GENDER DIFFERENCES IN INSTRUMENTED TREKKING POLE USE DURING DOWNHILL WALKING

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This study examined gender differences when hiking downhill with and without trekking poles. Fourteen men and thirteen women were recruited who had hiking and poling experience. Integrated and peak GRF and braking forces (BF), integrated EMG, and trekking pole forces were collected and analyzed. A MANOVA using mean gain scores examined statistical significance (p=.05). Moderate correlations were noted for pole forces and the dependent variables, but no statistical significance was found for the mean gain scores between gender. Trends were noted for peak Fz and BF between gender, with men demonstrating a greater reduction in forces. Men on average also generated greater pole loads, even when normalized for body mass. Four distinct patterns of pole use effectiveness were observed posthoc, but crossed gender lines. Overall, pole loading may be a contributing mechanism to a reduction in forces and muscle activity for men more so than women, but high subject variability limits the strength of this conclusion.

KEY WORDS: gait, hiking, forces, electromyography

INTRODUCTION: The benefits of hiking have been well established, but can be reduced by the incidence of injury or pain (Heggie & Heggie, 2004). Walking downhill causes changes in gait that increase the forces and moments acting on the body, including increased muscle activity of the lower extremity (Kuster, Sakurai & Wood, 1995) which increase the risk for overuse injury (Knapik, Harman & Reynolds, 1996). Trekking poles are thought to counteract the potentially harmful effects by reducing forces on the lower extremity. The effects of trekking pole use have been well established including significant decreases in foot plant forces (GRF, BF) and muscle activity of the lower extremity (Bohne & Abendroth, 2007; 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). No study has determined whether the effects seen with hiking pole use are the result of pole loading or some other mechanism that occurs during pole use. Research trends also indicate that men may be using poles more effectively than women when walking downhill (Abendroth, Benson & Bohne, 2003). Therefore, the purpose of the current study was to compare poling and gait forces between men and women during downhill walking. Specific goals were to first examine the relationship between pole load and un-weighting. That is, an increase in pole load was expected to correlate with a decrease in foot plant kinetics (GRF, braking forces (BF)) and muscle activity. The second goal was then to examine gender differences in the relative decrease in foot plant and pole forces, and muscle activity between the poling conditions.

METHODS: 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. 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 was used to simulate a hiking experience. A Bertec force plate (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. Surface electromyographic (EMG) data of the anterior tibialis (TA), gastrocnemius (GA), vastus lateralis (VL), and biceps femoris (BiF) muscles of the participant's dominant leg were measured (Bortec, Inc.). A foot switch in the participant's shoe measured foot stride time. Force plate and EMG data were collected using DATAPAC 2K2 software. Pole forces were collected via Bertec Acquire software. All data were collected simultaneously over 3 second intervals during the downhill portion of the walk. Data collected during the stance phase (when the participant's foot was in contact with the force plate), were used to perform analyses between pole use and gender.

GRF were converted to vertical GRF (VGRF) since the force plate was mounted at a 20 degree angle. Peak and integrated VGRF and BF were averaged over the ten trials for each condition. EMG data were rectified and integrated through a low-pass Butterworth filter at 10 Hz (IEMG). The individual muscles were averaged over the ten trials for each condition, and then summed for overall muscle use. The relative changes in conditions were calculated using mean gain scores (no poles - poles) for all variables. Positive mean gain scores indicated a greater force/activity was generated in the no-pole condition, while a negative mean gain score indicated a greater force/activity was generated for the pole condition. Pole loads were filtered at 500 Hz, and synchronized with the stance phase of the force data. The loads generated for both poles during this stance phase were integrated, averaged, and summed together.

Statistical analyses were performed using SPSS. Correlations between pole loading and the mean gain scores were made using Pearsons r. Positive correlations indicated that with more pole loading, a greater difference was also noted in the change in forces between the no pole and pole conditions (mean gain score). Comparisons between men and women for the mean gain scores between NP/P conditions were performed using a MANOVA. 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(CHECK THIS).

RESULTS: Small to moderate correlations were noted for pole forces to the mean gain scores (no pole – pole) for integrated VGRFs and peak VGRFs for both men and women, as well as for integrated BF and peakBF (see Table 1). However, no statistical significance was noted. Men demonstrated relatively stronger correlations for peak forces, while women demonstrated relatively stronger correlations for integrated forces. Correlations for IEMG were small, although stronger for the women.

Table 1. Correlations of pole forces to mean gain scores (no pole – pole) for integrated vertical ground reaction and braking forces (IVGRF & IBF), peak GRF and BF, and muscle activity.

	IVGRF	peakVGRF	IBF	peakBF	Summed IEMG
men	0.37	0.41	0.20	0.35	0.18
	(p = .09)	(p = .07)	(p = .24)	(p= .11)	(p=.27)
women	0.41	0.31	0.43	0.28	0.39
	(p = .08)	(p = .15)	(p = .07)	(p= .18)	(p=.09)

Mean gain scores for pole use between gender are shown in Figure 1. Women, on average, demonstrated more or similar forces and muscle activity when using poles in comparison to no poles, except for peakFz. Men demonstrated decreased peak forces in both VGRF and BF, but the integrated forces were greater during the poling condition. Less muscle activity was observed, on average, for men when using poles.

The MANOVA revealed no statistically significant differences for any of the force measurements or summed muscle activity, between men and women (Wilkes Lambda F = 7.7, df = 7, p = .37). Pole forces, even when normalized for body mass, was greater for men than women, although also not statistically significant, as part of the MANOVA. Stride time was the timing of a complete stride onto or off of the force plate.

