Biocybernetics and Biomedical Engineering
2011, Volume 31, Number 2, pp. 51–57

Can Vibration Stimuli to Planta Pedis Prevent the Fall Accident?

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Considering the aged population increase, the prevention of falls will become increasingly importance. One of the causes of elderly people fall is the decline of the balance ability. The purpose of this study is to examine the difference of the sensitivities to the single frequency vibration of three places in planta pedis. We made a simple vibration stimulator, which can give 225Hz vibration stimuli to three places of planta pedis. This frequency was decided by our prior study. The vibration stimuli places were the heel, the root of the big toe and the root of the little toe. The intensity of the stimulus was set to 90% of the smallest stimulus intensity that the subject could feel. We evaluated the effect of vibration stimuli by the center-of-foot-pressure (CFP) sway and the duration of one-leg standing with closed eyes. The results showed that the duration was extended and the locus length of CFP sway was decreased by the stimulation of only one place. The most effective place was the root of the big toe. Our result is that the vibration stimuli to planta pedis are useful for the fall prevention of elderly people.

K e y w o r d s: fall prevention, vibration stimuli, Vater-Pacini's corpuscle

1. Introduction

In Japan, the population of children decreased, and the population of elderly people increased recently. As a result, Japan became a super aged society. The fall accident of the elderly people is one of the main reasons that the elderly people become the bedridden patients or need nursing. It is reported that probability of occurrence of the fall accident is approximately 11% in elderly people 60 years of age or older. About 11% of elderly people who fell down were fractured [1, 2]. Therefore, the fall prevention for elderly person is important.

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Received 30 December2010; accepted 24 February 2011

Collins et al. showed that the center-of-foot-pressure sway decreases by the vibration stimuli of the white noise to planta pedis [3, 4].

In our prior study, we stimulated a single frequency vibration to three places of planta pedis, that is, the heel, the root of the big toe and the root of the little toe. The pressure distribution in the planta pedis when standing or walking is not uniform but is partially high at the heel, the root of the big toe and the root of the little toe. Therefore, we chose these three places as the stimuli places. The stimulation frequency was from 200Hz to 300Hz. By the vibration stimuli, the center-of-foot-pressure (CFP) sway in one-leg standing condition with closed eyes was reduced. The most effective frequency was 225Hz. The reduction of places for the stimulation makes the stimulator small. Therefore, it is necessary to search the most effective stimulus place.

The purpose of this study was to examine the difference of the sensitivities of three stimuli places. We stimulated each place chosen out of three places (the heel, the root of the big toe and the root of the little toe) separately and compared the difference of CFP sway.

2. Method

As the results of our prior study, the postural sway was reduced at 225Hz as shown by the mean results of all the subjects. In this study, we used a sine wave of 225Hz as vibration stimuli and evaluated the effect to the CFP sway in one-leg standing condition with closed eyes. The subjects were three young males. The subjects were 21, 22 and 25 years-old.

2.1. Vibration Stimulator

The vibration stimulator, shown in Fig. 1, consists of an oscillator, an amplifier, a piezo vibrator and an insole.

2.2. Experimental Conditions

Figure 2 shows the posture of a subject in experiments. The subject puts the hand on his waist, and stands with the right leg on the vibration stimulator, that is placed on the force plate. The left lower leg is kept perpendicularly with a floor and the foot is kept about 5cm above the floor. We direct subjects to keep the balance without using arms and a leg during the measurement with closed eyes.

The intensity of stimulus is set to 90% of the smallest stimulus intensity that the each subject can feel. As the result, the subjects do not feel the vibration.

