

Exercise Adherence and Physiological Responses in Pedometer and Nordic Walking Plus Pedometer Groups

Elizabeth A. Easley^{1,2,*}, David L. Wenos²

¹Department of Exercise Science, University of South Carolina Lancaster, Lancaster, United States

²Department of Health Sciences, James Madison University, Harrisonburg, United States

*Corresponding author: easleyea@mailbox.sc.edu

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Abstract The purpose of this study was to compare exercise adherence and physiological responses in a Pedometer Only group and a Nordic Walking Plus Pedometer group during an eight-week, free-living walking program. Thirty-four sedentary adults participated in the baseline evaluations which included assessments of resting heart rate, blood pressure, resting metabolic rate, pulmonary functioning, lipid panel, body composition, and volitional peak oxygen uptake. Twenty-five participants completed a follow-up evaluation after 8 weeks of a walking program (Pedometer Only group, n=12; Nordic Walking group, n=13). There were significant changes in resting metabolic rate and body fat with an increase of 189 kcals/day and a decrease of 1.26% body fat overall, respectively. These changes were not significantly different between groups when analyzed for treatment effect. Although there were no statistically significant differences in amount of time walked, the Nordic Walking Plus Pedometer group's median walk time was less than the Pedometer Only group's median walk time. It appears that Nordic walking poles improve physiological indices without affecting exercise compliance.

Keywords: *exercise compliance, walking poles, metabolism*

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1. Introduction

A physically inactive lifestyle, which most American adults lead, is associated with cardiovascular disease and obesity. [1] Although the benefits of exercise are well-established and widely understood, the prevalence of overweight and obesity is still steadily increasing. Lack of time or inconvenience, family and work responsibilities, and health issues are often cited as reasons for attrition in exercise intervention research. [2-8] Psychological aspects such as motivation, locus of control, or self-efficacy also may affect adherence to formal programs. [3,7,8,9] In the research setting, group assignment has also been reported to affect whether the participants will continue with the program or drop out. [2,3,6,10]

Walking is commonly used in exercise interventions likely because it is a familiar mode of exercise; it can be easily incorporated into activities of daily living; and low intensities benefit health. [11] The use of pedometers to quantify exercise is well documented. Some studies have observed the effect of pedometers on motivation or cue to exercise or specifically to count the number of steps walked daily. [10,12-17] Recently, the use of Nordic walking poles has become more popular. Walking poles are used similarly to those used in cross country skiing and add an upper body component to walking. [18] This

potentially increases exercise intensity and energy expenditure, and reduces the load placed on the walker's lower body. [19-23] Utilizing technology, such as pedometers and/or tools, such as Nordic walking poles may influence the way that an individual engages with their physical environment. Brownson et al. [24] reported increases in physical activity in individuals that began using environmental supports such as treadmills, neighborhood streets, or indoor gyms. Therefore, it is possible for the availability of pedometers and/or Nordic walking poles to increase or decrease physical activity. The purpose of this study was to compare compliance to exercise assignment in walking groups and to compare physiological changes between a Pedometer Only (P) group (walking group utilizing only a pedometer) and a Nordic Walking Plus Pedometer (NW) group (walking group utilizing both Nordic Walking poles and a pedometer) after an eight-week walking intervention.

2. Materials and Methods

2.1. Experimental Approach to the Problem

Participants were randomized into one of two exercise assignment groups: P or NW. More specifically, assignment of individuals to groups was based on a restricted randomization, where pairs of individuals were

first matched on body composition within each gender and then each matched pair was randomly split between the two walking groups. Each participant was instructed how to properly use the pedometer (Digi-walker SW-401, New-Lifestyles, Inc., Lees Summit, MO) and the individual's stride length was entered into the device according to the manufacturer's instructions. Nordic walking poles (Leki USA, Inc., Buffalo, NY) were adjusted according to the participants' height (when arms were bent at 90° the participant could comfortably hold the poles) and each participant was instructed in correct pole technique and practiced this technique with the researchers present. Participants were instructed to walk with the poles angled back using an alternating foot-pole strike pattern. The minimum walking goal was 90 minutes for the first six weeks. At week 7, the minimum goal increased to 150 minutes of walking per week. Participants were instructed to only wear their pedometer during exercise sessions. Weekly logs were provided for participants to record the date and the time spent walking. At the end of the week, the participants were instructed to open their pedometer, record the number of steps in their log, and then reset it for the new week.

