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# Field Testing of Physiological Responses Associated With Nordic Walking

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*This study compared the physiological responses (oxygen consumption and energy expenditure) of Nordic Walking to regular walking under field-testing conditions. Eleven women (*M *age = 27.1 years,* SD *= 6.4) and 11 men (*M *age = 33.8 years,* SD *= 9.0) walked 1,600 m with and without walking poles on a level, 200-m track. For women, Nordic Walking resulted in increased oxygen consumption (*M *= 14.9 ml·kg*$^{-1}$*·min*$^{-1}$*,* SD *= 3.2 vs.* M *= 17.9 ml·kg*$^{-1}$*·min*$^{-1}$*,* SD *= 3.5;* $p < .001$*), caloric expenditure (*M *= 4.6 kcal·min*$^{-1}$*,* SD *= 1.2 vs.* M *= 5.4 kcal·min*$^{-1}$*,* SD *= 1.2;* $p < .001$*), and heart rate (*M *= 113.7 bpm,* SD *= 12.0 vs.* M *= 118.7 bpm,* SD *= 14.8;* $p < .05$*) compared to regular walking. For men, Nordic Walking resulted in increased oxygen consumption (*M *= 12.8 ml·kg*$^{-1}$*·min*$^{-1}$*,* SD *= 1.8 vs.* M *= 15.5,* SD *= 3.4 ml·kg*$^{-1}$*·min*$^{-1}$*;* $p < .01$*), caloric expenditure (*M *= 5.7 kcal·min*$^{-1}$*,* SD *= 1.3 vs.* M *= 6.9 kcal·min*$^{-1}$*,* SD *= 1.8;* $p < .001$*), and heart rate (*M *= 101.6 bpm,* SD *= 12.0 bpm vs.* M *= 109.8 bpm,* SD *= 14.7;* $p < .01$*) compared to regular walking. Nordic Walking, examined in the field, results in a significant increase in oxygen use and caloric expenditure compared to regular walking, without significantly increasing perceived exertion.*

*Key words:* energy expenditure, walking, walking poles

The health benefits of regular physical activity and increased physical fitness are well known (Pate et al., 1995). However, the acceptance of regular physical activity as a means to improve health has been slow, and reducing the prevalence of physical inactivity in the U.S. continues to be a top public health priority (U.S. Department of Health and Human Services, 1996). The causes of physical inactivity are numerous; however, lack of time and access to exercise facilities are frequently listed as primary reasons for not exercising regularly (King et al., 1992). Regular walking has been suggested as a means of exercise that is feasible for most individuals (Rippe, Ward, Porcari, & Freedson, 1988). The accumulated health benefits of exercise have been correlated to the number of calories expended each week through physical activity (Duncan et al., 1991; Lee, Hsieh, & Paffenbarger, 1995; Lee & Paffenbarger, 1998). Numerous strategies such as hand weights and walking poles have been used to increase the caloric expenditure associated with walking. The additional muscle recruitment associated with upper-body work during walking has been found to significantly increase caloric expenditure at any given walking speed (Evans, Potteiger, Bray, & Tuttle, 1994; Graves, Martin, Miltenberger, & Pollock, 1988; Graves, Pollock, Montain, Jackson, & O'Keefe, 1987; Miller & Stamford, 1987; Porcari, Hendrickson, Walter, Terry, & Walsko, 1997; Rodgers, VanHeest, & Schachter, 1995). The use of Nordic Walker poles is particularly promising, as the poles provide stability that may promote physical activity among older individuals and those with orthopedic and balance concerns.

