

The Kinesiological Effect of Japanese Geta Clogs on Gait: A Pilot Study

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Abstract. The purpose of this study was to investigate the function of Japanese Geta clogs. We measured the foot pressure and the distance between the Geta and the heel. An F-scan and three-dimensional motion analyses were done. Toe pressure increased in the stance phase at toe-off, and we confirmed that heel-Geta contact is present at the beginning of swing phase. The distance between the Geta and the heel increased from heel-off to toe-off and decreased from toe-off to mid-swing. The results suggest that active toe movement occurs during Geta gait, and the use of Geta clogs may contribute to preventing foot disorders and falls. Geta may be useful for foot and toe strengthening.

Key words: Geta clogs, Three-dimensional motion analysis, Fall prevention

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INTRODUCTION

Japan is rapidly becoming an aged society. A major problem is that many older people are becoming bedridden due to decreased walking, balance, and strength, leading to falls. Falling is a predominant cause of people becoming bedridden. The prevention of falling has been studied from many aspects.

In addition, Handa et al.¹⁾, who studied static balance, and Kabe et al.²⁾, who studied dynamic balance, reported that the strengthening of the toes may improve walking ability and decrease the risk of falling. We also believe that toe strengthening is important for maintaining balance and preventing falls, and proper footwear may promote toe strengthening. In Japan, Geta clogs are used often by men performing martial arts, such as Sumo wrestlers and Judo wrestlers, who probably hope to strengthen their toes by doing so.

The Geta are wooden clogs that one slips onto the

foot and fastens by a strap (Fig. 1). Geta were worn often by footwear for the Japanese 50 years ago, until sneakers and shoes came into fashion, caused by the Western influence in the change in clothes, etc. Other studies⁵⁾ have concluded that shoes that do not fit properly cause foot disorders, such as hallux valgus. Therefore, in our study, we aimed to improve the feet and toes through the use of Geta. In a previous study³⁾, we made a modified Geta to use for promoting foot and toe health. Then we performed several research projects on the various effects⁴⁾. Although it is known that Geta are good for foot health, little is known about the mechanisms involved. Therefore, the purpose of this study was to investigate the mechanisms involved in foot health promotion of the Geta clogs.

METHODS AND SUBJECTS

Subjects

We divided 15 subjects into two groups and



Fig. 1. Geta and Markers. We measured the distance between the Geta marker and ankle marker (G-H distance).

performed two separate experiments.

a) Foot pressure group

Five normal persons (5 males) participated in this study. Their mean age was 34 ± 7 years.

b) The three-dimensional motion analysis group

Ten normal persons (10 males) participated in this study. Their mean age was 24.70 ± 9.41 years.

Foot pressure samples were collected, and the distance between the Geta and the heel was measured by using a computer. Informed consent was obtained from all subjects.

Data collection

a) F-scan (Fig. 2)

An F-scan (Nitta, Inc) was used to assess foot pressure during walking and to determine how and how much the foot and Geta come in contact. This system consists of thin sensor sheets (0.15 mm), a computer, and an interface for the computer. The F-scan's sensor sheets were placed on the surface of the Geta when the foot pressure was investigated. The F-scan data was collected at 60 Hz.

b) Three-dimensional motion analysis (Fig. 3)

A VICON 512 three-dimensional motion analysis system (Oxford Metrics, Ltd) and the VICON Clinical Manager (VCM) software were used to capture and analyze the three-dimensional distance between the Geta and the heel (G-H distance), to verify foot and Geta contact, and to determine when the contact occurred during the stance and swing phases. The system includes 4 cameras, 2 force plates, a computer, and the interface for the

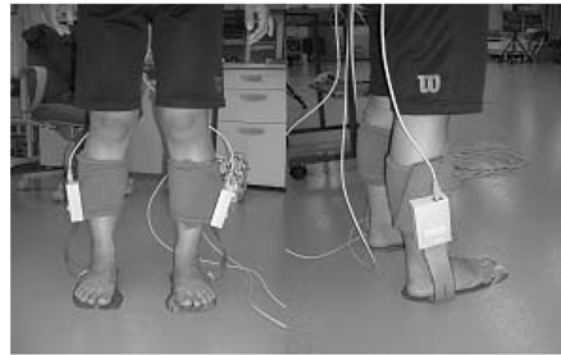


Fig. 2. F-scan equipment. We used the F-scan to measure foot pressure while using the Geta.

computer. The Vicon data was collected at 120 Hz. To measure the G-H distance, reflective markers were attached to the Geta and the foot.

