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Spatiotemporal gait pattern in children with and without Down Syndrome while walking from level surface to stairs

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Spatiotemporal gait pattern in children with and without Down Syndrome while walking from level surface to stairs

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Introduction

Children with Down syndrome (DS) display a delayed motor development, and show clumsy and less coordinated gait pattern [1]. Compared to typically developing children (TD), children with DS walk with a notably slower speed, a shorter stride length, a limited range of motion in ankle joint with increased plantar flexion, and reduced dorsal flexion throughout the gait cycle [2, 3]. When negotiating an obstacle, children with DS show shorter stride length and greater step length variability, and stop in front of the obstacle before stepping over it [4].

Few study has been conducted to investigate the biomechanical pattern of stairs walking in children with DS. The purpose of this study was to understand the spatiotemporal gait pattern of children with and without DS while walking from level surface to stairs.

Method

Participants: There were 11 TD children (4 M/7 F) and 5 children with DS (2M/3F). Mean (SD) age of the TD group was 7.7 (1.6) years, height 1.30 (0.09) m, and mass 29.1 (6.3) kg. Mean (SD) age of the DS group was 9.3 (2.6) years, height 1.24 (0.09) m, and mass 33.4 (13.0) kg.

Experimental design: There were three custom three-step wooden staircases with different riser heights: 17cm (LS), 24cm (MS), and 31cm (HS). Participants were asked to walk along the 5-meter walkway, and then step up the three-stair cases. Each participant completed five trials for each staircase and the order of the conditions was randomized. A Vicon full-body PSIS model and an 8-camera Vicon motion capture system was used for data collection.

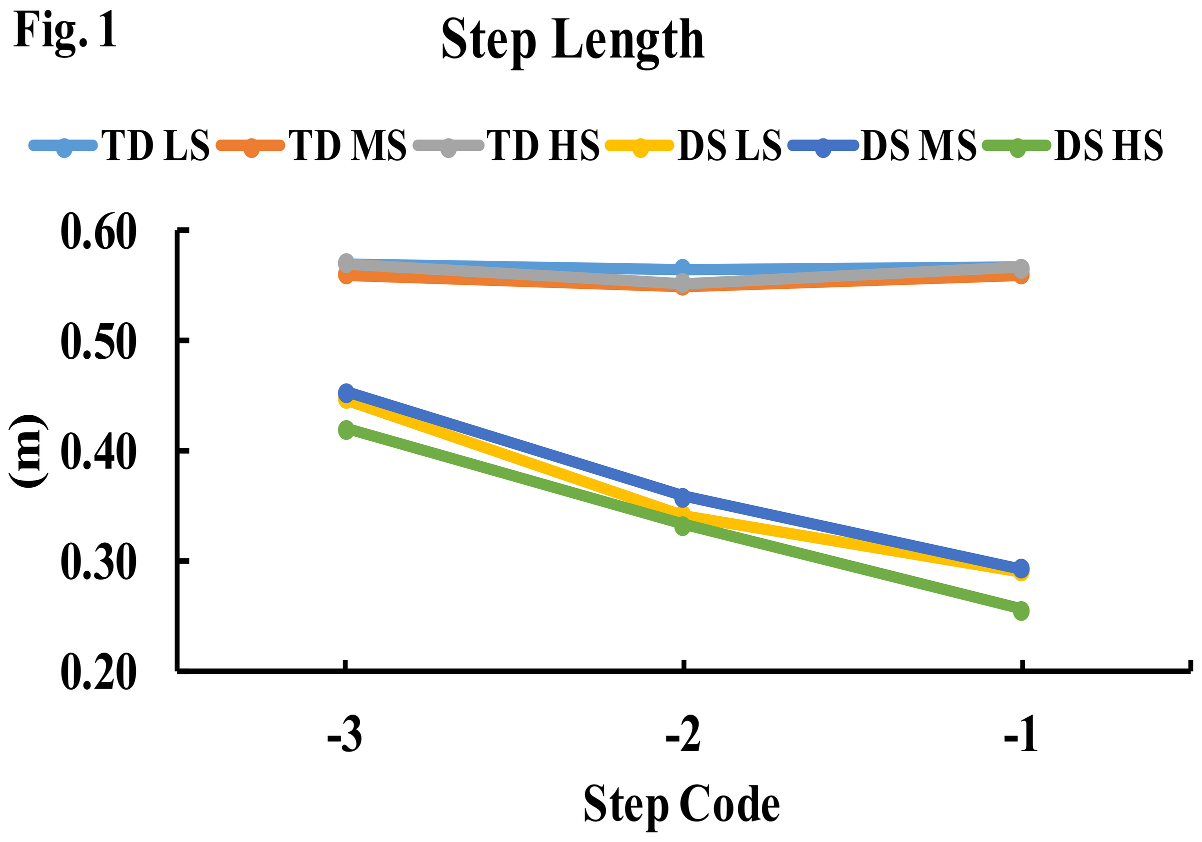
Data analysis: Customized MATLAB program was used for data analysis. Heel markers were used to identify gait events for the last 3 steps before walking up the stairs (i.e., approaching phase), coded as step -3, -2, and -1 from farthest to the nearest to the stairs. Toe markers were used to identify gait events of the first 2 steps while walking up the stairs (i.e., ascending phase), coded as step 1 and 2.

