AN ENERGY-EFFICIENT LOCOMOTION: SAMURAI-INSPIRED NAMBA WALKING

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Namba walking, in which the arm and the ipsilateral leg are moved at the same time, in contrast to normal walking, is believed to be more energy-efficient. The purpose of this study was to investigate the differences between Namba walking and normal walking in terms of their gait kinematics and energetics. Our findings indicated that different lower limb energy absorption strategies were adopted for Namba walking, as compared to normal walking. In Namba walking, energy absorption capacities were increased in both hip and ankle joints, suggesting that Namba walking can potentially dissipate external impact forces more effectively.

KEY WORDS: walking, namba, energy efficient, movement.

INTRODUCTION: In ancient Japan (Edo Period 1603-1868), the people learned to walk in a special style called Namba walking, in which the arm and the ipsilateral leg are moved at the same time, in contrast to normal walking. This way of walking is more compact and connected, with high upper and lower body integration.

This style of movement is believed to be more energy-efficient and less fatiguing, and the people, who adopt this style, tend to have increased efficiency in walking performance and moving speed (Louis-Frédéric & Roth, 2002; Yamamoto, 2005). The principles of Namba are inherent in the Japanese martial arts such as karate. In sports, a Japanese runner Suetsugu Shingo, credited Namba for the medal he won in 2003 IAAF World Championship (Beech, 2004).

Currently, most of the information about Namba is available in Japanese. There is no scientific literature that investigates the energy efficiency of Namba walking. In this study, Namba walking and normal walking were examined in order to understand the differences in terms of their gait kinematics and energetics.

METHODS: Ten healthy participants (5 male and 5 female; age: 23.0±1.2 years old, height: 166.7±8.5m, body mass: 62.3±10.0kg) from the local university, without any lower limb musculoskeletal injuries, were enrolled in this study conducted at the motion analysis laboratory. All participants were instructed to perform 3 normal walking trials and 3 Namba walking trials, walking across a 9m walkway at a self-selected walking speed. The trials were recorded simultaneously by the 8-camera VICON Motion Systems (Oxford Metric, UK) with a sampling rate of 100Hz and two Kistler force plates (Kistler Instrument Corp., Novi, MI) with a sampling rate of 1kHz. A total of 16 passive reflective markers were attached to the participant's body according to the lower extremity Plug-In-Gait marker set (Vicon, Oxford, UK). Prior to the experiment, informed consent was obtained from all subjects, based on the approval by the Institutional Review Board. The subjects were allowed to practice namba walking in order to adapt to the new walking pattern and environment.

All kinematic and energetic data were averaged for each subject across three trials. Work was calculated from the time integral of joint power. The gait parameters were then analyzed using paired t-test ($p<0.05$) to identify significant differences between normal and Namba walking. All data were analyzed using OriginPro 9.0 statistical software.

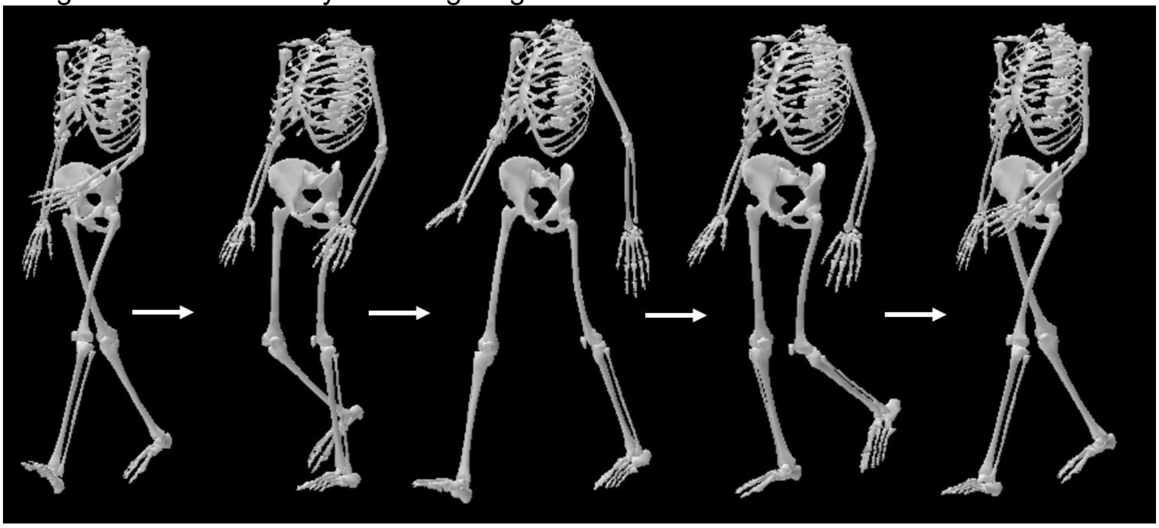

Figure 1. How Namba Walking works: arm and ipsilateral leg are moved at the same time.

