

#### ABSTRACT

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Power Poles are specially constructed, rubber-tipped walking poles designed to be incorporated during walking in order to mimic the arm action of cross-country skiing. This study compared the acute physiological responses of walking with and without Power Poles in 14 male Phase III/IV cardiac rehabilitation (CR) patients (M age = 61.6 yrs). Following instruction on the proper use of the poles and adequate time to practice, each subject completed two 8-minute walking trials on a level treadmill, once with and once without poles. Each trial was conducted at an identical speed for each subject in a randomized order. Heart rate, systolic blood pressure, diastolic blood pressure (DBP), ratings of perceived exertion, and ECG responses were recorded every 2 minutes. Oxygen consumption in ml/kg/min was measured continuously and recorded each minute. Results between trials were compared with paired t-tests. Calculated  $O_2$  pulse (ml  $O_2$ /heart beat) values indicated that changes in cardiorespiratory parameters were commensurate with the increase in mass of exercising muscle associated with using the poles. There was a significant increase in DBP (4 mm Hg); however, it is doubtful that the magnitude of this increase poses a threat to these patients. The only dysrhythmias noted were isolated PVCs with no differences between the trials. There was no significant ST depression for either trial. It appears that the use of Power Poles is a safe and effective method to increase the intensity of walking exercise in Phase III/IV CR patients.