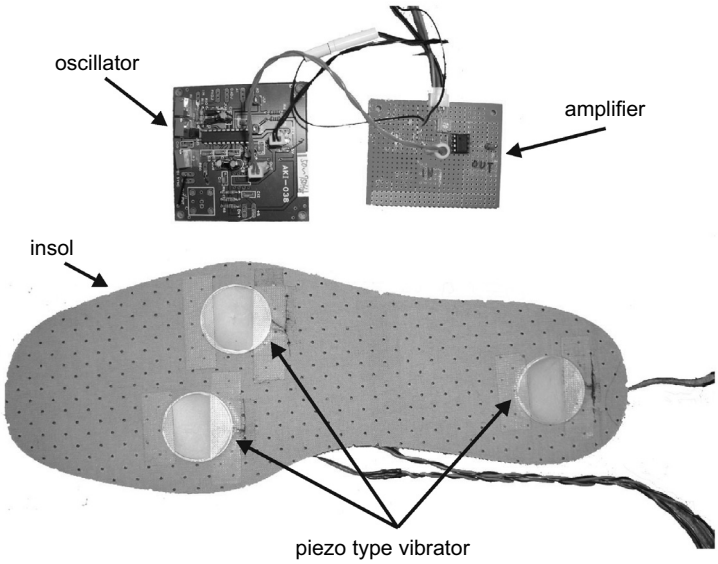

Fig. 1. Configuration of the vibration stimulator

Fig. 2. Posture of the subject during the experiment

2.3. Experimental Procedure

The measurement starts when the subject closes his eyes and lifts his left leg up, and ends when the subject loses his balance. In this study, we judge the subject lose balance when the following conditions occurred.

1) The position of the supporting leg moves.
2) Non-supporting leg conflicts with a supporting leg.
3) A hand leaves the waist.

The experimental conditions are as follows:

1) No vibration.
2) Vibration stimuli to three places.
3) Vibration stimuli to the heel only.
4) Vibration stimuli to the root of the big toe only.
5) Vibration stimuli to the root of the little toe.

The procedures are as follows:

1) We match the position of the piezo vibrator with podalic size of the subject.
2) The subject is standing on the vibration stimulator.
3) We increase the applied voltage to the piezo vibrator slowly and stop the voltage increase when the subject feels vibration.
4) We set this voltage as 100% and change the voltage to 90%. Therefore, the subject does not feel vibration even if we apply the vibration stimuli during the measurement.
5) The subject keeps the posture of one-leg standing as shown in Fig.2.
6) When the subject prepares the posture and closes of his eyes, the subject signals us.
7) Immediately after the signal of the subject, we start the measurement.
8) We finish the measurement when the subject lost his balance.
9) The subject takes the 5-minute break.

We repeat steps from 2) to 9).

The measurement parameters are the duration and the locus length of the CFP sway. The locus length of the CFP sway is calculated in 10 seconds. The calculation is done when the subject keeps the posture more than 10 seconds. The calculation segment of the locus length of the CFP sway is the segment of five seconds before and after the center time of each measurement.

3. Results

3.1. The Duration of the Condition of one-leg Standing with Closed Eyes

We measured 10 times the duration of the condition of one-leg standing and a locus of the CFP sway for each condition. Figure 3 shows the results of the averaged duration of each subject. This shows that the duration of the condition of one-leg standing with closed eyes has a tendency to improve when giving planta pedis vibration

stimuli for all the subjects. Comparing the individual stimulation with three places' stimulation, the stimulation to the root of big toe shows almost the same effect the of stimulation in three places. The results for the subject 3 show rather long duration. But the tendency is the same as for the other subjects.

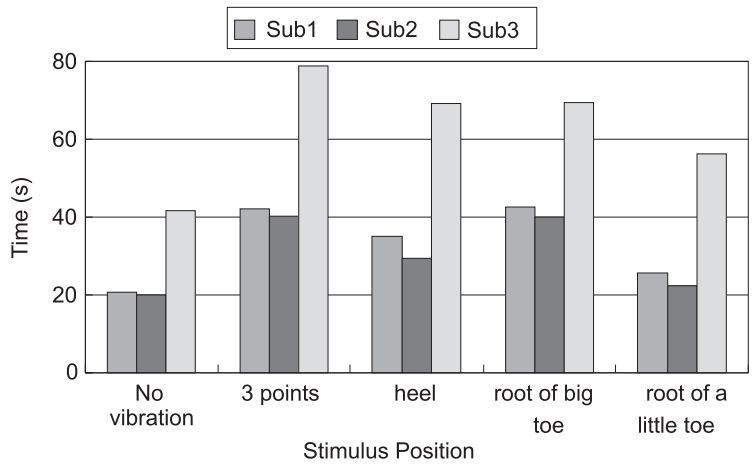

Fig. 3. The averaged duration of the condition of one-leg standing with closed eyes

3.2. Locus Length of CFP Sway

Figure 4 shows the averaged locus length of the CFP sway for ten second periods. This result shows significant improvement with vibration stimuli. In addition, it shows that the stimuli to the root of the big toe give almost the same effect as the three places' stimuli.

