TRANSITIONING TO THE NEXT LEVEL: FOOT POSITION AND HIP MUSCLE ACTIVTY DURING STAIR WALKING

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INTRODUCTION

Stairs are everywhere. And although using stairs is a common and simple task, anyone can be seriously injured when traveling up or down stairs. In fact, according to the National Safety Council, accidents during stair walking are ranked as high as second among the primary causes of unintentional injuries [1].

In order to maintain lateral stability during walking in the natural environment, we continually modify foot placement in an effort to modulate our base of support. The base of support can be improved with increased lateral step width and increased external foot rotation. We define step width as the lateral distance between the two calcanea (heels) during double support stance and external rotation as the lateral distance between the two halluces (toes) with respect to the line of progression during stance [2]. Thus, the measurement of step width and external rotation provides functional insight regarding lateral stability.

The hip adductors and hip abductors aid in the control of foot placement during level walking. The adductor longus (ADL) is active during terminal swing for the control of foot placement and single support stance for pelvic stabilization [3]. The tensor fascia latae (TFL) is active during the first third of stance in order to steady the pelvis and during the first half of swing in order to promote foot clearance [3]. Currently, there is no published data documenting how the muscle activity of these two muscles is modified during up or down stair walking.

The purpose of the present study was to determine if foot placement and hip muscle activity are modified during transitions between level and stair walking. We hypothesized that, compared to level walking, lateral step width, measured at the heel, and external foot rotation, measured at the toe, would be larger during the transition strides between level and stair surfaces. Likewise, in order to accomplish this wider foot placement, we hypothesized that mean abductor muscle activity would be less while mean tensor fascia activity would be greater than level walking during the transition strides.

METHODS

Six men and six women completed the protocol. All of the walking trials were completed at a self-selected velocity on a 25 m walkway. We utilized a custom-built portable apparatus composed of four stairs (20.32 cm rise x 27.94 cm run) continuous with a 3.66 m plateau.

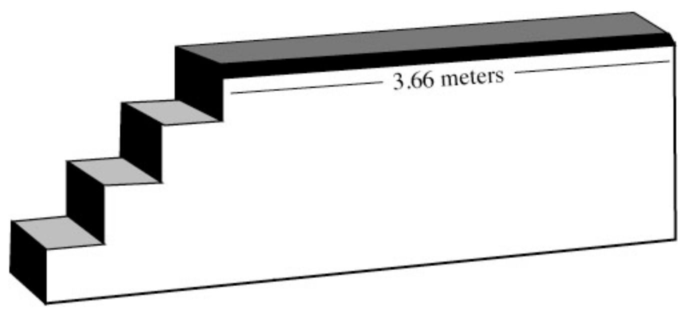

Figure 1. Portable stair apparatus.

In addition to level walking, we collected 5 stair walking trials for each of the following 6 conditions; transition from floor to up stair (L-UP), up stair only (UP), transition from up stair to plateau (UP-L), transition from plateau to down stair (L-DN), down stair only (DN), and transition from down stair to floor (DN-L).

We collected kinematic data with a six-camera, passive marker 3D photogrammetry system and electromyography signals using a wired amplifier system. Prior to data collection, we placed retroreflective markers on the first metatarsal (toe) and posterior calcaneus (heel) of both shoes for each participant. In addition, we placed surface electrodes on the tensor fascia latae (TFL) and adductor longus (ADL) muscles.

Foot placement and muscle activity were analyzed across all conditions using a repeated measures design (ANOVA) and Newman-Keuls post hoc tests. Significance was defined as $p \leq 0.05$.

RESULTS AND DISCUSSION

In support of our hypothesis, compared to level walking, step width and external rotation were larger during all down stair conditions and step width was larger during the transition from level walking to up stair walking. Interestingly, external rotation was smaller during the up stair conditions, possibly as an effort to maximize propulsion [4].

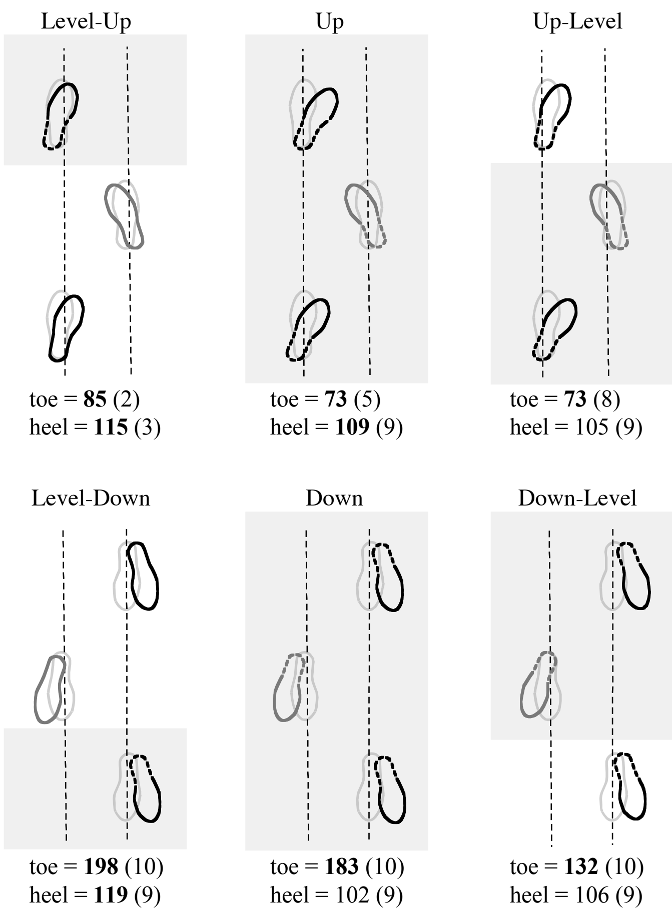

Figure 2. Schematic representation of toe and heel placement as a percentage of level walking. The values are mean *(standard deviation)* for the 6 participants. The bold values indicate a statistically significant difference ($p < 0.05$) compared to level walking. The shaded areas represent the stairs. The transparent shoe prints represent the level walking placement and the superimposed black (left foot) and grey (right foot) shoe prints represent how the placement changed during each stair condition. Please note that the dashed heel print represents steps where the forefoot contacted the ground first to initiate stance.

ADD	*swing*	*stance*
L-UP	**200** *(22)*	**186** *(32)*
UP	**257** *(31)*	**192** *(28)*
UP-L	**237** *(25)*	**147** *(21)*
L-DN	**77** *(18)*	**141***(26)*
DN	**77** *(21)*	**159** *(17)*
DN-L	**85** *(27)*	**146** *(16)*

TFL	*swing*	*stance*
L-UP	104 *(42)*	**243** *(51)*
UP	**163** *(41)*	**166** *(64)*
UP-L	**144** *(55)*	106 *(68)*
L-DN	107 *(52)*	**124** *(57)*
DN	**132** *(52)*	**139** *(60)*
DN-L	**128** *(51)*	97 *(34)*

Table 1. Adductor longus (ADD) and tensor fascia latte (TFL) data during swing and stance for each of the six experimental conditions as a percentage of level walking. The values are mean *(standard deviation)* for the 6 participants. The bold values indicate a statistically significant difference ($p < 0.05$) compared to level walking.

CONCLUSIONS

To summarize, in comparison to level walking, during the up stair walking conditions, step width was larger while external rotation was smaller. During the down stair walking conditions, both step width and external rotation were larger. These results illustrate that the transition from level to stair surfaces did, in fact, challenge lateral stability. In order to maintain stability, the participants increased their base of support with a wider step width and decreased adductor activity.

REFERENCES

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