THE ACUTE PHYSIOLOGICAL RESPONSES TO WALKING  
WITH AND WITHOUT POWER POLES IN  
PATIENTS WITH CARDIAC DISEASE

A MANUSCRIPT STYLE THESIS PRESENTED

TO

THE GRADUATE FACULTY  
UNIVERSITY OF WISCONSIN-LA CROSSE

IN PARTIAL FULFILLMENT  
OF THE REQUIREMENTS FOR THE  
MASTER OF SCIENCE DEGREE

BY

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COLLEGE OF HEALTH, PHYSICAL EDUCATION, AND RECREATION  
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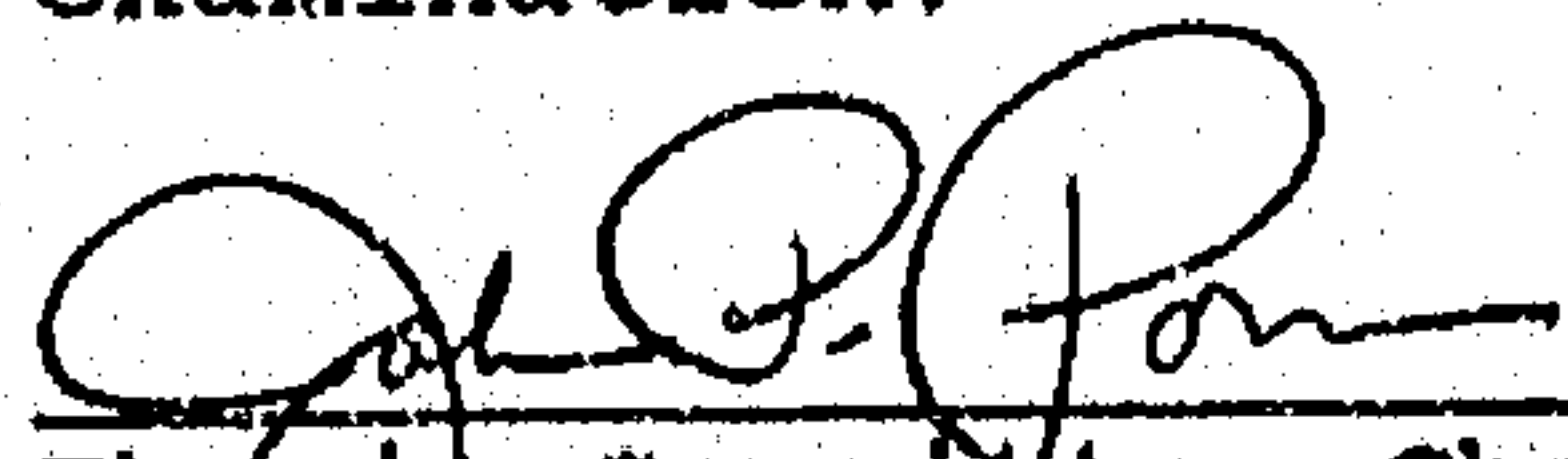
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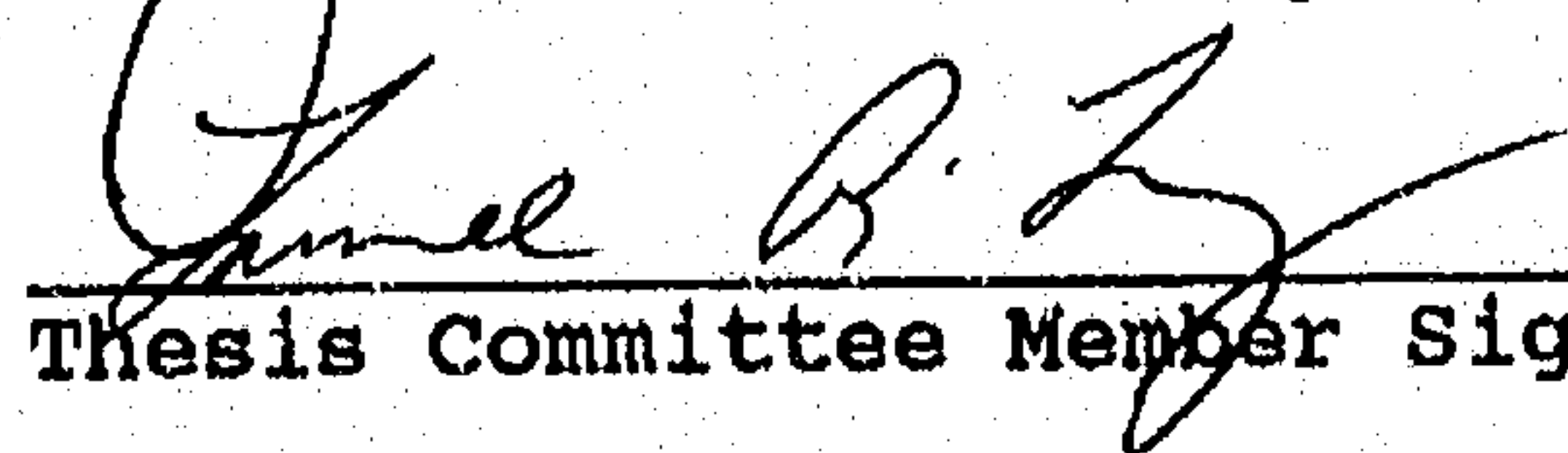
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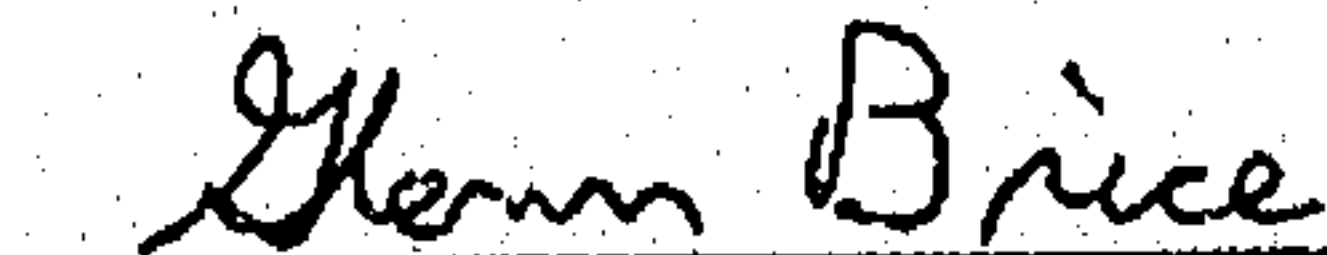
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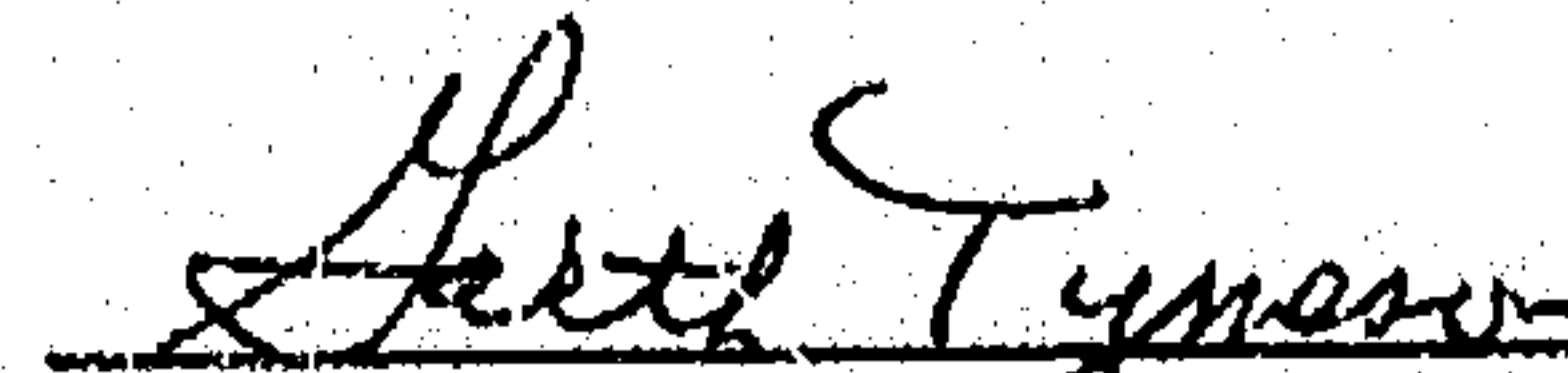