2.2. Participants

This study was approved by the Institutional Review Board (IRB) and informed consent was obtained from each participant after the procedures, risks, and benefits were thoroughly explained. Participants were recruited via email and word of mouth at a university in the southeast region of the United States. The study was intended for a sedentary population, therefore individuals that scored a 4 ("I am doing vigorous exercise less than 3 times per week or moderate physical activity less than 5 times per week.") or below on the Center for Disease Control and Prevention and American College of Sports Medicine activity guidelines were accepted as participants. [16] Those that met or exceeded the physical activity guidelines of the CDC/ACSM were excluded from this study. Thirty-four participants (30 women and 4 men) began the 8-week program. Participants were recruited 3 different times and were accepted to the program spanning a five-month period. Participants that met the criteria were told that the study was comparing physiological changes between two walking groups. Physiological measures were evaluated pre- and post-intervention. Twenty-five adults (48.84 yr \pm 10 yr; 166.0 cm \pm 7.8 cm; 80.5 kg \pm 15.9 kg) completed the 8-week evaluation (13 from the walking poles plus pedometer group and 12 from the pedometer only group). Of the 25 participants, 21 were female (48 yr \pm 10.5 yr; 164.4 cm \pm 7 cm; 79 kg \pm 14.8 kg) and 4 were male (53 yr \pm 5.6 yr; 174.6 cm \pm 6.7 cm; 88.3 kg \pm 21.8 kg). The overall age range for the entire group was 22 – 68 years. The mean volitional peak oxygen uptake of this group was 24.5 ml/min/kg (\pm .971, SE).

2.3. Pre- and Post-Laboratory Measures

Resting heart rate and blood pressure were taken using an automated blood pressure cuff while the participant was seated (Tango, SunTech Medical, Morrisville, NC). Resting metabolic rate (RMR) was measured using the

BodyGem indirect calorimeter (Microlife Medical Home Solutions, Golden, CO). Participants sat in a reclined position for 7-10 minutes, while wearing a nose clip and breathing into the mouthpiece inserted into the flow tube of the calorimeter. Bone mineral density of the middle finger was measured using the Accudexa Bone Mineral Density analyzer (Schick Technologies, Inc., Long Island, NY). Forced vital capacity (FVC) and maximal voluntary ventilation (MVV) were both measured using a desktop spirometer (Cosmed Pony). A lipid profile (total cholesterol, high density lipoproteins, low density lipoproteins, triglycerides, and glucose) was measured with the Cholestech LDX (Cholestech Corporation, San Diego, CA) using a single finger stick. Body composition was measured using air displacement plethysmography (Cosmed BodPod).

To determine peak oxygen uptake (VO_2 peak), participants performed a ramped maximal walking protocol to volitional fatigue on a treadmill while oxygen consumption was measured (Cosmed Quark K4b²). A maximal walking test was chosen to evaluate the participants' fitness levels because of the sedentary nature of this population. Many of the participants in this study presented with comorbidities and most were at least of moderate risk for exercise testing. Participants were fitted with a heart rate monitor and face mask. Participants warmed up for 3 minutes at a speed between 2 and 3 miles per hour. The test was conducted at 3 miles per hour. Every three minutes, the grade increased by 2.5%. At the end of each stage, rating of perceived exertion was recorded. Recovery data were collected for an additional 3 minutes.

2.4. Walking Intervention Data

Participants were instructed at baseline to walk a minimum 90 minutes for the first 6 weeks and then increase to a minimum of 150 minutes per week for the last 2 weeks. The target of 150 minutes per week was chosen due to the ACSM position stand regarding physical activity which recommends a minimum of 30 minutes of moderate exercise at least 5 days per week. [25] Average walk times in the P group and NW group were examined and compared to the prescribed time. Adherence was calculated as the amount of time spent walking divided by the amount of time prescribed. Additionally, median walk time and median step counts were examined.