Both Rodgers et al. (1995) and Porcari et al. (1997) found the use of walking poles to increase oxygen consumption, heart rate, and caloric expenditure compared to walking alone. However, in these studies, testing was performed on a motorized treadmill. Planting and pushing off with a walking pole on a moving treadmill belt does not accurately represent natural walking pole mechanics, which may affect the energy expenditure associated with walking pole use. New portable metabolic equipment has made field testing

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of oxygen use a practical alternative to laboratory testing (Hausswirth, Bigard, & Le Chevalier, 1997). The use of portable metabolic equipment allows researchers to examine oxygen consumption and caloric expenditure under more natural exercising conditions, avoiding the biomechanical restrictions associated with motor-driven treadmills. The goal of this study was to compare the energy expenditure of walking with and without Exel Nordic Walker (Exel Oyj, Mäntyharju, Finland) poles while exercising in the field.

## Method

### Participants

The Cooper Institute Institutional Review Board approved the study, and prior to participation, all participants provided written, informed consent. Eleven women and 11 men volunteered for this research study. The descriptive characteristics of the participants are presented in Table 1. In general, the participants were moderately fit, normotensive, and normal weight. Female participants' ages were *M*age = 27.1 years, *SD* = 6.4, and the males participants' ages were *M*age = 33.8 years, *SD* = 9.0. All participants were trained on the proper poling technique for Exel Nordic Walker poles, and all underwent a maximal oxygen uptake test (Bruce treadmill protocol) in the laboratory prior to field testing (Bruce, Kusumi, & Hosmer, 1973).

### Field Testing Procedures

All participants walked two successive trials of 1,600 m on a level, 200-m track. One trial consisted of regular walking (no poles), and the second consisted of Nordic Walking (with poles). The order of pole use was administered in a randomized and counterbalanced manner for each participant. An effort was made to test during the cooler periods of the day. However, variations in climate conditions were such that many tests were performed under high ambient temperature ($M$ = 30°C, range = 22–40°C). Participants were asked to work at an intensity similar to their regular aerobic exercise workouts. A hand-held stopwatch was used to measure trial and lap duration. Every 200 m, heart rate, rating of perceived exertion (RPE; scale 6–20 by Borg), and lap time(s) were recorded (Borg, 1982). After the first trial, participants were informed of their average time to walk one lap. During the second trial, the participants were verbally informed of each lap time and asked to adjust their walking speed, if necessary, to assure that the total walking time of the two trials was comparable. At the end of the first 1,600-m trial, the participants rested until their heart rate was within 5 beats of their pretesting resting heart rate.

### Heart Rate Monitoring

During field testing, heart rate was monitored with a Polar Vantage XL (Polar Electro Oy, Kempele, Finland) telemetric heart rate monitor. Participants wore the transmitter belt (band) just below the sternum, and a researcher who walked with the participant at all times wore the receiving watch. This allowed the participant's heart rate to be monitored without having to stop or break the walking stride in order to read the watch.

### Indirect Calorimetry

Metabolic gases were continuously measured during field testing with a Cosmed K4b$^2$ (Cosmed S.R.I, Rome, Italy) portable indirect calorimetry system. The Cosmed K4b$^2$ has been shown to be a valid and reliable measure of oxygen consumption across a wide range of work rates (King, McLaughlin, Howley, Bassett, & Ainsworth, 1999). The unit was carried in a chest harness and weighs approximately 550 g. A soft rubber mask, which covers the participant's mouth and nose, was attached to a flowmeter and held in place by head straps. The system was calibrated immediately before each test session as directed by manufacturer guidelines. The Cosmed K4b$^2$ has an electronic marking feature for marking data during testing by pressing a button. The start and stop of each trial was electronically marked. Thus, we hade two synchronized sets of stop and start data for each trial, an electronic set marked on the raw data from the meta-

