INTRODUCTION

The pedobarograph is commonly used in the clinical setting to 1) design and assess the effectiveness of orthoses (Hodge et al., 1999; Kato et al., 1996), 2) evaluate the effect of treatment by examination before and after a surgical procedure (Hee et al., 2001; Metaxiotis et al., 2000; Oeffinger et al., 2000); and 3) monitor progress by means of sequential measurements (Cavanagh, 2000; Hughes J, 1993). Significant variations of peak pressure with different gait parameters were shown by Law and Mak (2003). In 1991, Hughes et al. conducted a study to recruit 10 subjects to walk at 3 different speed set by metronome. i.e. 84 steps/min, 112 steps/ min, and 144 steps/min. Results shown that contact duration on the medial forefoot, big toe, and base of 5th MT shown significant decrease with increase speed. However, contact duration on the heel decrease with increase speed. However, variation of the temporal information with different gait parameters as effect of walking speed due to change of either cadence or stride length only, walking base width, and foot progression angle with the other gait parameters well monitored is not fully understood. A study was launched to evaluate the variance of the foot motion under different gait parameters by using dynamic pedobarograph measurement.

OBJECTIVES

To evaluate the variation of temporal information measured due to changes of the Walking speed, Walking cadence, Stride length, Walking base, and Foot progression angle.

METHODS

Seventy-four healthy subjects, 50% female, between 11 and 56 years old with mean age of 24 years old and average body mass index of 21.4 kg/m² volunteered to participate in the study. (Fig.1) The inclusion criteria included 1) No complaint of foot pain within the last 1 year before experiment, and 2) No obvious foot deformities can be detected.

In-shoe plantar pressure during walking on the treadmill in canvas shoes (Double coin, China) were collected by using F-scan insole sensor was trimmed to fit into the right side of canvas shoes, and determine the 1st to 5 th metatarsal heads (MTHs). With subject stands on both feet comfortably, pressure was applied on the dorsum of each MTH to determine the MTH location on the insole pressure sensor. (Picture 1) MTHs locations determined before warm up walking, before experiment and after the whole experiment. Ten minutes of walking trial on the treadmill was given before measurement taken for the subject to familiar the treadmill, selection of a relax and comfortable speed, and recording the cadence for that particular speed. 9 sets of plantar pressure measurements, with 10 steps for each set, were performed. Subjects were asked to vary different gait parameters once in a time, based on the normal gait in the first 10 minutes of walking trial. 9 sets of measurements including walks with wide walking base/ narrow walking base, walks with out toeing/ in toeing gait, increase/ decrease the walking speed by 0.2 m/s by changing the cadence only, increase/ decrease the walking speed by 0.2 m/s by changing the stride length only, and Normal walking trial. Cadence was guided by metronome. The sequence of measurement is in a Latin square sequence between different subjects to minimize the sequential effect. Instant of contact, instant of lift up, and duration of contact over metatarsal heads (MTHs) and heel center region were determined from the pedobarograph. Each data were normalized by the total foot contact time of that particular step. Within subject comparison was done by using 3 factors repeated measure analysis of variance (ANOVA), α = .05, and further analysis by 2 factors repeated measure ANOVA, α = .05, to compare the foot pressure measurements, with 10 steps for each set, were performed. Subjects were asked to vary different gait parameters once in a time, based on the normal gait in the first 10 minutes of walking trial. 9 sets of measurements including walks with wide walking base/ narrow walking base, walks with out toeing/ in toeing gait, increase/ decrease the walking speed by 0.2 m/s by changing the cadence only, increase/ decrease the walking speed by 0.2 m/s by changing the stride length only, and Normal walking trial. Cadence was guided by metronome. The sequence of measurement is in a Latin square sequence between different subjects to minimize the sequential effect. Instant of contact, instant of lift up, and duration of contact over metatarsal heads (MTHs) and heel center region were determined from the pedobarograph. Each data were normalized by the total foot contact time of that particular step. Within subject comparison was done by using 3 factors repeated measure analysis of variance (ANOVA), α = .05, and further analysis by 2 factors repeated measure ANOVA, α = .05, to compare the foot pressure measurements, with 10 steps for each set, were performed. Subjects were asked to vary different gait parameters once in a time, based on the normal gait in the first 10 minutes of walking trial. 9 sets of measurements including walks with wide walking base/ narrow walking base, walks with out toeing/ in toeing gait, increase/ decrease the walking speed by 0.2 m/s by changing the cadence only, increase/ decrease the walking speed by 0.2 m/s by changing the stride length only, and Normal walking trial. Cadence was guided by metronome. The sequence of measurement is in a Latin square sequence between different subjects to minimize the sequential effect. Instant of contact, instant of lift up, and duration of contact over metatarsal heads (MTHs) and heel center region were determined from the pedobarograph. Each data were normalized by the total foot contact time of that particular step. Within subject comparison was done by using 3 factors repeated measure analysis of variance (ANOVA), α = .05, and further analysis by 2 factors repeated measure ANOVA, α = .05, to compare the foot
contact behaviour between normal and different gait parameters.