2.5. Statistical Analyses

Independent sample t-tests were used to analyze adherence data (median walk times and step counts) and ANOVA F-tests were used to examine differences in time walked and adherence percentage by week and group using IBM SPSS 24.0. IBM SPSS 24.0 was used for the analysis of the physiological data (resting heart rate, resting blood pressure, resting metabolic rate, body composition, forced vital capacity, maximum volitional ventilation, volitional peak oxygen uptake, total cholesterol, low density lipoproteins, and high density lipoproteins). ANOVA F-tests were performed with a split-plot design in which the plots were designated as the participants, the whole-plot treatment was whether the participant was assigned to poles or not, and the split-plot

treatment was pre versus post testing times. This tested for the overall effect of the treatment (poles versus no poles), whether there was an effect regardless of treatment (pre versus post effect), and the pre versus post effect depending on the treatment interaction. Standard deviations were used for the means of the demographic data, however standard errors were used for the physiological and adherence data. A level of significance was set at $p \leq 0.05$.

3. Results

3.1. Adherence Data

Adherence percentages per week by group can be found in Table 1. While there were no significant differences in adherence percentage by week between groups, there was an overall significant difference between weeks ($p = .005$) regardless of the group. Tukey's HSD post hoc found that overall adherence percentage for week 7 (78.61%) was significantly lower than week 4 (126.53%; $p = .025$) and week 6 (130.09%; $p = .012$). Adherence percentages exceeding 100% are the result of participants exceeding the prescribed time. Median walk times and step counts are found in Table 2 and Table 3, respectively. The medians of walk times and step counts were used to control for possible outliers. Several participants had weeks with one or more outliers which would have affected mean values, either logging zero minutes or hundreds of additional minutes. The median walk times were 117.20 minutes/week and 109.65 minutes/week for the P group and the NW group, respectively. The median step counts were 13258.83 steps/week and 13096.04 steps/week for the P and NW groups, respectively. There were no statistically significant differences when comparing adherence between groups (Table 4).

Table 1. Adherence percentage (%) by week for Pedometer Only (P, n = 12) and Nordic walking (NW, n = 13) groups

	Weeks							
	1	2	3	4	5	6	7*	8
P	110	112	123	130	135	121	82	95
NW	121	116	116	123	105	138	75	84

*Overall adherence for Week 7 (78.61%) was significantly lower than Week 4 (126.53%, $p = .025$) and Week 6 (130.09%; $p = .012$).

Table 2. Median walk time for Pedometer Only (P, n = 12) and Nordic walking (NW, n = 13) groups

	Median walk time (min/week)	Std. error of the mean of the median walk time (min/week)
P	117.20	± 13.70
NW	109.65	± 6.99

Table 3. Median step counts for Pedometer Only (P, n = 12) and Nordic walking (NW, n = 13) groups

	Median step counts (steps/week)	Std. error of the mean of the median step counts (steps/week)
P	13258.83	± 1748.38
NW	13096.04	± 1334.06

Table 4. Independent sample t-test for median walk time and median step count between groups

	Mean difference of the medians	Std. error of the mean differences	p value
Median walk time (min/week)	7.55	± 15.02	.630
Median step count (steps/week)	162.79	± 2178.52	.941

3.2. Physiological Data

Physiological data were collected at baseline and after 8 weeks of walking. Resting metabolic rate and percent body fat were both significantly different from pre- to post-tests independent of treatment. The results of the split-plot design ANOVA show an increase in resting metabolic rate from 1608.14 calories to 1796.89 calories ($p = .0026$) and a decrease in body fat from 40.03% to 38.79% ($p = .0196$). However, these changes could not be attributed to a treatment effect (poles or no poles). There were no other significant results.

4. Discussion

The goal of this investigation was to evaluate any differences in adherence and physiological responses between P and NW groups after an 8-week walking program. Few studies have examined exercise adherence and Nordic walking; however, it can be difficult to compare these to the present study due to differences in how adherence is defined. Piotrowicz et al. [26] reported a high adherence rate (94.7%) to Nordic walking in heart failure patients participating in a home-based training program. In this study, "adherent" was defined as meeting the number and duration of prescribed exercise by 80% or more. [26] Participants in a study by Figard-Fabre et al. [27] also demonstrated high levels of adherence ($\geq 94\%$ over a four-week period) which was defined as the number of Nordic walking sessions attended divided by the number of sessions prescribed. Takeshima et al. [28] also found high attendance rates in groups of older adults participating in supervised Nordic walking (80.2%), conventional walking (78.2%), and resistance training (90.2%). Conversely, Gram et al. [29] reported lower adherence (completion of $\geq 70\%$ of exercise sessions) rates in a study comparing a Nordic walking group (54.5%) and exercise intervention group (50%).