Two experiments were separately carried out. The subjects walked at a self-selected speed along a 10-meter walkway, five times in bare feet and five times while wearing Geta. We believe that we could infer foot joint and muscle activity by calculating foot and Geta contact. These Geta clogs are easy to walk in. However the subjects were not immediately able to walk at one speed while wearing the Geta. Therefore, the subjects practiced the Geta gait prior to the experiment until the speed was the same as when walking barefooted. Since the subjects were instructed not to let the Geta clogs flip-flop on the floor while walking, they had to curl and squeeze the toes to avoid it, so, in this way, the use of the toe muscles was insured.

Data processing

Figures 4 and 5 show the data used for analysis. Figure 4 shows the G-H distance, and Fig. 5 shows the foot pressure data. The gait cycle was determined by confirming the time of the floor reaction, and we then extracted the peak of the G-H distance. Total data were expressed as means \pm SD. We compared the foot pressure with the gait cycle to know exactly when contact occurred.

The shape of the Geta used in our study

The wooden Geta clogs used in this study were those made for a previous study⁴⁾. The Geta sole is similar to a shoe sole in that is covered with rubber for shock absorption. The surface of the Geta is flat and the sole curved, so foot-off can occur easily.

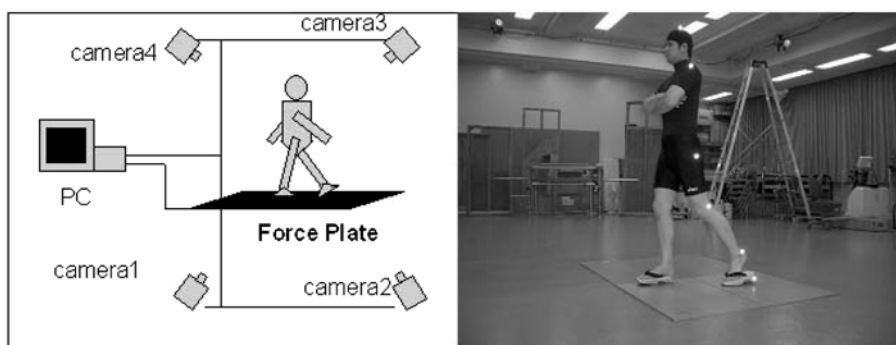


Fig. 3. VICON 512 system. This system consists of two force plates, four cameras and a data-collecting computer.

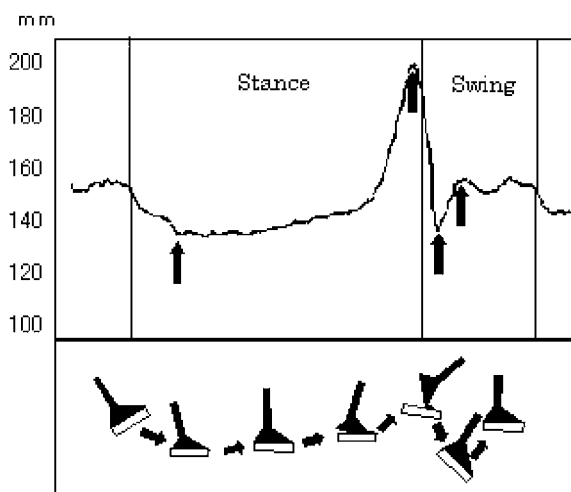


Fig. 4. Measuring points used to calculate G-H distance. Top: arrows indicate the points used for measurement (see Table 2). Bottom: the probable foot and Geta movements related to the gait cycle.

The incline of the front of the Geta is 1.5 mm. Similar to thongs, a material strap attached the Geta to the foot. The weight of each clog was 275 g (Fig. 1).

RESULTS

Toe pressure

We measured the peak of toe pressure during the stance phase. When compared to bare-footed gait, the toe pressure increased in the Geta gait from 12.66 ± 5.92 kgf to 15.38 ± 4.46 kgf. The peak contact occurred at pre-toe-off.

G-H distance

We measured the peak contact pressures using the G-H distance, as indicated in Fig. 4. The shortest G-H distance was 128.31 ± 6.01 mm, which occurred after heel contact. G-H distance increased to 208.94 ± 12.26 mm at pre-toe-off. On the other hand, 134.43 ± 6.62 mm was the shortest distance, which occurred at the beginning of the swing-phase, and 151.83 ± 6.91 mm was the longest distance occurring during the swing phase.

The changing of foot pressure

During the stance phase, foot contact started at the heel, moved to the lateral border of the foot, and then moved to the forefoot. Toe pressure increased gradually, and the peak was recorded before toe-off.

Heel pressure was measured at the beginning of swing phase. The forefoot pressure was observed throughout the swing phase. Toe pressure was measured at the end of the swing phase.

DISCUSSION

Kanai³⁾ reported that there is a possibility of toe muscle strengthening while walking with Geta clogs, which he deduced from an increase in toe pressure and EMG activation of intrinsic foot muscles during Geta gait in his study. In our study, similar results were found.

The questions we asked here were: 1) why does the Geta gait result in toe strengthening?; and 2) are there any other possible effects of the Geta gait?

