TREKKING POLE FORCES DURING DOWNHILL WALKING

Michael Bohne[1], Greg Dixon[2], and Julianne Abendroth[2]

Utah Valley University, Orem, Utah USA[1]
Willamette University, Salem, Oregon USA[2]

This study examined gender differences when hiking downhill with trekking poles. Fourteen men and thirteen women were recruited who had hiking and poling experience. Integrated pole forces were examined over two pole strikes (left pole followed by right pole) prior to and during a stance phase of a step. Total pole force was compared between gender, as well the percent of pole force during the actual stance phase of the step. Left and right pole strikes were also examined for symmetry. Men generated a greater combined pole force than women (0.61N/kg vs. 0.48N/kg) but the differences were not statistically significant. During the stance phase, 48% of the combined pole force occurred for men, but only 35% of the pole force was noted for the women. Pole forces were less symmetrical for the women as well, although also not statistically different. Similar total pole forces between gender with less pole force during stance phase indicates pole walking technique differences rather than a lack of upper body strength, for women, who previously demonstrated less footfall force changes when walking with poles than without, in comparison to men.

KEYWORDS: gait, hiking, gender

INTRODUCTION: The effects of trekking pole use while walking downhill have been well established including significant decreases in foot plant forces (ground reaction forces (GRF), braking forces (BF)) and muscle activity of the lower extremity (Bohne & Abendroth, 2007; Schwameder, Roithner, Muller, Niessen, & Raschner, 1999, Willson, Torry, Decker, Kernozek & Steadman, 2000); however, the mechanism behind these effects is not well understood. Theoretically, with pole use, a portion of the force acting on the body is transferred to the upper extremity, thus decreasing the forces acting on the lower extremity (pole loading). Previously, it has been demonstrated the effects seen with hiking pole use are the result of pole loading during the stance phases of walking. This research also indicated that men appear to use poles more effectively than women when walking downhill (Abendroth, Dixon, & Bohne, 2009). However, it remains unclear whether the lesser force reduction noted in the previous study was due to women being unable to load the poles as effectively as men. It has been suggested that women lack the necessary upper body strength to transfer forces to the upper extremity with pole use.
Therefore, the purpose of the current study was to compare poling forces between men and women during downhill walking, before and during the stance phase of a step. Specific goals were to examine pole loading during a full stride (left and right pole strike), beyond a specific stance phase, between gender. It was hypothesized that significantly different pole load forces, per body kilogram, would be seen between men and women. This would correlate with previously examined decreases in foot plant kinetics, thus supporting the idea that women lack in upper body strength, and so unweight to a lesser degree than men are able to. If women do in fact load the poles in a similar manner as men, then pole walking techniques may be the reason behind the differences in subsequent foot force differences between gender. A secondary goal of the research was to examine pole force symmetry, when walking with two poles. Pole force asymmetry may also indicate walking technique differences.

METHOD: Twenty-seven healthy volunteers with previous hiking and pole use experience were recruited, and all signed informed consents (14 men, 13 women: age 39 ±12; 43±13 and mass 82.2 ±6.5; 61.2±7.1 kg, respectively). Approval for the study was obtained from the University IRB.

Participants were instructed to wear their preferred hiking shoes, and then assigned to walk in a predetermined, counterbalanced order which included a no pole (NP) and a pole (P) condition. Participants walked at a self-selected pace, although walking speed was held constant between conditions using a Brower timing system. Additionally, the participants used a self-selected poling technique. Pole length was self-selected due to the experience of the participants. Participants completed 10 successful trials (complete force plate contact during "natural stride") in each condition.

A wooden ramp with ascending and descending 20 degree slopes (3.3 m descent) was used to simulate a hiking experience. A Bertec force plate (40 cm x 60 cm; 1000Hz) mounted flush in the down slope portion of the ramp was used to collect ground reaction and braking forces (GRF/BF). Bertec instrumented Leki trekking poles (1000 hz) were used to measure pole load. Pole forces were collected via Bertec Acquire software. All data were collected simultaneously over 3 second intervals during the downhill portion of the walk. Pole forces were examined over two pole strikes, consisting of a left and right side strike, prior to and during the foot strike on the force plate. The pole forces were integrated and averaged over ten trials, for both sexes. The loads were then normalized to body mass (N/kg) for each participant. Data collected prior to, during and after the stance phase (when the participant's foot was in contact with the force plate), were used to perform analyses between pole forces and gender.