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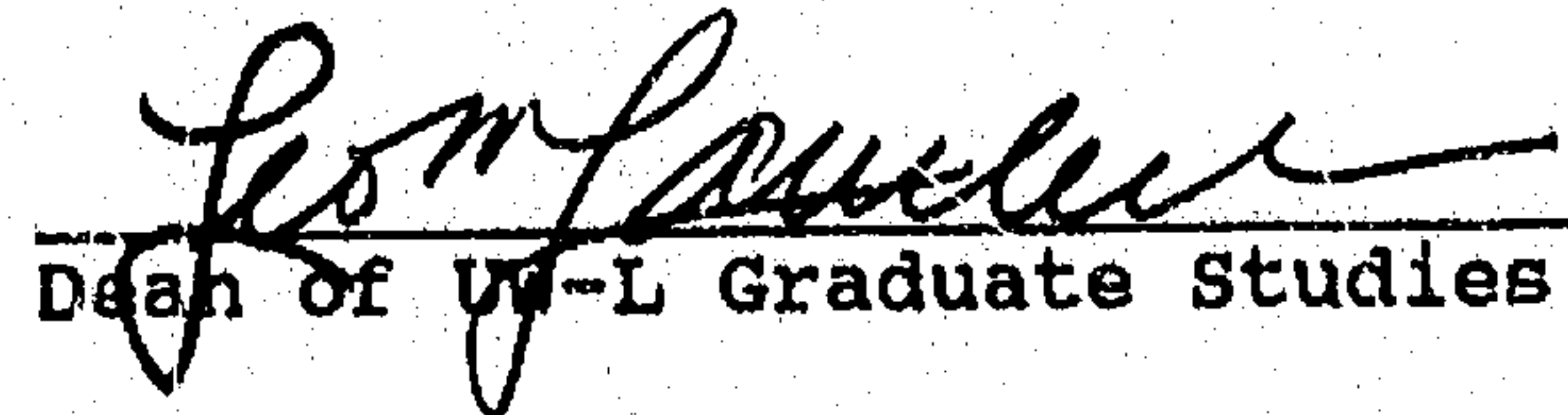
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## INTRODUCTION

Fitness walking is the most popular form of exercise for weight control and improvement of functional aerobic capacity in apparently healthy adults and cardiac patients.<sup>1</sup> However, because some individuals cannot walk fast enough or are orthopedically limited, walking may not provide sufficient aerobic stimulus to elevate their heart rate (HR) into a cardiorespiratory training zone.<sup>2</sup>