From heel contact to heel-off during stance

After heel contact, the G-H distance decreases at

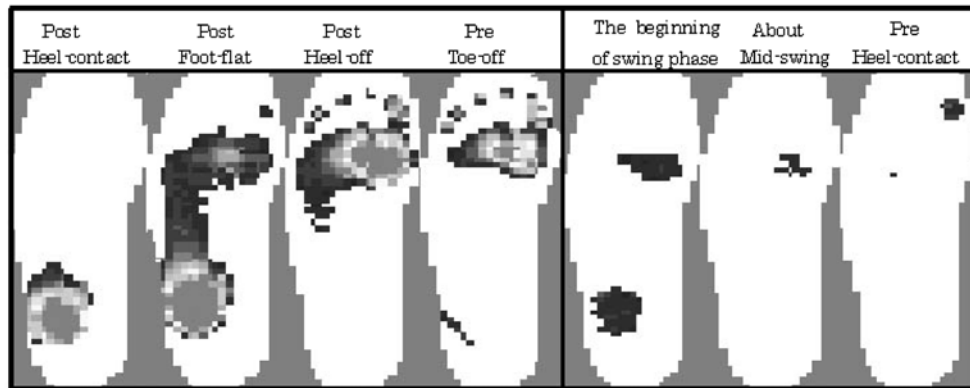


Fig. 5. Foot pressure during Geta gait. Post Heel Contact: The foot pressure observed at heel contact. Post Foot Flat: The pressure observed on the lateral border of the foot. Post Heel Off: Foot pressure observed at the forefoot. Pre Toe Off: The toe pressure peak was measured at this time. Geta and heel contact start. The beginning of swing phase: Geta and heel contact was observed. Mid-swing and pre heel contact: Toe and forefoot pressure was observed during swing phase.

Table 1. Toe pressure and G-H distance

Type of Gait	Toe Pressure (kgf)
Barefoot	12.66 ± 5.92
Geta	15.38 ± 4.46
Phase	G-H Distance (mm)
Heel contact	128.31 ± 6.01
Toe-off	208.9 ± 12.26
Minimal swing	134.43 ± 6.62
Maximal swing	151.83 ± 6.91

once and then increases slowly to heel-off. Foot pressure starts at the heel, moves to the lateral border of the foot, and then moves to the forefoot. Therefore, we think that the decreasing G-H distance causes the soft tissue to become compacted by the weight of the body and to cause ankle inversion to shift to eversion.

From heel-off to toe-off during stance

After heel-off, the G-H distance increases suddenly and peaks before toe-off. The toe pressure peak was recorded at this time. In our understanding, the peaks for the G-H distance and toe pressure have a common effect, where the produces toe hyperextension with a contraction of the toe flexors, which is nearly what is seen when walking barefooted. Nakamura⁶⁾ reported that

ankle plantar flexion and toe extension occurred almost simultaneously when barefooted, which we think is very similar to our results. In this study, we found that the increasing G-H distance occurs during ankle plantar flexion, which means that it is most probable that passive toe movement (metatarsophalangeal hyperextension) occurred.

From toe-off to swing phase

After toe-off, the G-H distance decreases suddenly, and approximately the same data is noted as at heel contact. We confirmed that the heel-Geta contact is present at the beginning of swing phase. The heel pressure measurement and the decreased G-H distance probably occurred at the same time (Figs. 4 and 5). We think that these two results confirm our conclusion that active toe flexor muscle movement is most likely causing this action. Takahashi⁷⁾ reported in his EMG study on Geta gait that the flexor hallucis longus and other intrinsic muscles contracted during the swing phase. We agree with his postulation that muscle movement occurred to approximate the sole of the foot and the Geta. In our study, we confirmed that the toe pressure increased during the swing phase of the Geta gait. Toe flexor muscle activation must have occurred to stabilize the Geta (Fig. 6). Therefore, we believe that the Geta gait is very useful for training toe movements.



Fig. 6. Geta and toe movement. Left: The Geta is unstable when the toe muscles are inactive. Right: The Geta is stabilized by toe muscle action.

Other possible effects of Geta gait, and the future direction of this study

We noted that the G-H distance graph was similar to the metatarsophalangeal (MP) angle and medial arch height graphs in previous studies: MP joint angle, medial arch height and ankle joint angle were related through the windlass mechanism. In addition, Hashimoto⁸⁾ reported that when compared to walking barefooted, the medial arch movement decreased when wearing orthopedic shoes.

If the G-H distance is related to the MP angle and ankle joint angle, we expect that the Geta gait causes almost the same toe extension as seen in barefooted gait. As a result of the windlass mechanism, the medial arch height changes following toe MP extension. It is necessary to clarify that the medial arch actually does change during Geta gait by using a three-dimensional motion analysis system, electro-angle gauge, etc., in future studies.

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