In the present study, the adherence percentages in the both groups were high throughout the duration of the investigation, with the average overall walk times often being higher than the time prescribed. The high adherence rate in the present study is in agreement with previously reported compliance and attendance rates reported by others. [26,27,28] Group assignment (poles versus no poles condition) did not affect adherence percentage, however there was an effect based on week. Week 7 had significantly lower adherence compared to weeks 4 and 6. This is likely due to the increase in the prescription from 90 minutes to 150 minutes. By week 8, the overall adherence rate was not significantly different than any other week. Despite a significant decrease in adherence in both groups during week 7, every week falls under the

adherence definition set by Gram et al. [29] and weeks 1-6 and 8 would be considered adherent based on the definition by Piotrowicz et al. [26] Finally, it is worth noting that use of the Nordic walking poles did not deter individuals from participating in this study.

The average median walk times were 117.20 minutes/week and 109.65 minutes/week for the P group and the NW group, respectively. There were no significant differences between the average median walk times ($p = .630$) when comparing the P group and the NW group. The average median step counts were 13258.83 steps/week and 13096.04 steps/week for the P and NW groups, respectively. Similar to the median walk times, there were no significant differences between median step counts. This suggests that the step counts are comparable to the walk time logged. Previous studies related to exercise suggest that group assignment may affect adherence. [2,3,6,10] Morey et al. [3] reported that participants that were assigned to a group that required aerobic activity had higher adherence than those assigned to a group that required aerobic activity and flexibility exercises. Additionally, in a study by Hulquist et al. [10] in which participants were instructed to walk 30 minutes or 10,000 steps per day, all dropouts were from the 30-minute group with most subjects stating their attrition was related to their group assignment. [10] Figard-Fabre et al. [27] reported higher adherence in the Nordic walking group when compared to the walking group and suggested the interest in trying a new activity as a possible reason. However, the lack of significant differences in median walk time between groups in the present study implies that group assignment did not affect compliance in the present study.

These findings are important in demonstrating that the use of the Nordic walking poles functioned in a way that did not decrease physical activity. Despite Nordic walking poles being a novel exercise technique to most, this task did not deter participation within the NW group compared to the P group. This may be related to previous reports of lowered ratings of perceived exertion [30,31,32]. Renshaw et al. [33] discussed Newell's model of constraints theory [34], describing how constraints can influence an individual's response to particular activity. Given that the population of the present study were previously sedentary individuals with low cardiorespiratory fitness levels (personal constraints), it is possible that the prescribed exercise felt easier and more enjoyable to the participants in NW group [27,31]. The perceived benefits of utilizing Nordic walking poles must have been greater than any of the perceived environmental constraints, such as participation in an unfamiliar activity that is not commonly practiced in the United States or task constraints, such as using the Nordic walking poles for exercise.

The only statistically significant physiological changes were in resting metabolic rate and body composition. RMR increased by 189 kcal/day regardless of treatment after an eight-week walking intervention. This is similar to results from Tremblay et al. [35] which reported an increase in resting metabolic rate in obese women when expressed per unit of fat-free mass following aerobic training for eleven weeks. Additionally, Lennon et al. [36] found an increase in RMR after nine weeks of prescribed exercise. Conversely, many studies have reported no change or decreases in RMR after an exercise intervention

lasting between 8-12 weeks. [37,38,39] Roeffey et al. [21] suggested that when measuring RMR using indirect calorimetry with ventilated canopy or mouthpiece and nose-clip the change in RMR must be at least 98 kcal/day or 135 kcal/day, respectively, to be regarded as a significant outcome of the training intervention. While our value of 189 kcal/day may be meaningful, it should be interpreted with caution as we used a hand-held indirect calorimeter and there was lack of control over testing times and fasting prior to testing. However, the BodyGem hand-held calorimeter has been determined valid and reliable against indirect calorimetry with the use of ventilated canopy. [40] Additionally, in overweight and obese subjects, the BodyGem was found to be more comparable to the criterion method (indirect calorimetry with ventilated canopy) than the Harris-Benedict equation. [40]

Similar to the change in RMR, there was an overall effect on body composition. Total body fat percentage decreased by 1.26% regardless of pole or no pole condition. This reduction in total body fat is small however this change occurred as the result of short 8-week walking intervention. Regularly accumulating the recommended amount of physical activity would likely have greater implications. Figard-Fabre et al. [27] also found significant decreases in body fat percentage in NW (-0.9%) and walking (-1.2%) groups in a twelve-week intervention in obese women using the skin-fold thickness method. Gram et al. [29] reported significant reductions in total fat masses in a NW group at 4 months and 1 year (-1.0 kg and 1.8 kg, respectively) and in a strength training and aerobic exercise group at 1 year (-1.5 kg).