Two pole loads, consisting of the left and right strike prior to and during the collected left side stance phase of the foot strike were synchronized with the stance phase of the force data. The average loads generated for both poles during this stance phase were integrated and averaged over the ten trials. Left and right integrated pole forces were compared with each other, and between gender. Percent of poles forces used during the stance phase of one step divided the integrated pole force was also calculated and compared between gender. Statistical analyses were performed using SPSS(version 16.0). Comparisons were made between men and women for the pole forces using a mixed 2-way ANOVA (pole side x gender). Percent of pole forces during the stance phase were compared using a Chi-Square test. Statistical significance was set at an alpha = .05 for comparisons. Statistical power was calculated to be 80%, based on the selected sample size and an effect size of 0.7.

RESULTS: Figure one demonstrates the average (SD) for left and right pole use (with a left foot strike on the force plate), between gender, as well as the amount of force generated by pole use only during the stance phase of the foot strike. The men, on averaged produced integrated pole forces of 0.30 and 0.31$\pm$15 N/kg for left and right pole strikes. Women produced 0.22 and 0.26$\pm$.14N/kg for their respective pole strikes. For men, the stance phase pole forces were 48.5% (0.29 N/kg) of the total pole force used when the left and right pole forces were combined. The women used 35.2% (0.17N/kg) of the combined pole force during their stance phase.

The 2 way mixed ANOVA demonstrated no significant main effects for gender (F= 1.49, df = 1, p= .234). The main effect of pole symmetry was also non-significant (F=2.95, df = 1, p = .098). Interaction between pole symmetry and gender was not statistically significant as well (F= 0.67, df=1, p=.42). Effect sizes (ES) were examined between gender for practical significance. A moderate effect size was noted for the combined integrated pole force (ES = 0.44) between gender. Pole symmetry ES for women was moderate at .36 but men's were low at .10. A significant difference between the percent of pole force use during stance phase with men and women (p=.035) was noted, using a Chi Square.

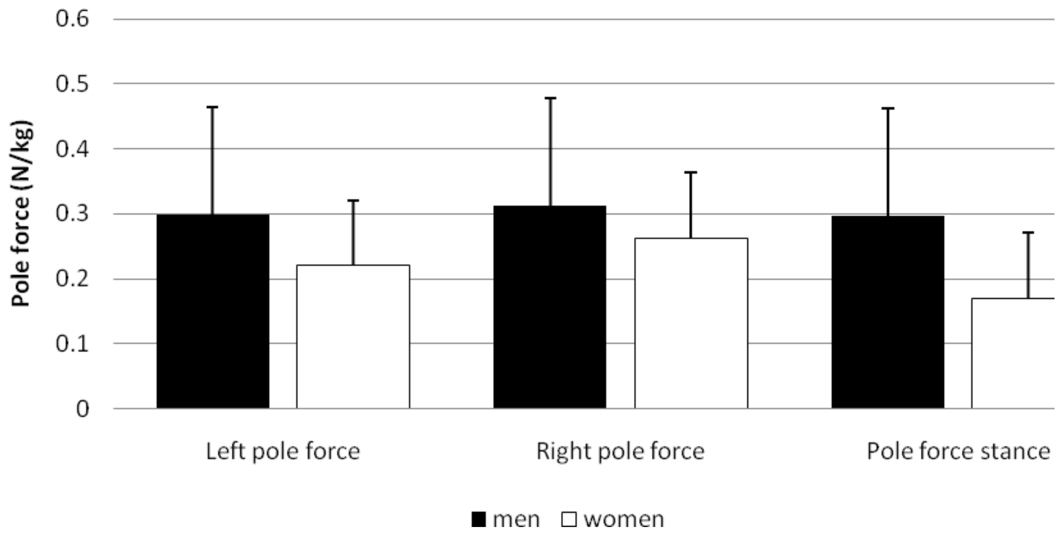

Figure 1. Forces applied to left and right poles during a pole plants (beyond and during stance phase) as well as total pole force used during stance by gender.