**Table 1.** Participant characteristics

| Variable | All participants ($N$ = 22) *M* | *SD* | Men ($n$ = 11) *M* | *SD* | Women ($n$ = 11) *M* | *SD* |
|---|---|---|---|---|---|---|
| Age (years) | 30.5 | 8.4 | 33.8 | 9.0 | 27.1 | 6.4 |
| Weight (kg) | 74.5 | 18.1 | 86.9 | 16.6 | 62.1 | 8.5 |
| Height (cm) | 175.2 | 10.7 | 184.0 | 6.4 | 166.3 | 5.1 |
| BMI (kg·m$^{-2}$) | 24.0 | 3.6 | 25.5 | 3.4 | 22.5 | 3.3 |
| Resting HR (bpm) | 67.6 | 11.3 | 67.2 | 10.5 | 68.0 | 12.5 |
| SBP (mmHg) | 120.3 | 13.0 | 127.3 | 10.2 | 113.3 | 11.9 |
| DBP (mmHg) | 75.4 | 9.3 | 77.6 | 9.7 | 73.1 | 8.7 |
| HRmax (bpm) | 177.5 | 14.0 | 177.5 | 18.6 | 177.5 | 8.0 |
| $VO_2$max (ml·kg$^{-1}$·min$^{-1}$) | 45.8 | 12.0 | 47.0 | 15.8 | 44.6 | 7.8 |

*Note.* BMI = body mass index; HR = heart rate; SBP = systolic blood pressure; DBP = diastolic blood pressure; HRmax = maximum heart rate; $VO_2$max = maximum oxygen uptake.

bolic unit, and a handwritten set from the stop watch. All data from the portable unit were downloaded to a Windows-based personal computer, and resultant data were synchronized with an external timepiece.

### Data Analysis

First, the start, stop, and test durations of the stopwatch and electronic data were compared to assure consistency. Then, using the stopwatch-measured lap times, every 200 m was marked on the raw data, and mean oxygen update ($VO_2$), caloric expenditure, and respiratory exchange ratio (RER) values were calculated for the 90 s preceding every 200 m. There was no significant trend across distance walked for any of the measured physiological variables. Thus, the data were averaged over the 1,600 m, and the paired *t* test was used to compare regular walking to Nordic Walking. All data with a $p < .05$ confidence level were considered statistically significant. All data are presented as means and standard deviations.

## Results

There were no significant differences in time to complete the 1,600 m when walking regularly or Nordic Walking for women ($M = 980$ s, $SD = 39$ vs. $M = 994$ s, $SD = 44$, respectively) or men ($M = 1{,}026$ s, $SD = 78$ vs. $M = 1{,}009$ s, $SD = 75$ s, respectively). The average walking speed for women was $M = 3.7$ mph, $SD = 0.14$ ($M = 5.9$ km·h$^{-1}$, $SD = 0.23$) and for men, $M = 3.6$ mph, $SD = 0.26$ ($M = 5.6$ km·h$^{-1}$, $SD = 0.26$).

As shown in Table 2, walking with poles significantly increased oxygen consumption, caloric expenditure, heart rate, and heart rate as a percentage of maximum heart rate for men and women. For women, Nordic Walking resulted in increased oxygen consumption ($M = 14.9$ ml·kg$^{-1}$·min$^{-1}$, $SD = 3.2$ vs. $M = 17.9$ ml·kg$^{-1}$·min$^{-1}$, $SD = 3.5$; $p < .001$), caloric expenditure ($M = 4.6$ kcal·min$^{-1}$, $SD = 1.2$ vs. $M = 5.4$ kcal·min$^{-1}$, $SD = 1.2$; $p < .001$), and heart rate ($M = 113.7$ bpm, $SD = 12.0$ vs. $M = 118.7$ bpm, $SD = 14.8$; $p < .05$) compared to regular walking. For men, Nordic

