

## The Influence of Flip-flops Gait on the Muscle Activity of Tibialis anterior and Gastrocnemius

The fact that flip-flops, one of many different types of unstable shoes, are light and relatively easy to put on, accounts for their popularity among people. But because flip-flops rely heavily on the support of a single thong between your first and second toes, they impose a huge amount of pressure onto lower leg. Thus in the following experiment we tried to examine the different effects of flip-flops and running shoes in terms of their effect on muscle activity and fatigue of tibialis anterior and gastrocnemius during walking. In order to measure an electromyogram we used Free EMG system. 10 men and 10 women in running shoes ran on treadmills for 15 minutes at 4.8km/h, 2 days later the same experiment was carried out, but this time, in flip-flops. p value turned out to be greater than .05 and thus there was no considerable difference between the effects of flip-flops and running shoes on muscle activity and fatigue during walking. Therefore we conclude that despite the fact that flip-flops are considered unstable, their effects on muscle activity and fatigue of tibialis anterior and gastrocnemius are negligible.

Key words: *Flip-Flops; Walking; Muscle Activity; Muscle Fatigue; Lower Leg*

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## INTRODUCTION

The peoples of today walk in shoes generally, while the way of walking barefoot used to be the most common style of walking before the civilization of mankind(1). The humans who walk in the erect position, definitely required to wear the footwear in order to protect their feet against injuries during the movement and the footwear should not only take care of human body, supporting the whole body and absorbing the shock from movement but also transform the wearer's pathological gait into the normal one by correcting the wearer's defect. However, the tendency of attire has kept on being changed in the wake of the civilization's continuous progress and, keeping pace with this tendency of attire, the footwear has also been diversely transformed in line with each footwear's own purpose(3). Though we can not overlook the fact that the original function of protecting foot is important as the role of footwear, it is more important for us to make the footwear fit wearer's own foot shape properly(1). Also it should

be noticed that the shape of footwear may give influence to the stability of body balance and the gait pattern or the muscle strength may be influenced by the footwear shape(4, 5).

The flip flop shoe that recent peoples preferably choose to put on, has already solidified its position as a fashion item because it can be easily put on and run dry quickly after getting wet and diverse designs are available with flip flop shoes. However, the wearer of flip flop puts on that footwear and walks, holding only a thong of it with his first and second toes. So the wearer comes to apply immoderate force to his lower leg and foot in order to hold it. Such immoderate force may have the wearer hold incorrect posture of walking and the incorrect posture may cause a body structural lesion(6, 7).

Reviewing the preceding research papers, it is noticed that such researchers as Ahn(8), Lee et al.(9), Oh(10) and Yoo(11) have reported on the change of muscle activity following the change in heel height and the researchers such as Shin et al.(12) and Shin et al.(13) have studied on the variance of muscle activity

activity depending on footwear types. However, it was brought to the researcher's notice that almost no thesis was written, using the parameter of flip flops. Also there has been some researches which analyzed kinetic characteristics related with the wearing of flip flops and studied on the change of plantar pressure caused by the wearing of flip flops. But no research has excogitated the muscle activity, colligated with the wearing of flip flops.

Accordingly, the researcher has compared the muscle activity of tibialis anterior and gastrocnemius while walking in flip flops with that of tibialis anterior and gastrocnemius while walking in sneakers and tried to investigate what influence would be given to lower leg by wearing of flip flops.

## METHODS

### Research Subject

10 male and 10 female adults whose lower extremities have not been injured for the recent 6 months and whose lower extremities have no congenital deformity and have no orthopedics disease or transform, were randomly selected among those who are attending N university in Cheonan, Choongnam. All the subjects have had the flip flop shoes on.

Table 1. Characteristics of subjects

	Mean±SD
Age(Yrs)	21.45±0.55
Height(cm)	170.4±6.85
Weight(kg)	71.19±8.25

### Measuring Equipment

In order to look into how the footwear type affects the activity and fatigue of tibialis anterior and gastrocnemius, Free EMG system(BTS, Italy) was used for the measurement and the treadmill of SKY Life 5300(Maxton healthcare, Korea) was mobilized during gait.

### Attaching Electrode

To measure the electromyogram value, the maximum voluntary isometric contraction was sought through manual muscle test, attaching EMG electrode to the muscle belly of tibialis anterior and

gastrocnemius(14), that is, the part where the activation of muscle is most brisk. When the subjects perform maximal isometric contraction, they are to hold the posture of contraction for 5 seconds. And the electromyogram signals only during 3 seconds except the first and last one second are to be collected as research materials.

### Procedure

In order to look into the alteration of muscle activity caused by wearing of flip flop shoes, the researcher set the group of sneakers as the control group and set the group of flip flops as the experimental group. The sneakers group was instructed to wear the sneakers they usually used and the flip flops group was arranged to put on the flip flop of one single brand.

The subjects were instructed to walk on a treadmill for 15 minutes at the speed of 1.34m per second (about 4.8km per hour), the normal pace, wearing sneakers(15). Again they walked in flip flops at the speed of 4.8km per hour for 15 minutes, after they had taken 2 days' rest to get rid of fatigue influence.

The muscle activity was measured three times when 4~5 minutes passed, 8~9 minutes passed and 14~15 minutes passed and the mean values of these 3 measurement values were calculated for the processing.

