EFFECTS OF WIDE STEP WIDTH ON STAIR ASCENT KNEE KINETICS IN OBESE PARTICIPANTS

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INTRODUCTION

The obese population is 6.8 times more likely to develop knee osteoarthritis (OA) [3]. Medial compartment knee OA is associated with an increased internal knee abduction moment during level walking. Obese participants display an increase in non-normalized peak knee extension moments and knee abduction moments, compared to healthy-weight individuals [2].

Stair ascent studies have found that healthy-weight participants exhibit greater normalized peak knee extension moments and decreased knee abduction moments [6], compared to level walking.

A wider step-width (SW) has been shown to reduce the peak knee extension moment and knee abduction moment during level walking, and stair ascent[1, 4, 7]. However, this has not been studied in an obese population. The purpose of this study was to determine the effects of increased SW on knee biomechanics during stair ascent of obese and healthy-weight participants.

METHODS

Fourteen healthy-weight (age: 21.6±0.5 years, height: 1.7±0.1 m, mass: 66.3±9.3 kg, BMI 22.5±1.9 kg/m^2) and ten obese (age: 25.7±5.8 years, height: 1.7±0.1 m, mass: 100.6±12.6 kg, BMI 32.8±2.7 kg/m^2) participants were recruited to participate in the study. All participants were between 18 and 40 years old. Obese participants had a BMI between 30.0 and 39.9 kg/m^2, while healthy weight participants were between 18.0 and 24.9 kg/m^2.

A 12-camera motion analysis system (240 Hz, Vicon Motion Analysis Inc., UK) was used to obtain the three-dimensional kinematics during the test. Reflective anatomical and tracking markers were placed on both sides of feet, ankles, legs, knees, thighs, and hips. Each participant performed five successful trials of stair ascent in each of two test conditions, preferred and wide SW. SW was defined as the mediolateral distance between the center of masses of both feet during midstance. The wide SW was set as twice the participant's preferred SW, which has been shown to significantly reduce loading-response knee abduction moment [4, 5]. SW was calculated using the second and third steps. A speed range, average speeds ±5%, was used to monitor the speed of movement trials.

A low-pass 4th order Butterworth filter at a cutoff of 8 Hz for kinematic and joint moment calculations, and at 50 Hz for GRF calculations. A 2 x 2 (Group x SW) mixed design analysis of variance (ANOVA) was performed to analyze selected variables (22.0 IBM SPSS, Chicago, IL). An *a priori* alpha level was set to 0.05 for all statistical tests.

RESULTS AND DISCUSSION

A wider SW reduced loading-response peak vertical GRF (p=0.045, Table 1). The obese group demonstrated significantly larger loading-response and push-off peak vertical GRFs (both p<0.001).

Significant Group x SW interactions were observed for both loading-response and push-off peak medial GRFs (all p<0.001, Table 1). This interaction indicated that the obese group increased to greater extents. The post hoc comparisons showed that the obese group had greater mean loading-response peak medial GRF during both preferred (p=0.008) and wide (p=0.001) SW compared to the healthy-weight group. Additionally, the obese group demonstrated greater mean push-off peak GRFs for preferred (p=0.033) and wide (p=0.001) SW (Table 1).

Obese participants had significantly larger loading-response peak knee extension moments ($p < 0.001$). The interaction approached significance for the loading-response peak knee abduction moment ($p = 0.051$) (Table 1). Post-hoc comparisons revealed that only obese participants experienced a decrease in knee abduction moment when SW was increased ($p=0.020$). During push-off, an interaction ($p=0.022$) was seen for peak knee adduction moment, suggesting that the wide SW increased the peak knee adduction moment for both groups, but obese participants showed a greater increase than the healthy-weight group. Post-hoc comparisons revealed that wide SW increased the push-off peak knee adduction moment in both obese ($p=0.003$) and healthy-weight ($p<0.001$) participants. Obese participants had greater push-off peak knee adduction moments during preferred ($p=0.003$) and wide ($p=0.030$) SW conditions.

This study was performed to find differences in knee biomechanics of obese and healthy-weight people during stair ascent at their own preferred and wider SW. We found that obese participants experienced higher medial and vertical GRFs, loading-response peak knee extension moments, and push-off peak knee adduction moments. A significant decrease in the loading-response knee abduction moment in the obese population indicates that a clinical modification to train obese participants to ascend stairs with a wider SW may lower loading on the medial knee compartment.

CONCLUSION

Further research should be performed to expose how SW effects biomechanics of the hips and ankles in obese and healthy-weight individuals. Investigation of the effects of increased SW may benefit from investigating muscle activation and joint loading patterns through modeling software such as OpenSim. Lastly, intervention studies on the efficacy of an increased SW gait modification on the obese population are merited to determine the extent in which this modification may help reduce the risk of development of knee osteoarthritis in this population.

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Table 1: Peak Mediolateral and Vertical GRFs (N), Knee Extension and Knee Abduction Moments (Nm) for Stair Ascent: mean ± STD.

	Healthy		Obese		Int.	Grp.	SW
Variable	Preferred SW	Wide SW	Preferred SW	Wide SW	p	p	p
LR Peak Vertical GRF	759.6±96.0[a,#]	728.6±85.2[#]	1079.2±106.5	1069.0±150.9	0.296	**<0.001**	**0.045**
PO Peak Vertical GRF	823.8±142.2[#]	820.3±118.9[#]	1136.8±111.0	1163.0±114.6	0.349	**<0.001**	0.472
LR Peak ML GRF	-39.0±14.1[a,#]	-91.78±20.3[#]	-59.3±20.4[a]	-135.5±35.1	**<0.001**	**0.002**	**<0.001**
PO Peak ML GRF	-29.7±17.3[a,#]	-82.2±24.9[#]	-48.9±24.5[a]	-131.6±40.1	**<0.001**	**0.004**	**<0.001**
LR Knee Extension Moment	104.1±22.6[#]	105.3±25.2[#]	153.8±26.3	159.7±29.4	0.264	**<0.001**	0.091
LR Knee Abduction Moment	-21.8±11.1	-20.7±7.7	-25.0±11.3[a]	-18.5±14.2	0.051	0.904	**0.009**
PO Knee Adduction Moment	10.8±4.2[a]	15.0±5.7[#]	17.7±15.8[a]	27.5±12.6	**0.022**	**0.022**	**<0.001**

a: Significantly different from Wide SW of the same subject group, #: Significantly different from Obese of the same SW, ML: Mediolateral, LR: Loading Response, PO: Push-off Response, GRF: Ground Reaction Force, Int.: Interaction, Grp.: Group Main Effect, SW: Step Width, Bold: p-values indicate significance.