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Effect of Improperly Sized Shoes on Gait

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Abstract

Although shoes are conventionally chosen based on the size indicated on the label, it is also possible to accurately gauge foot size using a technique known as morphometry to measure the three-dimensional shape of feet in a state of rest. However, because shoe sizes differ slightly for each shoe manufacturer despite the use of a standardized labeling system, there is no guarantee that consumers will be able to choose a pair of shoes that properly fit the size of their feet. Furthermore, some consumers are in the habit of wearing larger shoes to accommodate the width of their feet. The purpose of this study was to develop a quantitative understanding of the relationship between shoe size (foot length) and gait by using techniques such as electromyogram of the lower leg, measurement of ground reaction force, and subjective evaluation.

The subjects, five male university students with no history of leg injury, all had a foot length of 26.5 cm and a foot width of size D as defined by JIS standards. Prior to the experiment, the subjects' consent were obtained after briefing them on anticipated risks and safety considerations, management of their personal information, and other aspects of the study. Experimental samples consisted of a total of five D-width shoes in sizes ranging from 26.0 cm to 28.0 cm, in 0.5 cm increments. Each subject was fitted with an electromyogram measuring device on the gastrocnemius and tibialis anterior muscles on his right leg, and a plantar pressure distribution measuring sheet was placed in each of the sample shoes. Each subject took 10 strides while wearing each sample shoe along a predetermined route in the lab, under which a device for measuring floor reaction force had been installed. After each subject had walked in each shoe sample, they filled out a questionnaire on the sensations experienced while walking. When the shoe size (foot length) was at least 1 cm longer than the subject's proper size, a significant increase in activity by the gastrocnemius muscle was noted along with a significant decrease in the floor reaction force value (F2) at kick-off. These changes were attributed to the psychological effects of factors such as ease of kick-off. The findings suggest that the parameters used in this study, including muscular activity level, floor reaction force peak value, and gait reproducibility, have the potential to serve as useful indicators in evaluating the functional compatibility between shoe wearers and shoe size.

Keywords: Shoe Size (Foot Length); Gait; Lower Leg; Ground Reaction Force; Subjective Evaluation; Gastrocnemius; Tibialis Anterior

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1 Introduction

Currently, the aging of Japanese society is becoming a significant issue. According to demographic data compiled by the Ministry of Health, Labour and Welfare in 2012, the number of elderly individuals as a percentage of the country's total population has been increasing annually, rising from 4.9% in 1950 to 23.0% in 2010. At the same time, the birthrate has been declining, and some experts predict that the population-aging rate will exceed 30% in 2030 [1]. As Japan continues to evolve into a rapidly-graying society, the number of people involved in sports is increasing, and 48.2% of all people who engaged in some sport over the last year cited "building strength" as a goal, reflecting a rising awareness of sport as a facilitator of good health [2]. In this way, health consciousness has been increasing, and walking has become the most popular activity for maintaining fitness. According to a study conducted by the Public Relations Office of the Cabinet Office Minster's Secretariat, walking was the most common type of exercise during the last year [3]. About 40 million people are said to walk regularly, and an extremely large number of people engage in some sort of exercise for the purpose of staying in good health. Health-conscious people work to maintain a healthy lifestyle through basic physical exercise, for example by running or walking. As a result, many consumers exhibit a high level of interest in the shoes they wear.

Recently, running and walking shoes with a variety of functions have been introduced in the athletic shoe market, representing an increasingly broad range of options for consumers. However, most shoes are chosen based on labeling that has been chosen by manufacturers during the design stage or by trying on shoes in stores. Some manufacturers have recently begun to offer morphometry as a way to measure the three-dimensional shape of the foot using foot-measuring instruments in stores. However, the labeling of shoe sizes is determined by manufacturers, and shoes incorporate some degree of toe room, typically around 1 to 2 cm of space between the tip of the wearer's toes and the end of the shoe. Individual manufacturers have their own standards for toe room, which also varies with the shoe design. This way, even shoes labeled with the same size reflect a variety of sizes and standards, and it is not always possible to choose a shoe that fits based on size labeling or foot morphometry. Wearing shoes that are too small for one's feet or shoes that do not match the shape of one's feet can lead to foot diseases such as hammer toe or hallux valgus. On the other hand, some consumers find themselves choosing shoes that are too large to make up for their narrow width. There is an empirical basis for expecting that wearing shoes that are too large for one's feet will make walking difficult. However, the effects of improperly sized shoes on gait remain unclear, and there has been very little scientific research on the subject.

The purpose of this study was to provide a quantitative accounting of the relationship between shoe size (foot length) and gait by using techniques such as electromyogram of the lower leg, measurement of ground reaction force, and subjective evaluation [4].

2 Methodology

In this study, electromyograms of the lower leg were taken, ground reaction force and tracked load point movement was measured while the subjects were walking. A questionnaire was also administered, asking subjects to rate the sensation of walking in terms of four characteristics: ease of kick-off, shoe comfort, shock, and fit. Then the effects of improper shoe sizing were quantified