

INFLUENCE OF THONG FLIP-FLOPS ON RUNNING KINEMATICS IN PRESCHOOLERS

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INTRODUCTION

Footwear is important in human movement because it is the interface between the foot and the ground in shod activities. The foot is the first and sometimes only interaction with the ground and plays a key role in the regulation of normal walking gait patterns [1]. There is a plethora of research on varying types of footwear, but a type that has not been thoroughly investigated is thong style flip-flops. With casual observation of an increase in the wearing of flip-flops by children and the anecdotal evidence provided by podiatrists that flip-flops are poor footwear choices, the effects of wearing flip-flops on gait mechanics warrants investigation. Therefore, the purpose of this study was to determine if thong style flip-flops have an effect on the movement patterns of preschool-age children while running when compared to athletic sneakers.

METHODS

Twelve (8 F and 4 M) preschool-age children (age $56.27 \text{ mos} \pm 3.32$) were used for this study. Two participants at a time reported to the Auburn University's Sport Biomechanics Laboratory for testing. The athletic shoes used in the study were the TT Jetstream (for males) and TT Pandora (for females) by Stride Rite® (Figure 1). The flip-flops were generic flip-flops purchased at a local department store (Figure 2).



Figure 1: Stride Rite® TT Pandora and TT Jetstream



Figure 2: Generic flip-flop

Upon arriving to the lab for testing, the children were randomly assigned to a footwear order (flip-flops or sneakers first). Retroreflective markers were then placed on four anatomical locations on both lower extremities: (1) greater trochanter of the femur, (2) lateral epicondyle of the femur, (3) lateral malleolus of the fibula, and (4) distal portion of the fifth metatarsal. For the athletic shoe condition, the foot was palpated through the shoe and the marker was placed on the shoe above the distal portion of the fifth metatarsal. A researcher then demonstrated the task of running to the participants. Each participant ran through the capture volume at a self-selected pace for a distance of 7.6 m. Participants were encouraged to run as fast as they could. For the capture volume, a Canon 3CCD Digital Video Camcorder was placed perpendicular to the sagittal plane of the motion, 5.8 m away. This process was repeated for the other participant. After the successful completion of data collection for both participants, the participants footwear was switched and the data collection procedures were repeated.

The kinematic variables of interest were stride length (SL), average hip velocity in the x direction (V_{HX}), and peak ankle dorsiflexion during the swing phase of the non support leg (θ_{DSW}). Digital video was digitized post data collection using Ariel Dynamics APAS v12.2.0.1. SL was determined using the lateral malleolus marker from initial contact of the right foot until initial contact of the ipsilateral limb. θ_{DSW} was calculated as the angle between the lower leg (as determined by the line from the lateral epicondyle of the femur to the lateral malleolus) and the foot (as determined by the line from the lateral malleolus to the distal end of the fifth metatarsal). Data were analyzed with a one-way ANOVA with repeated measures for each dependent variable, SL, V_{HX} and θ_{DSW} .

RESULTS AND DISCUSSION

The result of this study show a significant main effect of footwear on SL. Specifically, the flip-flops resulted in shorter stride length than athletic shoes (Table 1). The findings align with previous research that demonstrates a decreased stride length in adults who wore flip-flops [2]. A possible explanation for the decreased stride length is the decreased mass of the flip-flop, which would decrease the inertia of the foot during the swing phase [3]. Another explanation could be that the children take a shorter stride to decrease the swing phase in an attempt to keep the flip-flop on the foot. Therefore, the child may want to (a) get the foot back to the ground to take advantage of the assistance of the ground and/or (b) strike the ground with foot in a more horizontal position. This phenomenon was noted by DeWit and colleagues (2000), in a study comparing barefoot versus shod conditions. This study resulted in shorter step lengths and larger step frequencies in the barefoot condition, and they attributed the results to a different “touch down” geometry [4].

Surprisingly, there was not a significant main effect of footwear on V_{HX} (Table 1). Particularly in light of the significant stride length difference. The combination of these two outcomes (stride length and velocity) indicate that even though the children had longer strides, when they wore athletic shoes, they did not have an increased velocity in the x direction. It is hypothesized that the lack of significance was due to the relatively few number of participants and not the mean difference of $.27 \text{ ms}^{-1}$.

It was hypothesized that there would be a decreased dorsiflexion angle due to the implied moment at the ankle from the toe flexors trying to “grip” the flip-flop; however, no differences were observed at the ankle during the swing phase (Table 1).

CONCLUSIONS

There is an abundance of literature of the effects of footwear type, design, or modification on gait mechanics; however, it is lacking in the area of the effects of flip-flops on gait mechanics. This study illustrates that thong style flip-flops do alter the performance of the task of running in preschool-age children as seen in the decreased stride length, while wearing flip-flops. Whether the result of a decreased stride length is a direct result of altered mechanics to keep the flip-flop on the foot or because of the mass differences in the footwear is still in debate.

In conclusion, there was a difference in stride length in preschoolers while wearing thong flop-flops when compared to athletic sneakers. There were no differences in dorsiflexion angle or hip velocity.

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Table 1: Effect of footwear on SL, V_{HX} , and θ_{DSW} ($p \leq .05$). Significance noted*

	Footwear	N	Mean	SD	<i>F</i>	<i>p</i>	η^2	Power
SL (m)*	Flip-flops	12	1.3921	.159	9.366	.011	.460	.795
	Sneakers		1.6723	.340				
V_{HX} (ms^{-1})	Flip-flops	12	2.7102	.458	2.773	.124	.201	.331
	Sneakers		2.9819	.521				
θ_{ASW} (°)	Flip-flops	12	102.83	5.23	.608	.452	.052	.110
	Sneakers		104.99	8.92				