**RESULTS**

By using repeated measure ANOVA analysis for the temporal data measured in different conditions, the changes due to different gait variance can be shown in terms of percentage of total foot contact duration.

**Walks with narrower base:** 3% statistically significant decrease of contact duration were shown at the 1st MTH and heel region. 2%, 2% and 1% statistically significant delay to contact with the floor were shown for the 1st, 2nd and 3rd MTH, respectively. 2% statistically significant delay to lift up from the floor was shown for the 5th MTH but 3% statistically significant earlier to lift up from the floor was shown for the heel. (Fig. 2)

**Walks with wider base:** 6% and 2% statistically significant increases of contact duration were shown at the 1st and 2nd MTH, respectively. 2% and 6% statistically significant decrease of contact duration were shown at the 4th and 5th MTH region, respectively. 1% statistically significant earlier to contact with the floor were shown for the 3rd and 4th MTH. (Fig. 3)

**Walks with lower speed by reducing the cadence:** 2% statistically significant increase of contact duration were shown at the 3rd and 4th MTH region. 1% statistically significant earlier to contact with the floor were shown for the 3rd and 4th MTH. (Fig. 4)

from the floor were shown for the 4th and 5th MTH, respectively. (Fig. 3)

**Walks with higher speed by increasing the cadence:** 2% statistically significant earlier to lift up from the floor were shown for the 3rd and 4th MTH. (Fig. 5)
Walks slowly by shorten the stride length: 2%, 3% and 2% statistically significant increases of contact duration were shown at the 2nd, 3rd and 4th MTH region, respectively. 2%, 2%, and 1% statistically significant earlier to contact with the floor were shown for the 2nd, 3rd and 4th MTH, respectively. (Fig. 5)

Walks with higher speed by increasing the cadence: No statistical significant different can be shown. (Fig. 6)

Walks with higher by lengthen the stride length: 1% statistically significant delay to contact with the floor was shown at the 4th MTH. (Fig. 7)

Walks with out-toeing gait: 2% and 3% statistically significant increases of contact duration were shown at the 1st MTH and heel, respectively, but 4% and 4% statistically significant earlier to lift up from the floor were shown for the 4th and 5th MTH, respectively. (Fig. 8)

Walks with in-toeing gait: 6% statistically significant decrease of contact duration were shown at the heel, but 3% and 6% statistically significant increase of contact duration were shown at the 4th and 5th MTH region, respectively. 1%, 1% and 3% statistically significant earlier to contact with the floor were shown for the 3rd, 4th and 5th MTH, respectively. 6% and 3% statistically significant earlier to lift up from the floor were shown for the heel and 1st MTH, respectively, but 1% and 3% statistically significant delay to lift up from the floor were shown for the 4th and 5th MTH, respectively. (Fig. 9)

DISCUSSION

From the above experiment result, more information about the foot contact events in different walking condition were acquired. Also, percentages of variance between different walking conditions were evaluated. Care must be taken during pedobarography measurement to avoid the changes of foot motion due to different walking gait. Gait parameters, especially foot progression angle and walking base width, must be monitored when we perform foot plantar pressure measurement.

REFERENCES


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