The overall changes after the 8-week intervention suggest that Nordic walking caused no greater physiological response than regular walking for a sedentary, predominantly female population. This is in accordance with Jacobson et al. [30] who reported that there was no difference in oxygen consumption, energy expenditures, or heart rate when comparing poles and no poles conditions during acute exercise bouts on a motorized treadmill. Conversely, the majority of the studies on Nordic walking reported increases in heart rate [19,31,32] and oxygen consumption [18,19,31,41] during acute bouts of exercise. The minimal changes in the Nordic Walking group may be attributed to lack of supervision during pole use or the short duration of the walking program and small sample size.

The present study failed to show any significant changes in aerobic fitness or lipid cholesterol. Hagner et al. [42] investigated the effects of a twelve-week Nordic walking program on physiological outcomes in women in different stages of menopause. The authors found significant increases in VO_2 max and HDL cholesterol and significant decreases in LDL cholesterol, triglycerides, and waist circumference. In the current 8-week study, we used a single finger-stick for analysis, while Hagner et al. [42] were able to use serum blood draws after a 12-week study. In a four-month Nordic walking or prescribed exercise intervention in diabetic subjects, there were no differences in VO_2 max, triglycerides, or HDL cholesterol regardless of treatment group. [29] It has been suggested the conflicting results regarding physiological changes in Nordic walking studies may be attributed to differences intensity during training. [27] Participants in the current

study walked at a self-selected pace without instruction regarding intensity. Gram et al. [29] instructed participants in both Nordic walking and exercise groups to work at 40% VO₂ max minimally. In the study by Hagner et al. [42] the subjects walked at heart rate intensities of 100-140 beats per minute. Figard-Fabre et al. [27] instructed participants to walk at a moderate self-selected pace for four minutes and then at maximal walking speed for one minute. This bout was repeated six times to reach the thirty-minute walking goal. Figard-Fabre et al. [27] reported that the Nordic walking group walked at higher intensity for a longer period of time compared to a walking group. The results of this study were significant decreases in diastolic blood pressure in both groups and higher VO₂ max in the Nordic walking group when compared to the walking group at the end of 12 weeks. [27] Kukkonen-Harjula et al. [43] reported increased VO₂ peak in both Nordic walking and walking groups after a thirteen week walking program. During training these participants were encouraged to walk at an intensity at which breathing was increased. [43]

This investigation was restricted to a sedentary adult population (with a starting fitness level of 24.5 ml/min/kg) in which participants were selected to participate under free-living conditions. Therefore, diet and location/terrain of walking were not controlled in the current study. Additionally, walking time was evaluated via the use of self-report walking logs. Future investigations should consider controlling these factors, as well as time of day for testing. Regulating intensity may also provide additional insight into metabolic changes and give researchers an alternative method to monitor adherence.

Despite utilizing self-report for physical activity accumulation throughout the 8 weeks of this investigation, pedometers were used to objectively measure walking. Pedometers were utilized instead of other physical activity monitoring devices due to the ease of use, familiarity, and cost effectiveness [44]. Participants in this study were asked to only wear the pedometers during their walking sessions and were only instructed to record their weekly step counts. Therefore, participants were not blinded to the step counts and it is possible that feedback influenced their physical activity [44].

5. Conclusions

Although there were no differences between the treatments in amount of body fat lost, the NW group's median weekly walk time was 7.5 minutes less than the P group. Although this amount of time is not statistically significant, it appears as though the NW group was able to walk slightly less than the P group and still reduce body fat and potentially increase resting metabolic rate. Participants did not always meet their minimum goals for weekly walk times independent of treatment; however, providing one supervised session per week throughout a Nordic walking program may help individuals accumulate more walking time. [9,27] Hartvigsen et al. [45] compared improvement in chronic low back pain in a supervised Nordic walking group, walking group, and a control group that was encouraged to be active. While there were no significant differences between the groups, the greatest

rate of improvement was in the supervised group. [45] Finally, controlling for diet and extending this program for a longer duration than eight weeks may result in more pronounced physiological changes.

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Competing Interests

The authors have no competing interests.

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