To enhance cardiorespiratory fitness, the American College of Sports Medicine<sup>3</sup> generally recommends 15 to 60 minutes of continuous aerobic activity at 40 to 85%  $VO_{2max}$  or 55 to 90% of maximal HR 3 to 5 days per week. While walking may elevate HR to a certain extent, additional movements from large muscle groups can be included for a greater HR response. Various modalities have been used to increase exercise intensity for walkers. Numerous studies have found that the addition of weight to the hands,<sup>4,8</sup> wrists,<sup>2,6,9</sup> and ankles<sup>6,10</sup> can increase the exercise intensity of walking. Recently, the use of an aero-belt has also been found to be useful for this purpose.<sup>11-13</sup>

A relatively new method to increase the exercise intensity of walking is the use of walking poles,<sup>14</sup> which effectively incorporate the large muscles of the upper body while walking. The additional muscle movement increases the

energy cost of walking, which may result in a greater cardiovascular benefit for the user. The increased use of the upper body allows for higher intensities to be obtained without having to walk at greater speeds.<sup>15</sup>

Walking poles, which resemble the poles used during cross-country skiing, are specially constructed with a rubber-tip that contacts the surface while walking. The use of walking poles is very similar to the technique used during the push-off phase in cross-country skiing while diagonally striding.

Several studies have been conducted on the acute physiological responses associated with hand-held walking poles in apparently healthy adults. Rodgers et al.<sup>14</sup> studied walking pole use during steady-state treadmill walking, and found that the poles enhanced the oxygen consumption and HR responses associated with walking by 11 and 8%, respectively. Hendrickson, Porcari, Terry, Brice, and Chase<sup>16</sup> found that walking with poles increased  $VO_2$ , HR, and caloric expenditure (Kcal/min) by 20% when compared to walking without poles.

One possible drawback to the use of walking poles may be the effect on blood pressure (BP). An elevated BP response has been observed during walking with hand-held weights,<sup>2,6,7,9</sup> and has been associated with the isometric

component of gripping the weights.<sup>6,7,17</sup> The occurrence of a pressor response may be hazardous, especially in cardiac patients, due to an increased myocardial oxygen demand associated with increases in afterload.

The effect of walking pole usage on BP has not been investigated. However, walking poles have a supportive strap attached near the grip which may reduce the need to grip the pole itself. The relaxed grip may lessen the isometric effort, and may not elicit an excessive pressor response. Other studies have found that the increase in HR with hand weights is due to an increase of energy demands, not the pressor response, and can be considered safe for cardiac patients.<sup>2,4</sup>

To this author's knowledge, there has not been a study investigating the use of walking poles with a cardiac rehabilitation population. Previous studies utilized apparently healthy adults with no signs or symptoms of cardiac disease. The purpose of this study was to determine the acute physiological responses to walking with and without walking poles in cardiac patients, and to determine walking pole safety in terms of hemodynamic and electrocardiographic (ECG) responses.

## MATERIALS AND METHODS

Subjects

Fourteen male volunteers were recruited from the Phase III and IV Cardiac Rehabilitation (CR) unit of the La Crosse Exercise and Health Program (LEHP). All volunteers had documented cardiac disease, as manifested by the medical events listed in Table 1.

Table 1. Events causing entrance into the cardiac rehabilitation program

Event	Frequency
Myocardial Infarction	5
CABG x 2	3
CABG x 3	2
CABG x 4	1
CABG x 2 + Aortic Valve Replacement	1
Known CAD from catherization	2

CABG = coronary artery bypass graft surgery; CAD = coronary artery disease

Prior to the beginning of the study, human subject approval was obtained from the Institutional Review Board at the University of Wisconsin-La Crosse. Subjects were asked to sign an informed consent document (see Appendix A) and obtain written permission from their primary care physician

(see Appendix B). In addition, subject files were reviewed to identify any circumstances which would preclude accurate assessment of ECG responses to exercise (i.e., LVH, LBBB, and digitalis).

Each subject must have had a graded exercise test (GXT) within the previous year. Information from the subject's last symptom-limited GXT is presented in Table 2. These

Table 2. Maximal data from last symptom limited graded exercise test

	Mean $\pm$ SD	Range
HR (bpm)	144 $\pm$ 30.6	97 - 198
SBP (mm Hg)	175 $\pm$ 24.4	140 - 220
DBP (mm Hg)	74 $\pm$ 11.8	58 - 104
METs	11.5 $\pm$ 2.1	7.7 - 14.9

data were used to quantify exercise responses during the two walking conditions. For all practice and testing sessions, subjects were informed that medication should be taken as prescribed. Drugs taken by subjects included beta blockers, calcium channel blockers, nitrates, aspirin, anticoagulants, and lipid-lowering agents.