Spatiotemporal parameters included step length and width during the approaching phase, and vertical toe clearance and horizontal toe velocity when the toe was above the edge of the stairs during the ascending phase.

Statistical analysis: A series of 3-way (group x stairs x step) mixed ANOVA with repeated measures were conducted on dependent variables. Post-hoc pairwise comparisons with Bonforreni adjustments were conducted when appropriate. Statistical significance was set at α=0.05.

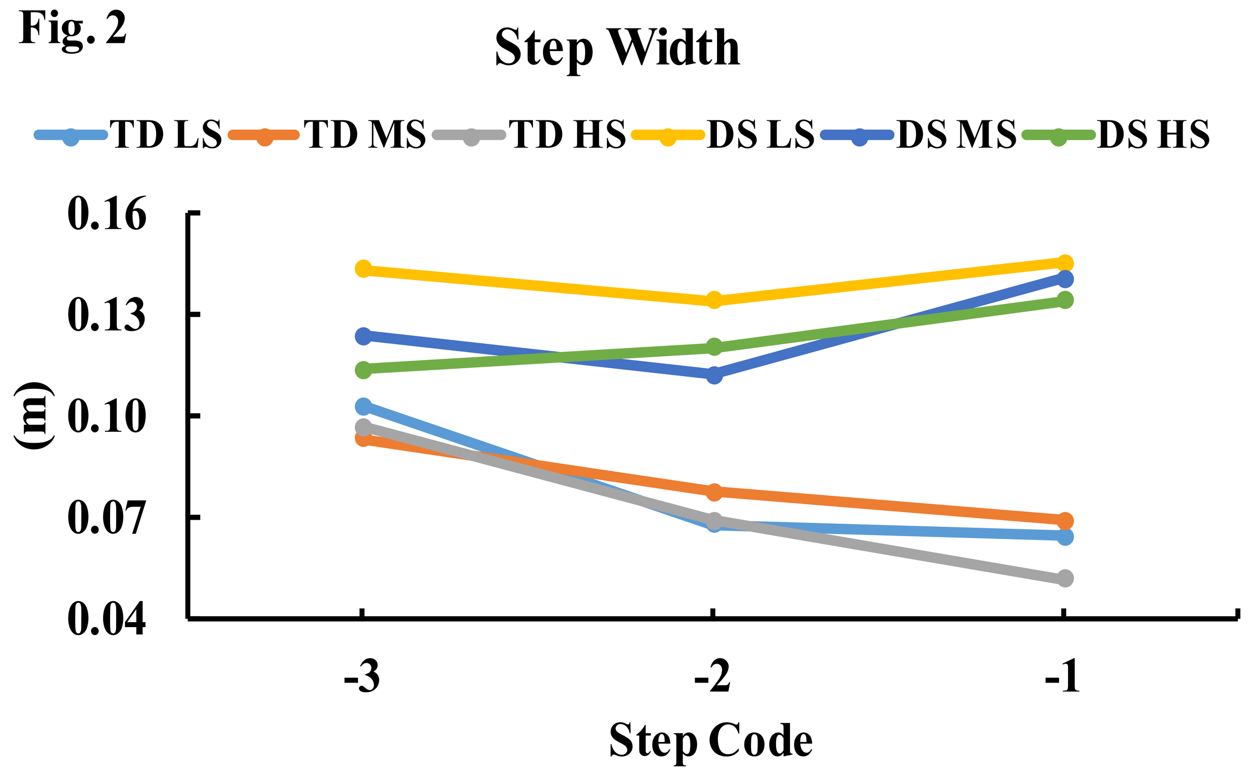
Results and Discussion