### Data Analysis

The program of SPSS version 18.0 was used for the statistical process in this research. The normality was established through K-S test (Kolmogorov-Smirnov Test) and the independent two samples t-test was used in order to look into the difference between the sneakers and flip flop shoes in terms of causing muscle activity and fatigue. The level of statistical significance was set at  $\alpha = .05$ .

## RESULTS

### Muscle Activity between Sneakers Group and Flip flop Group

An experiment was conducted in this research, in order to investigate what differences would exist between walking in sneakers and in flip flops, concerning the activity of Tibialis anterior and Gastrocnemius. And the experiment did not show any significant difference between the two(table 2).

**Table 2** Comparison of muscle activity between sneakers group and flip flop group (unit: mV)

		Mean±SD	t	p
LTA	Sneakers	.44±.194	-.474	.638
	Flip flops	.48±.219		
RTA	Sneakers	.44±.209	-.449	.656
	Flip flops	.48±.240		
LGCM	Sneakers	.56±.238	.515	.609
	Flip flops	.52±.188		
RGCM	Sneakers	.51±.214	-.808	.424
	Flip flops	.56±.180		

p<.05

LTA: Left tibialis anterior      RTA: Right tibialis anterior  
 LGCM: Left gastrocnemius      RGCM: Right gastrocnemius

## DISCUSSION

As per the results of an experiment in this result where the muscle activity and fatigue while walking in flip flops, was compared with those while walking in sneakers, no significant statistical difference in terms of muscle activity and fatigue was shown in both Tibialis anterior and Gastrocnemius(p>.05). Lee has reported that ankle joint dorsiflexion was seen not to be so brisk while walking in flip flops since the heel part area of flip flop shoe is saliently wider, at the time of heel strike, than that of other shoes. The view in the report by Lee seems to be very similar to the contention of this research that there was no significant difference between walking in flip flops and in sneakers in terms of the activity and fatigue of tibialis anterior, the agonistic muscle for dorsiflexion(3). The thong of flip flops, inserted between the first and second toes, seems to be an obstacle that prevents its wearer from making enough dorsiflexion because the thong of flip flop shoes compel the wearer to hold it using the two toes.

Kwon et al, reported that the activity of tibialis anterior was seen to be significantly higher with curved rear balance shoes than normal shoes and the activity of gastrocnemius showed a significantly higher mean value with curved rear balance shoes than normal shoes but they were not statistically significant, when he compared the normal shoes and curved rear balance shoes, focusing on the muscle activity of lower extremities(16). Though the rear part curved shoes, a kind of unstable footwear mentioned in the study of Kwon et al., is of different

kind, compared to the flip flops in this research, we can presume that the muscle activity does not always show a significant difference because of the unstable footwear(16).

Burgess and Swinton have reported that walking on a treadmill in flip flops showed no significant difference in the aspect of the activity of medial gastrocnemius, compared to barefoot walking. Though the flip flops were compared with sneakers instead of barefoot in this research, their report is similar to the contention of this research in that the activity of gastrocnemius showed no significant difference(17). Consequently, it is considered that the wearers of flip flops in the preceding research and this research did not feel such inconvenience as bring about a significant difference concerning the activity of gastrocnemius.

On the other hand, Carina et al, have reported that the unstable footwear is to increase the muscle activity of lower leg in order to control the wearer's walking posture. However, the muscle activity showed no significant difference in this research, being different from the result of preceding research(18). This research maintains that walking in flip flops doesn't make a significant difference in terms of muscle activity and fatigue when it was compared with walking in sneakers. The researcher considers this is because the sole of flip flops in the preceding research consisted of 3 parts(toe part, middle part and heel part) of different density, while the sole of flip flops in this research was a whole sole of single density.

The time of walking in flip flops for 15 minutes, set in this research, seems to be limited to ensure the same activity as daily living's, so the difference between sneakers' group and flip flops' group might not have been significant in this research. And the number of subjects was too few to be generalized. Also, the fact that the selection of unstable footwear was confined to only one brand of flip flops out of various models for the purpose of generalization, might work as limitation in this research. Also it should be pointed out that only two specific muscles of lower leg were analyzed to compare the muscle activity and fatigue in this research, though there are various human body segments, involved in walking process.

Accordingly it is suggested that we should study on how the various body segments involved in walking are to be influenced by wearing of flip flops and sneakers respectively. Also, we should study on what influence would be given by wearing of flip flops specially while conducting life activity, not while

walking on a treadmill, concerning the muscle activity and fatigue.

Therefore, more researches should be conducted in the future, making up for the limitations mentioned hereinbefore.

## CONCLUSION

This research intended to look into how the wearing of flip flops would give influence to lower leg muscle by comparing the activity of tibialis anterior and gastrocnemius while walking in flip flops with that while walking in sneakers. The following conclusions were drawn from the experiment in this research.

1. No significant change in muscle activity of both left and right tibialis anterior was caused by wearing of flip flops( $p>.05$ ).
2. No significant difference in muscle activity of both left and right gastrocnemius was shown due to the wearing of flip flops( $p>.05$ ).
3. No significant change in muscle fatigue of both left and right tibialis anterior was caused by wearing of flip flops( $p>.05$ ).
4. No significant change in muscle fatigue of both left and right gastrocnemius was exhibited due to the wearing of flip flops( $p>.05$ ).

Accordingly, it can be inferred that the muscle activity and fatigue of lower leg showed no difference between while walking in flip flops and while walking in sneakers.

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