### Procedures

The type of walking poles used in this study were Power Poles (NordicTrack). Power Poles are constructed of light-weight aluminum and weigh approximately 1-lb each (440 grams). The body of the pole is constructed in such a way that it compresses during initial contact with the ground and then springs back to its normal length through the push-off phase of the walking stride. Additionally, the body of the poles are made to be adjustable to the height of the use. The tip of the pole is made of 100% rubber and is designed to be shock absorbent and slip resistant. The handles of the Power Poles are anatomically designed to fit the hand.

Following individualized instruction on proper use of the poles, each subject completed 4 to 10 practice sessions during their regular cardiac rehabilitation exercise program. Once subjects were comfortable walking with the poles, they were asked to come to the laboratory for a practice session.

The practice session held in the laboratory allowed the individual to become familiar with all testing procedures and to practice walking with the poles on a treadmill. A 12-lead ECG was monitored and BP was taken while the subjects walked. Subjects also practiced breathing through

a mouthpiece to be used during testing until they were comfortable breathing through it.

The treadmill speed to be used for testing was determined during the laboratory practice session. A speed was chosen which elicited a HR in the lower portion of the subject's target HR zone when walking without poles. Each subject's target HR zone was determined from the subject's most recent symptom-limited GXT. Once speed was determined, it was recorded, practiced, and used during testing trials. The average speed used was  $3.6 \pm 0.4$  mph.

Upon completion of the practice session in the lab, subjects were encouraged to continue practicing walking with the poles until they were tested. All subjects returned for the testing session within 2 weeks after the laboratory practice session. Each individual's height was measured to the nearest centimeter, and weight to the nearest 0.1 kilogram. Subjects were prepared for a 12-lead ECG using the standard Mason-Likar configuration.

Subjects were instructed to sit quietly on a chair placed on the treadmill for 5 minutes, after which a resting ECG, HR, and BP were measured. Subjects were then connected to a Quinton Q-Plex metabolic cart for the measurement of respiratory data.

Subjects began walking at the previously determined treadmill speed, either with or without poles, for 8

minutes. The walking trials were presented in a randomized order. The following variables were averaged and recorded each minute from the expired gas data: ventilation ( $V_E$ ), oxygen consumption ( $VO_2$ ) in liters per minute (l/min) and milliliters per kilogram per minute (ml/kg/min), and respiratory exchange ratio (RER). Calculated oxygen pulse ( $O_2$  pulse) values were also determined from the metabolic and HR data.

Ratings of perceived exertion (RPE), HR, and BP were obtained during the last 30 seconds of each 2-minute period, with BP measured in the left arm using the first and fourth Korotkoff sounds as the systolic blood pressure (SBP) and diastolic blood pressure (DBP), respectively. Subjects were instructed to continuously swing the right arm while BP was being measured.

The ECG, as displayed on a Marquette ECG monitor, was viewed continuously during exercise and recovery, and a recording was made during the last 10 seconds of every other minute. Interpretation of the ST segments in leads II, V1, and V5 were read from the ECG recordings and used for determining ischemic responses, while dysrhythmias were counted automatically by the Marquette ECG system.

Upon completion of the first 8-minute trial, subjects completed a 2-minute active cool down period consisting of

slow walking on the treadmill. Subjects were then disconnected from the metabolic cart. This was followed by a 5-minute rest period in order to allow the HR to come within 10 beats per minute (bpm) of resting heart rate (RHR) values. After the rest period, subjects began the second condition following identical procedures as the first condition. At the conclusion of the second 8-minute trial, subjects were disconnected from the metabolic cart and allowed to cool down until HR was within 10 bpm of RHR values. Final ECGs and BPs were obtained before each subject was disconnected from the ECG monitor.

#### Statistical Treatment of the Data

Standard descriptive statistics were used to summarize characteristics of the subject population (see Table 3).

