unstable shoes is the soft hemicycle structure, During the heel-strike greater compressive deformation occurred in the soft unstable shoe and reduce the activity of the knee joint coronal In the process of the land, and thus reduce the knee adduction lever, at the same time, soft material and the material of MBT shoes foot heel similar help buffer. MBT footwear instability arises mainly in the longitudinal direction, Shoes are used in this study, instability arises mainly in the horizontal, This is similar to the Easy Tone[25] .Therefore in the mid - stance knee joint Angle change on the surface of the coronary increases, knee adduction moment is relatively increase while wearing MBT. During the toe-off external knee adduction moment of soft unstable shoe was also slight decrease compared with the hard unstable shoe. Its principle may be consistent with the foot heel position of unstable elements, but not reduce the size of the heel-strike. While the unstable element added on the rear foot and the forefoot is the same specification, but the forefoot unstable element for the impact of the knee joint is relatively smaller. Haim used the Apos System, which is a foot-worn platform with a specially designed sole that is capable of attaching to two different heights movable rubber convex elements, Long-term wearing shoes with this system can effectively improve the symptoms of knee osteoarthritis. Although this study has changed the unstable element of hardness, choose only the middle position and add the unstable element of the same height. Future studies can add unstable elements of different locations and highly on the basis of hardness further analysis. The resultant ground reaction force of three shoes condition in all stance phase exhibited no statistically significant differences. However, previous studies have shown that there is a slight increasing in the ground reaction force when wearing MBT shoes compared to barefoot and wearing ordinary shoes, The high ground reaction force will increase the risk of injury , and the unstable shoe structure on anteroposterior accelerating the speed of walking when wearing MBT shoe, thus the momentum of distal joints increases, so as to increase the ground reaction force. And the experimental shoes chosen in this study is unstable shoes with different hardness without ordinary shoes, which can do the further study in the later research. While the two unstable shoes in this experiment mainly provided the lateral instability, Easy Tone experimental conditions similar to the experiment, his results show that the ground reaction force seems to have a rising trend in the early stance, but did not give a certain answer. But up to the present, the unstable shoes structure will not significant effects on the ground reaction force.

CONCLUSION

The shoes with lateral instability will increase the activity of the knee joint in the process of walking and it will increase the knee adduction moment, compare to hard unstable shoe walk in soft unstable shoe the external knee adduction moment was decrease in all stance phase. The unstable element attached to the forefoot has more significant effect on the knee compared with the rear-foot during the gait cycle. There was no significant change of the ground reaction force under the two experimental conditions.

REFERENCES

REFERENCES

[1] S Ahlback,*ActaRadiologica: Diagnosis*, **1968**, 277, 7–72.
[2] DT Felson; EL Radin, *Journal of Rheumatology*, **1994**, 21(2),181–183.
[3] JT Dearborn; CL Eakin; HB Skinner, *AmericanJournal of Orthopedics*, **1996**, 25(1),18–26.
[4] KR Kaufman, *Journal of Biomechanics*, **2001**, 34(7), 907–915.
[5] AJ Baliunas, *Osteoarthritis and Cartilage*, **2002**, 10(7), 573–579.
[6] J Martel-Pelletier, *Clinical Rheumatology*, **2008**, 22(2), 351–384.
[7] JA Buckwalter, *Clinical Orthopaedics and Related Research*, **2001**, 385, 36–45.
[8] TB Birmingham, *Arthritisand Rheumatism*, **2009**, 61(5), 648–657.
[9] CFukuchi, *Footwear Science*,**2009**, 4(3), 206-212
[10] W Kakihana; M Akai; K Nakazawa; T Takashima; K Naito; S Torii, *Arch Phys Med Rehabil*, **2005**, 86, 1465-1471.
[11] RJ Butler; S Marchesi; T Royer; IS Davis, *J Orthop Res*, **2007**, 25, 1121-1127.
[12] Y Kuroyanagi; T Nagura; H Matsumoto, *Osteoarthritis Cartilage*,**2007**, 15, 932-936.
[13] AO Radzimski, *The knee***2012**, 19. 163-175.
[14] B Nigg, *Footwear Science*,**2011**,6, 121-122.
[15] BNigg, *Clinical sciences*, **2006**,15, 1701-1708.
[16]B Nigg;S Hintzen;R Ferber, *Clinical Biomechanics*,**2006**, 21 (1), 82–88.
[17]L Yin; QC Mei; MR Graham; YD Gu, *JOCPR*, **2014**, 6(1), 645-649.
[18]SC Landry;BMNigg,*Footwear Science*, **2012**, 4(2),101-114.
[19] IKutzner; D Stephan, *Journal of Biomechanics*, **2013**, 46, 796-800.
[20] KLBennell, *Osteoarthritis and Cartilage*, **201**2, 20, 16-22.
[21] A Haim; G Rubin, *Journal of Biomechanics*,**2012**, 45, 41-45.
[22] EM Debbi; A Wolf; A Haim,*Journal of Biomechanics*, **2012**, 45, 1366-1371.
[23] M Taniguchi;H Tateuchi, *Gait & Posture*.**2012**, 35, 567-572.
[24] T Stöggl;AHaudum, *Clinical Biomechanics*,**2010**,25, 816-822.
[25] BHorsak;A Baca, *Clinical Biomechanics*, 2013, 28, 344-349.
[26] A Haim;G Rubin;N Rozen;YGoryachev;A Wolf, *Journal of Biomechanics*, **2012**, 45, 41–45.
[27] CN Isabel;CD Sartor, *Gait & Posture*, 2012, 36, 312–315.
[28] CE Milner;R Ferber;CD Pollard;J Hamill;IS Davis, *Med Sci Sports Exerc*, **2006**, 38, 323-328.