Fig. 1



The DS group showed a shorter step length than the TD group at the approaching phase. While the TD group walked with a similar step length, the DS group shortened their step length in sequence from step -3 to -1. Stair height did not affect step length in both groups (Fig. 1).

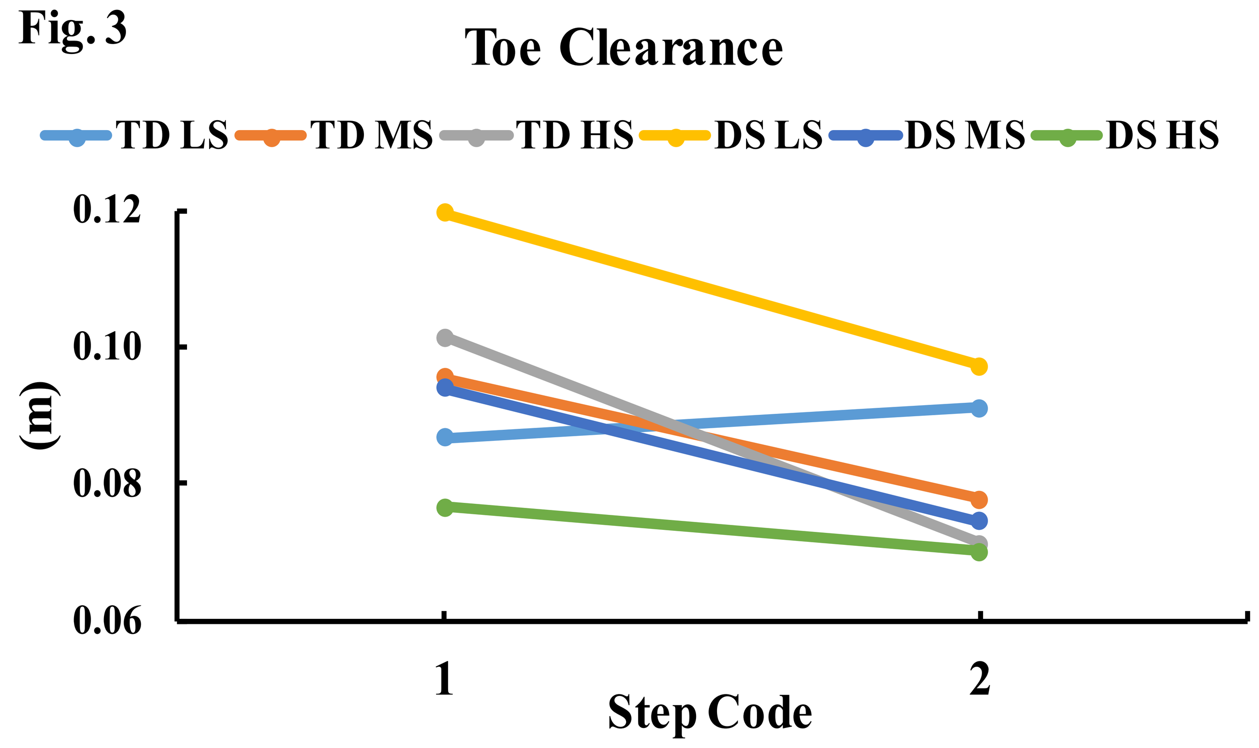
Fig. 2



The DS group displayed a narrower step width than the TD group during the approaching phase. While the TD group decreased step width in sequence from step -3 to -1, the DS group increased step width correspondingly (Fig. 2).