Table 3. Descriptive characteristics of the subjects

	Mean $\pm$ SD	Range
Age (yr)	61.6 $\pm$ 6.26	48 - 71
Height (cm)	178.6 $\pm$ 5.6	173 - 193
Weight (kg)	90.7 $\pm$ 13.2	73 - 112
Rest HR (bpm)	71 $\pm$ 11.1	52 - 90
Rest SBP (mm Hg)	114 $\pm$ 16.6	100 - 138
Rest DBP (mm Hg)	66 $\pm$ 8.95	56 - 86

Physiological responses to walking with and without Power Poles were compared with paired t-tests. Alpha level was set at 0.05 to achieve statistical difference. All dysrhythmias and ST-segment changes were noted and quantified to determine if differences occurred between conditions.

### RESULTS

The acute physiological responses to walking with and without Power Poles are presented in Table 4. Hemodynamic and metabolic variables increased during the first 3 minutes of each 8-minute trial and remained relatively constant thereafter, indicating a steady state had been attained. The values in Table 4 represent the averages of the final 4 minutes of each trial.

#### Physiological Responses

Heart rate was found to be significantly different between the two conditions ( $p < .05$ ). The average HR was 14 bpm higher (13%) when walking with poles (WP) compared to walking without poles (NP). In addition, the percentage of HRmax (exercise HR/maximum HR) increased from an average of 68 to 78% when comparing NP to WP. There were also significant differences in systolic and diastolic BP between the conditions ( $p < .05$ ). Systolic and diastolic BP were 16 and 4 mm Hg higher, respectively, during WP compared to NP.

Table 4. The acute physiological responses to walking with and without poles (n = 14)

	NO POLES	POLES
HR (bpm)	98 ± 14.6	112 ± 16.7 *
SBP (mm Hg)	136 ± 18.3	152 ± 16.7 *
DBP (mm Hg)	74 ± 9.6	78 ± 10.9 *
RPP (x 100)	134.4 ± 31.4	170.6 ± 39.2 *
V <sub>B</sub> (l/min)	36 ± 7.2	47.4 ± 6.9 *
VO <sub>2</sub> (l/min)	1.30 ± .18	1.60 ± .18 *
VO <sub>2</sub> (ml/kg/min)	14.7 ± 2.2	18.5 ± 2.5 *
O <sub>2</sub> Pulse	13.8 ± 2.4	14.8 ± 2.9 *
RER	.85 ± .05	.91 ± .03 *
RPE	11.8 ± 1.2	12.9 ± 1.3 *

All values represent means ± standard deviations.  
 \*POLES significantly different than NO POLES (p < .05).

Oxygen pulse is calculated as milliliters of oxygen consumed per minute divided by the exercise HR, and is considered to be an indirect measure of the pressor response.<sup>2,9</sup> Oxygen pulse was significantly higher WP (p > .05), which indicates that the increase in exercise intensity was related to an increase in energy expenditure. If a pressor response had occurred, O<sub>2</sub> pulse would have been lower during WP compared to NP.

Rate pressure product (RPP) is calculated as HR X SBP, and is considered an indirect measure of myocardial oxygen demand.<sup>7</sup> Since both HR and SBP increased when using poles, RPP also significantly ( $p < .05$ ) increased during WP. In addition, RPE was significantly ( $p < .05$ ) higher during WP compared to NP. The magnitude of this increase was 1.1 RPE units.

#### Metabolic Responses

Both absolute (l/min) and relative (ml/kg/min) oxygen consumption values ( $VO_2$ ) were significantly different between the conditions ( $p < .05$ ). During WP, absolute  $VO_2$  increased by an average of 0.30 l/min, while relative  $VO_2$  increased by an average of 3.8 ml/kg/min when compared to NP. This represents a 21% increase in oxygen consumption when comparing WP to NP.

Ventilation was also significantly different between the two conditions ( $p < .05$ ). Ventilation increased by approximately 24% when comparing WP to NP. Walking with poles also resulted in a significantly higher RER when compared to NP ( $p < .05$ ). The average RER values with and without poles were .91 and .85, respectively.

### Electrocardiographic Responses

The only dysrhythmias noted were isolated premature ventricular contractions (PVCs). There was no difference in the frequency of PVCs between the trials.