RESULTS: In this study, experimental results showed that with similar gait performance, Namba walking produced a significant increase in ankle dorsiflexion and hip flexion. The maximum ankle dorsiflexion angle in Namba walking (13.2±4.2°, $p<0.001$) was higher than that of normal walking (10.2±3.9°).
In addition, our findings indicated that there was a significant reduction in hip concentric work (energy generation) in Namba walking (0.16±0.06J/kg, p=0.007) compared to normal walking (0.20±0.07J/kg). Greater hip eccentric work (0.08±0.07J/kg, p=0.023) was also observed in Namba walking. For the ankle joint, there was more work absorption in Namba walking (0.24±0.06J/kg, p=0.004) compared to normal walking (0.20±0.04J/kg).

Table 1
Comparison of joint kinematic and energetic variables between normal walking and Namba walking. *Significant at p<0.05. **Significant at p<0.001.

	Normal walking	Namba walking	p-value
	Mean±SD	Mean±SD	
Hip			
Heel strike flexion angle (°)	23.29±8.97	24.63±9.70	0.01*
Maximum extension angle (°)	-16.15±9.73	-16.26±8.65	0.42
Total work generation (J/kg)	0.21±0.07	0.15±0.06	0.01*
Total work absorption (J/kg)	0.07±0.06	0.08±0.06	0.03*
Knee			
Maximum flexion in loading response (°)	11.72±5.68	14.47±6.34	0.06
Maximum flexion in swing (°)	49.58±9.06	48.95±9.83	0.30
Total work generation (J/kg)	0.18±0.06	0.21±0.06	0.119
Total work absorption (J/kg)	0.21±0.05	0.18±0.06	0.208
Ankle			
Maximum dorsiflexion(°)	10.20±3.87	13.17±4.17	<0.001**
Maximum plantarflexion(°)	-19.22±4.99	-18.38±6.47	0.19
Total work generation (J/kg)	0.33±0.05	0.36±0.10	0.01*
Total work absorption (J/kg)	0.18±0.05	0.22±0.06	<0.001**

DISCUSSION: Ankle stability is provided by the mortise formed around the talus by the tibia and fibula. Ankle is thought to be in the most stable position during dorsiflexion because in this position, the wider anterior portion of the talus wedges between the medial and lateral malleoli, and much of the mortise becomes occupied and the contact is maximal between the involved articulating surfaces (Turco, 1977). In Namba walking, with higher dorsiflexion angle, the mortise is occupied by the talus, and thus the foot's bony contact increases (Norkus & Floyd, 2001).Therefore, our findings appear to suggest that Namba walking may increase ankle stability during ambulation. Since the maximum ankle dorsiflexion angle was still within the normal range of motion (Baggett & Young, 1993), it would not increase the risk of interosseous tissue damage of ankle joint with excessive dorsiflexion (Wolfe, Uhl, Mattacola, & McCluskey, 2001).

Furthermore, this study also indicated that Namba walking may need less hip work in order to achieve the same performance. In Namba walking, energy absorption capacities were increased in both hip and ankle joints, suggesting that Namba walking can potentially dissipate external impact forces more effectively. With greater energy absorption capacities, more elastic energy could be stored and recoiled during propulsion phase (Takahashi & Stanhope, 2013).

The findings need to be viewed in light of several limitations. First, the sample size of this study is small, thus the results presented here may not be completely indicative of the true effect of Namba walking. Future studies could be directed at a larger cohort to draw conclusion on the changes induced by Namba walking. Second, the subjects were not fully accustomed to the new walking technique during the experiment. Even though they were allowed to practice namba walking in order to adapt to the new walking pattern prior to the experiment, the time was still not adequate for the adaptation of the new walking technique. Future efforts can be considered to allow the subjects to have longer adaptation period. Third, the limited length of the walkway (9 meters) is not a perfect platform to analyze the biomechanics of Namba walking as this will attenuate the accuracy of the findings due to constraints caused by the limited distance. Moreover, future efforts can also be considered to conduct the trials outdoors or with a treadmill to observe long-distance Namba walking or running. In addition, electromyography data should also be analyzed to understand the changes in muscles recruitment strategy caused by Namba walking.

CONCLUSION: In conclusion, this study demonstrated that Namba walking may be a more stable and energy-efficient style of walking. It may be beneficial for the athletes to incorporate this technique in their training in order to gain an extra edge in performance. Further studies such as incorporating Namba style movements in running will be conducted in order to investigate the potential of the Namba style in the aspect of sports and rehabilitation.

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