**Table 2.** Physiologic responses to regular walking and Nordic Walking

| | Regular walking | | Nordic walking | | Percentage change | *t* values |
|---|---|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* | | |
| Oxygen consumption (ml·kg$^{-1}$·min$^{-1}$) | | | | | | |
| Men | 12.8 | 1.8 | 15.5 | 3.4 | 20.0 | -3.81** |
| Women | 14.9 | 3.2 | 17.9 | 3.5 | 21.3 | -5.62*** |
| Combined | 13.9 | 2.7 | 16.7 | 3.6 | 20.6 | -6.58*** |
| Caloric expenditure (kcal·min$^{-1}$) | | | | | | |
| Men | 5.7 | 1.3 | 6.9 | 1.8 | 19.9 | -4.07*** |
| Women | 4.6 | 1.2 | 5.4 | 1.2 | 19.3 | -6.40*** |
| Combined | 5.2 | 1.4 | 6.2 | 1.7 | 19.6 | -6.38*** |
| HR (bpm) | | | | | | |
| Men | 101.6 | 12.0 | 109.8 | 14.7 | 8.2 | -3.34** |
| Women | 113.7 | 12.0 | 118.4 | 14.8 | 4.0 | -2.58* |
| Combined | 107.6 | 13.2 | 114.0 | 15.0 | 6.0 | -4.13*** |
| %HRmax | | | | | | |
| Men | 57.6 | 7.5 | 62.3 | 8.8 | 8.2 | -3.38** |
| Women | 64.0 | 6.0 | 66.7 | 7.6 | 4.0 | -2.65* |
| Combined | 60.8 | 7.4 | 64.5 | 8.4 | 6.1 | -4.26*** |
| RPE | | | | | | |
| Men | 8.7 | 1.3 | 9.3 | 1.3 | 8.9 | -1.25 |
| Women | 8.4 | 1.8 | 9.0 | 2.5 | 6.6 | -1.52 |
| Combined | 8.5 | 1.6 | 9.2 | 2.0 | 7.8 | -1.97 |
| RER | | | | | | |
| Men | 0.90 | 0.07 | 0.89 | 0.12 | -0.1 | 0.06 |
| Women | 0.95 | 0.19 | 0.88 | 0.16 | -5.9 | 1.52 |
| Combined | 0.92 | 0.14 | 0.89 | 0.12 | -3.0 | 1.29 |

*Note.* $M$ = mean; $SD$ = standard deviation; HR = heart rate, %HRmax = percent of maximum heart rate, RPE = rating of perceived exertion, RER = respiratory exchange ratio.
*$p < .05$.
**$p < .01$.
***$p < .001$.

Walking resulted in increased oxygen consumption ($M = 12.8$ ml·kg$^{-1}$·min$^{-1}$, $SD = 1.8$ vs. $M = 15.5$ ml·kg$^{-1}$·min$^{-1}$, $SD = 3.4$; $p < .01$), caloric expenditure ($M = 5.7$ kcal·min$^{-1}$, $SD = 1.3$ vs. $M = 6.9$ kcal·min$^{-1}$, $SD = 1.8$; $p < .001$), and heart rate ($M = 101.6$ bpm $SD = 12.0$ vs. $M = 109.8$ bpm, $SD = 14.7$; $p < .01$) compared to regular walking. The magnitude of increase in oxygen consumption and caloric expenditure was similar for women (19.9% and 19.3%) and men (20% and 21.3%) for oxygen consumption and caloric expenditure, respectively. Nordic Walking did not significantly affect RPE or RER compared to regular (normal) walking.

## Discussion

The primary findings of the study are that Nordic Walking results in increased oxygen consumption and caloric expenditure in women and men compared to regular walking, without significantly increasing perceived exertion. Our field study confirmed the findings of previous treadmill-based studies, which found that walking with poles significantly increased oxygen consumption and caloric expenditure (Rodgers et al., 1995; Porcari et al., 1997). Our finding of a 20.6% increase in oxygen consumption with Nordic Walking in the field is similar to the finding of Porcari et al. (1997) of a 23% increase when examining poling on the treadmill. However, our results are much higher than the finding of Rodgers et al. (1995) of only a 12% increase. Both this study and Porcari et al. (1997) allowed participants to select their own walking speeds, while Rodgers et al. had all participants walk at the same treadmill speed. Additionally, in both our study and Porcari et al. (1997), the participant-selected walking speeds were slower (5.7 and 6.3 km·h$^{-1}$, respectively) than those used in the Rodgers et al. (6.7 km·h$^{-1}$) study. The increased treadmill speed in the Rodgers et al. (1995) study may have reduced the participants' ability to use the poles to push off the moving belt and, thus, decreased upper body muscular work and subsequent oxygen consumption. By selecting their own walking speed in our study, participants may have selected a speed that allows for more effective use of the walking poles and, thus, increased upper body work and total body caloric expenditure.