ST-segment changes were measured directly from the ECG recordings as printed by the Marquette ECG system. ST depression was measured relative to the resting tracings taken before both conditions, and no significant ( $p > .05$ ) changes were found between conditions.

### DISCUSSION

The purpose of this study was to determine if walking with Power Poles could safely and effectively increase exercise intensity for cardiac patients compared to walking without poles at an identical speed. In the current study, the use of walking poles significantly increased the hemodynamic and metabolic responses compared to walking without poles. Also, ECG responses indicated that no dysrhythmias or significant ST depression occurred between the trials.

Increasing the exercise intensity of an activity may allow an individual to obtain greater physiological benefits. In the current study, the use of walking poles increased the energy cost of walking by 3.8 ml/kg/min above the oxygen cost of walking without poles. This 21% increase is consistent with previous findings from other researchers

using similar arm movement patterns either with poles,<sup>16</sup> hand weights,<sup>4,7</sup> or wrist weights.<sup>2,9</sup> In contrast to the current findings, Rodgers et al.<sup>14</sup> found a smaller increase of 11%. This may be attributed to the physical condition of their subjects, or to the type of walking pole used. The weight of the poles in the current study was approximately 1 lb (440 grams) each, whereas the weight of the poles used in the study by Rodgers et al.<sup>14</sup> was approximately .75 lb (345 grams) each.

Another possible factor that may have contributed to the difference in energy cost between the two studies may be the walking speed of the subjects. All of the subjects in the study by Rodgers et al.<sup>14</sup> walked at a speed of 4.2 mph during both conditions. At high speeds of walking, vigorous swinging of the arms is necessary to maintain coordination and momentum. The addition of walking poles at 4.2 mph resulted in a slight increase in oxygen consumption since the arm movement was already present during NP. In the current study, the average walking speed was 3.6 mph during both conditions. With the addition of walking poles, subjects were required to swing their arms through a greater range of motion when compared to NP, thus resulting in larger increases in oxygen consumption.

The addition of walking poles while walking resulted in a 14 bpm higher HR response compared to NP. The magnitude of this change is similar to those found by other investigators using walking poles<sup>14,16</sup> or wrist weights.<sup>2,9</sup>

The American College of Sports Medicine<sup>3</sup> generally recommends exercising at 70 to 85% of maximal HR to improve cardiorespiratory endurance. In the current study, the exercise intensity increased from 68% of maximal HR during NP to 78% of maximal HR during WP. Thus, the addition of poles while walking was effective in eliciting a greater HR response and bringing subjects into a higher cardiorespiratory training zone.

Oxygen pulse is used as an indicator of the pressor response, which must be considered when interpreting HR responses.<sup>2,9</sup> Oxygen pulse measures the changes in HR relative to the changes in oxygen consumption. In this study, O<sub>2</sub> pulse increased 7% from the NP to the WP condition. This increase indicates changes in HR were related to increases in energy expenditure and were not due to the pressor response mechanism. A decrease in the O<sub>2</sub> pulse during WP would have indicated that a pressure response may have been responsible for the increase in HR. Studies using similar arm movements have also shown a

tendency for  $O_2$  pulse to increase,<sup>2,6,9,18</sup> indicating that the HR changes were closely linked to  $VO_2$  values.

To this author's knowledge, there are no published studies that investigated BP responses when walking with walking poles. In this study, SBP increased 16 mm Hg when comparing NP to WP. Amos et al.<sup>2</sup> found similar results when cardiac patients swung 2.5-lb wrist weights to chin height while walking. The increase in SBP may be attributed to the increase in exercise intensity associated with the swinging of the arms through a similar range of motion during both studies. The increase in SBP is not of clinical significance, since the rise in SBP is consistent with the increase in energy cost during WP.

There was a small but significant increase in DBP of 4 mm Hg when using the poles. Studies using wrist weights found similar increases of 2 to 3 mm Hg when comparing weighted walking to unweighted walking.<sup>2,6,9</sup> The clinical significance of such a small increase in DBP is probably negligible. In fact, Lowe, Rothbaum, McHenry, Corya, and Knoebel<sup>19</sup> reported that a slight increase in DBP with exercise may actually be beneficial because it may enhance coronary filling and thus perfusion of the myocardium. Similarly, Bertagnoli, Hanson, and Ward<sup>20</sup> found that when isometric contractions were superimposed on treadmill

walking, the degree of ST segment depression was attenuated. The proposed mechanism was an increase in myocardial perfusion resulting from the higher diastolic pressures.