While walking to the staircase, the DS group shortened their step length and widened their step width to prepare themselves for a challenging motor task.

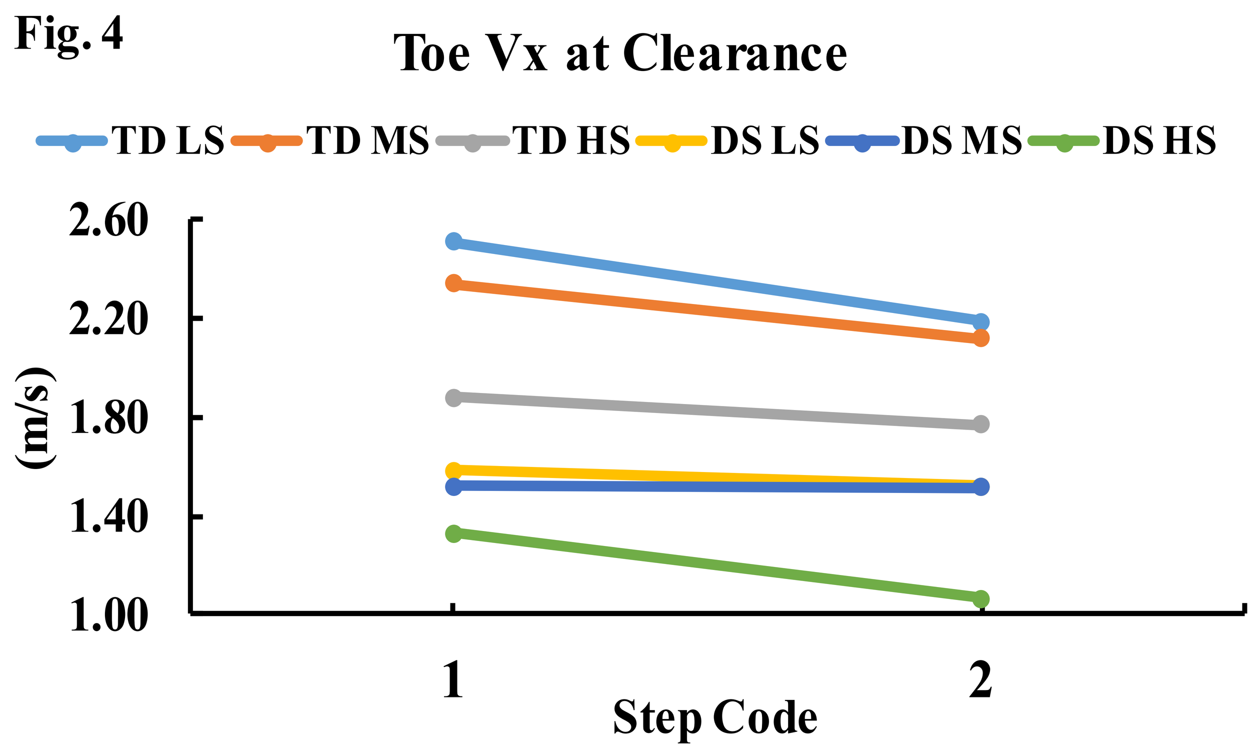
Fig. 3



Both groups showed a higher vertical toe clearance at step 1 than at step 2. The TD group had a similar clearance for difference heights. The DS group had a higher toe clearance at LS and MS and a lower clearance at HS than the TD group (Fig. 3).

The TD group was able to predict the height and made adjustment accordingly. The DS group cleared the LS and MS by a big margin, but markedly reduced the clearance in the HS condition, signifying their limited motor ability to negotiate higher stairs.

Fig. 4



Both groups displayed a faster velocity at step 1 than step 2. The DS group showed a slower horizontal toe velocity than the TD group. Also, with the increase of stair height, there was a decrease in toe velocity in both groups. (Fig. 4).

The DS group seemed to take slower and more cautious steps while walking up the stairs.

Conclusions

During the approaching phase, the DS group displayed a more cautious gait with a shorter step length and a larger step width. During the ascending phase, the DS group displayed some good adjustments in horizontal toe velocity but not in vertical toe clearance.

References

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