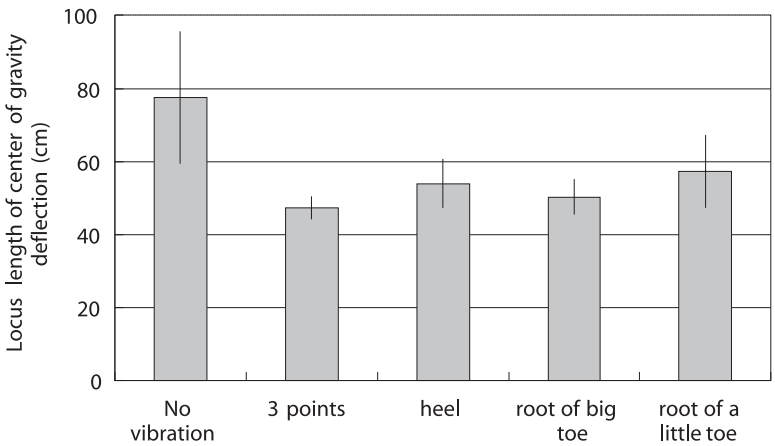

Fig. 4. The averaged locus length of the CFP sway

3.3. CFP Sways Areas

Figure 5 shows the averaged area of the CFP sway. It shows the significant difference between no vibration and the three places' vibration stimuli. In addition, it shows that the stimuli to the root of the big toe give almost the same effect as the three places' stimuli. The long duration of one-leg standing condition and the short locus length of the CFP sway with the closed eyes mean the stable standing with a little drift.

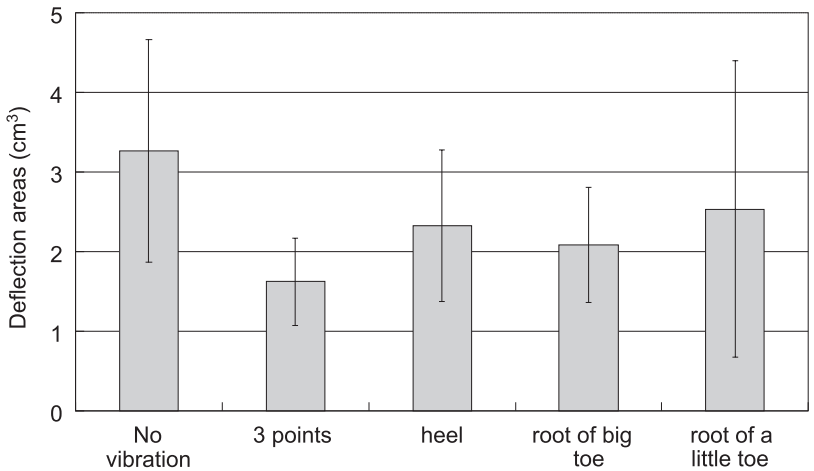

Fig. 5. The averaged deflection areas of the center of pressure

4. Discussion

The 225Hz vibration stimuli to the planta pedis gives a change of the duration and the CFP sway in the condition of one-leg standing with closed eyes. The vibration stimuli makes the duration of the condition of one-leg standing long, and the locus length of the CFP sway decreased, and the deflection area small. The vibration stimuli lengthen the duration of one-leg standing condition, reduce the locus length of the CFP sway and lower the deflection area. The small area of the CFP sway makes the stable standing. These results mean that the single frequency vibration stimuli are effective to the fall prevention. This may be brought by the difference in distribution of the corpuscle of Vater-Pacini.

5. Conclusions

In this study, we made a simple planta pedis vibration stimulator. This stimulator can give the vibration stimuli of a single frequency to the heel, the root of the big toe, and the root of the small toe separately. We evaluated an effect of the vibration

stimuli on the duration of one-leg standing condition, the locus length and the area of the center-of-foot-pressure sway, with closed eyes. The results showed that by the stimulation at only one place, the duration of one-leg standing condition was prolonged, and that the locus length and the area of the center-of-foot-pressure sway decreased. In particular, the stimulation at the root of the big toe was the most effective. Because the center-of-foot-pressure sway in one-leg standing condition is reduced, the vibration stimuli to planta pedis are effective for fall prevention.

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