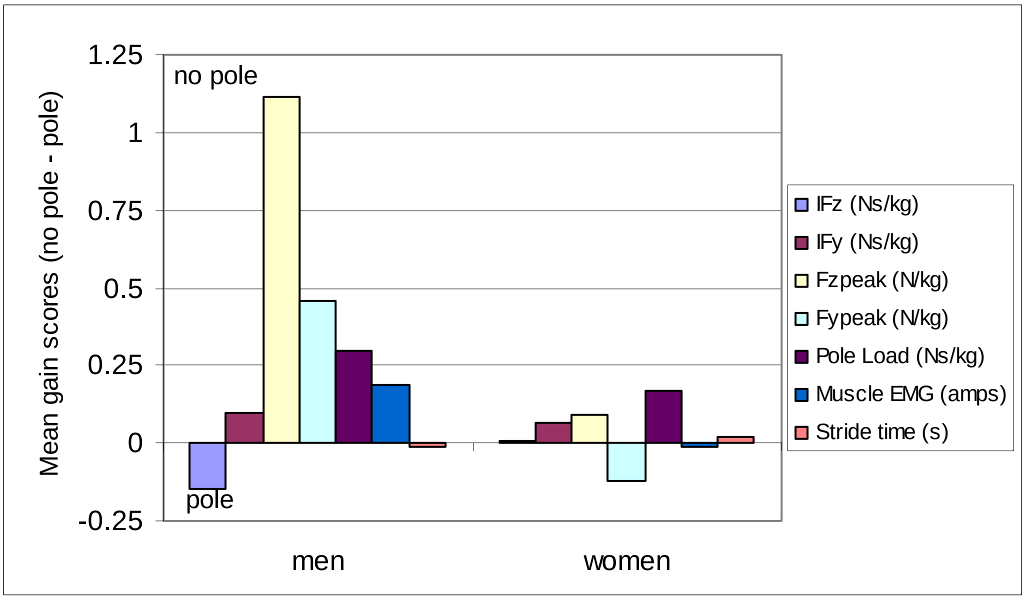

Figure 1. Mean gain scores for no pole vs. pole condition. Positive scores indicate greater force/activity without poles, while negative scores show greater force/activity while using poles.

Effect sizes (ES) were examined between gender for practical significance. Integrated VGRF and BF effect sizes were small (.31 and .15, respectively). Peak forces demonstrated greater ES (.65 and .72, for VGRF and BF, respectively). These differences included an average reduction of peak VGRF of 1.1 N/kg for men, and only 0.09 N/kg for women. For a typical 70 kg person, these peak forces would represent a 77 N reduction for a man, and a 6 N reduction for a similar sized woman. The braking forces were reduced for men by an average of 0.46 N/kg while women increased their braking forces with poles, by 0.12 N/kg. Likewise men reduced muscle activity by 18.7amps, while women increased muscle activity by 1.39 amps, when using poles. A moderate ES was noted at .42.
High variability within gender was noted. The data was reexamined posthoc, for effective pole use, which was defined as a reduction in IVGRF and/ or muscle activity. Four distinct patterns were noted. Eight participants (4 men, 4 women) demonstrated reductions in both forces and muscle activity, which would be the most effective use of poles. The average pole load for this group was greatest. A second group reduced forces overall, but not muscle activity (6 women, 1 man), while a third group reduced muscle activity but not forces, overall (2 women, 6 men). Both of these groups demonstrated similar pole forces. The final group (3 women, 3 men) demonstrated no reductions with pole use, and the pole load was small as well.

DISCUSSION: The primary purpose of this study was to examine the relationship between trekking pole load and the mean differences in foot plant forces and muscle activity for both men and women. Due to the moderate correlations between pole load and the relative decreases in foot plants forces and muscle activity observed, it is surmised that pole loading is partially responsible for the kinetic effects observed during trekking pole use, although the relationships are similar between men and women.
Pole use did not reproduce the expected results of reducing forces and muscle activity, on average, for men or women. While peak forces did decrease on average, with pole use, integrated forces for men increased, perhaps due to a technique difference, since the stride time was not different between conditions. A large variability within gender may have served to confound the results. From a practical significance, some gender differences do seem to exist. Men load the poles greater than women, even when normalized. When grouped by effective pole use, this distinction held true, with the men in the most effective group of lesser forces and lesser muscle activity demonstrating greater pole loading on average, than the

women in the same group. The second pattern of pole use, with lesser forces but greater muscle activity, was noted in more women. This may support the idea that women are not using to poles predominately to unweight, but rather may be using a combination of pole loading with more muscle activity to produce the unweighting effect. This effect may highlighted by the increase in the peak braking force for women when using poles, where the poles are not being used to slow their forward momentum. More men were in the third group of lesser muscle activity, but greater forces with pole use. These participants may be gaining some effect of pole use in terms of lessening muscle activity may lessen fatigue, even though the unweighting effect is missing. The final group, equal numbers of men and women, appear to gain no benefit from pole use. The four distinct pole use techniques appeared to be independent of any particular demographic that could have been predicted or controlled including age, gender, and hiking/pole use experience.

CONCLUSION: Gender alone does not appear to a predominant indicator in effective pole use. While some trends in gender differences were noted with pole use while hiking downhill, no definitive conclusions were drawn. When grouped by like-results, the most effective group who were able to reduce forces and muscle activity with pole use, also produced the greatest pole load, whereas the least effective group (greater forces and more muscle activity, with pole use) also produced practically no pole load, indicating that pole load may in fact be a contributing mechanism behind the effects of trekking pole use. However, as pole load was not strongly correlated to relative decreases in foot plant forces and muscle activity across the entire subject population, it cannot be concluded that pole loading is the only or primary mechanism behind the established effects of trekking pole use.

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