High variability within gender was noted for poling forces. Patterns were examined for age or experience with trekking poles, in relation to the pole forces, but no patterns could be discerned.

DISCUSSION: The primary purpose of this study was to examine gender differences with trekking pole loads prior to and during a stance phase of a downhill hike. This would better discern the role of using poles for unweighting vs. stability pole walking technique differences. Men do load the poles greater than women, even when normalized. However, this difference, when examining two full pole strikes, is relatively small. For a typical 70 kg male, the poles would be loaded with an average force of 42.7 N between the two poles (approx. 6% BW). The typical 50kg woman would load her poles with an average force of 24N (approx 5% BW). However, for men, 48% of the pole force was administered during the stance phase; while only 35 % of the pole force is noted during the stance phase for women. This may support the idea that women are not using to poles predominately to unweight but for other reasons, intentional or not. Previously it has been hypothesized that women employ an altered technique due to a lack of upper body strength to effectively unweight themselves during pole plants. However, the current results may indicate that there is a difference in technique of women while walking with poles, but may not be related to an upper body strength issue but rather to increase stability during the descent.

Previously reported foot strike data using the force plate included women, on average, demonstrating similar forces when using poles in comparison to no poles, except for peakFz. Men demonstrated decreased peak forces in both vertical ground reaction force (VGRF) and BF, but the integrated forces were similar during the poling condition and non-poling conditions. Specifically, an average reduction of peak VGRF of 1.1 N/kg for men, and only 0.09 N/kg for women was noted. The average braking forces were reduced for men by 0.46 N/kg while women increased their braking forces with poles, by 0.12 N/kg. (Abendroth, Dixon, & Bohne, 2009)

Pole load symmetry was noted as a secondary factor; women demonstrated less symmetry with left and right pole strikes than did men. It is possible, that while this asymmetry was small, it may be a further indication of technique differences between gender when walking with trekking poles. Additionally, dominant were not controlled and may lead to an explanation of the asymmetry. There is also a possibility that the velocity between walkers may play a role (although held constant within each participant), however, was not controlled in the current study.

Lastly, high variability among gender limits the strength of the conclusions. It was also noted that age and experience with trekking poles did not correspond to the pole loads noted.

CONCLUSION: Gender alone does not appear to a predominant indicator in effective pole use. However, technique differences may be more responsible for lesser transfer of forces from the lower extremities by women, than upper body strength, since women seem to load the poles at similar levels as men, when normalized to body mass. Examining the location and timing of pole plants, relative to foot strikes, may further indicate techniques differences with trekking pole walking, between gender. However, upper body strength was not measured in the current study and its role can be further analyzed.

REFERENCES:

Abendroth, J., Dixon, G., & Bohne, M. (2009) Gender differences in instrumented trekking poles use during downhill walking. 27th International Conference on Biomechanics in Sports. Limerick, Ireland. pp. 785-789.

Bohne, M., & Abendroth-Smith, J. (2007). Effects of hiking downhill using trekking poles while carrying external loads. *Med Sci Sport Exer,* 39(1), 177-183.

Schwameder, H., Roithner. R., Muller, E., Niessen, W., Rschner, C. (1999) Comparison of lower extremity joint kinetics during downhill walking with and without poles. *Journal of Sport Sciences*. 17:969-978.

Willson, J., Torry, M.R., Decker, M.J., Kernozek, T., & Steadman, J.R. (2000). Effects of walking poles on lower extremity gait mechanics. *Med Sci Sport Exer,* 33(1), 142-147.

Acknowledgement

The authors would like to thank Bertec Corp. for their efforts in designing and building the instrumented hiking poles.