As did Porcari et al. (1997), we found that both men and women increased oxygen use and caloric expenditure similarly when using walking poles; thus, there appears to be no preferential benefit to either gender. It is interesting to note that at self-selected speeds, the women walked at approximately the same speed as the men. However, the female group was very fit and generally 7 years younger than the male group.

In an attempt to simulate a typical normal daily workout, participants were asked to work at an intensity similar to their regular aerobic exercise workouts. This allowed the participants to adjust both walking speed and intensity of pole use to maintain a work intensity with which they were comfortable. During testing, we observed that at any given walking speed, the intensity of poling varied between individuals and that individuals who poled more intensely had higher oxygen consumption. This observation may partially explain the wide variation in differences in oxygen consumption with and without poles and supports the importance of field testing, as the role of poling-off intensity in total oxygen consumption may have been missed or underappreciated with treadmill testing. In women, the individual differences in oxygen consumption ranged from 8.0 to 47.6%, and in men the differences ranged from 4.8 to 62.7%. While on average the increase associated with Nordic Walking was ≈ 20%, there is potential for considerably more or less benefit depending on the selection of poling-off intensity. This may have particular significance for individuals who need to increase caloric expenditure but have walking speed limitations.

In agreement with Rodgers et al. (1995), we found the use of walking poles to have no significant effect on RPE. Our findings contrast those of Porcari et al. (1997), who found RPE to increase (+1.5) with the use of walking poles. Thus, it appears that the increase in oxygen consumption associated with walking pole use is accompanied by a very small, if any, increase in participant perceived exertion.

Although we found a significant increase in heart rate (6%), the increase was smaller than that found by both Porcari et al. (1997; 16%) and Rodgers et al. (1995; 9%). This may be associated with the hot outdoor testing conditions. Despite our attempts to start the tests during the cooler periods of the day, a few of the tests did not finish until it was very hot. This would not be an issue if there had been an equal number of tests for each trial order (regular-Nordic vs. Nordic-regular) that extended into the hotter part of these days. However, the majority of these extended tests (particularly in the women) were Nordic Walking followed by regular walking. Because heart rate response is relatively higher for similar workloads during conditions involving higher ambient temperature conditions, the average heart rate for the regular walking may have been artificially elevated by the few tests performed in the increased ambient temperature (Montain & Coyle, 1992). This would reduce the opportunity for heart rate differences between walking with and without poles. Unfortunately, lack of environmental control must be acknowledged as a potential confounding variable for outdoor field testing.

Our findings of increased caloric expenditure with no corresponding increase in perceived exertion during Nordic Walking may have important public health applications. Holding the number of exercise sessions per week and time per session constant, an individual stands to increase yearly caloric expenditure from physical activity by 20% using Nordic Walking compared to regular walking. Annually, this translates into 10,600 kcal (44,380 kJ) for a 70-kg man who walks 30 min a day, 5 days a week at 3.5 mph. Additionally, the increased stability and reduced loading provided by pole use might benefit older adults, individuals with orthopedic limitations, and individuals with balance problems. Confirming previous results generated from treadmill measurements, Nordic Walking, when examined in the field, results in a significant increase in oxygen use and caloric expenditure compared to regular walking, and it does so without increasing perceived exertion.

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