None of the subjects in the current study had an exaggerated BP response when using the poles. The highest SBP and DBP recorded were 192 and 93 mm HG, respectively. This is in contrast to previous research that has shown walking with wrist weights can exaggerate the BP response in some hypertensive responders,<sup>6</sup> caused by the increase in total peripheral resistance associated with the greater relative tension of the arms during exercise.<sup>6,21</sup>

A possible explanation for the relatively lower BP responses in the current study is that when walking WP, the backward movement of arms can be accomplished without gripping the handles firmly, thus relaxing the contraction of the forearm. In addition, walking poles have a supportive strap that can be wrapped around the wrist in order to help reduce the grip. Also, when compared to various wrist weights, walking poles weigh approximately 1 lb (440 grams) each, thus resulting in less of a strain on the upper body musculature since the muscles are working at a lower percentage of maximal voluntary contraction.

Hypothetically, this could also result in fewer orthopedic problems, and decrease the injury potential for the upper body.

An important finding of the current study was the absence of abnormal ECG recordings. The only dysrhythmias observed were PVCs, and there was no difference in the number of PVCs observed between trials. This finding is consistent with others who investigated ectopy with added weight.<sup>2,21,22</sup> There were also no changes in the degree of ST depression in leads II, V1, and V5 when walking with poles. Similarly, other studies have not reported ischemic changes despite elevated hemodynamic responses.<sup>2,20-22</sup> As explained by Bertagnoli et al.,<sup>20</sup> the enhanced coronary blood flow during exercise may offset the increased myocardial oxygen demand of the more intense exercise.

Ratings of perceived exertion were significantly higher with the use of walking poles. The magnitude of this increase (9%) is comparable to that found by Hendrickson et al.,<sup>16</sup> and is thought to be associated with the increase in muscle mass used during walking. In contrast, Rodgers et al.<sup>14</sup> did not see a change in RPE when using poles despite significant increases in HR and  $\dot{V}O_2$  values. A possible explanation could be that the subjects in Rodgers et al.<sup>14</sup> study were all physically active younger adults accustomed

to upper body work during exercise. The cardiac patients in the present study may not have been accustomed to using their arms during exercise, and this localized fatigue may have also resulted in higher RPE units. Amos et al.,<sup>2</sup> Graves et al.,<sup>7</sup> and Maud et al.<sup>18</sup> found that increases in RPE were similar when cardiac patients walked with hand and wrist weights which elicited similar increases in HR and  $VO_2$ .

To conclude, it appears that the use of Power Poles is a safe and effective method to increase the intensity of walking exercise in Phase III/IV cardiac rehabilitation patients. The use of walking poles should allow patients to realize greater benefits from their walking program while simultaneously conditioning the upper and lower body. Although no adverse hemodynamic or ECG responses occurred in this study, it is recommended that cardiac patients undergo a short screening program to determine the safety of using walking poles on an individual basis.

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APPENDIX A  
INFORMED CONSENT

## Informed Consent

## THE ACUTE PHYSIOLOGICAL RESPONSES TO WALKING WITH AND WITHOUT POWER POLES IN PATIENTS WITH CARDIAC DISEASE

I, \_\_\_\_\_, would like to volunteer to participate in a project to determine if the use of Power Poles while walking on a motorized treadmill increases the physiological responses associated with walking. Power Poles are specially constructed, rubber-tipped walking poles designed to be incorporated during walking exercise by mimicking the arm action of cross-country skiing. Participation in this project requires that I obtain written permission from my primary care physician, attend a practice session, and perform two walking trials during a testing session, one with the Power Poles and the other without.

The two walking trials will consist of walking on a motorized treadmill for 8 minutes each at a predetermined speed. The speed of the treadmill during each trial will remain constant. I will be allowed to rest between the trials until my heart rate drops to within 10 beats of my preexercise heart rate.

During the walking trials, I will be connected to a Quinton Q-Plex metabolic cart, which will measure oxygen consumption. Blood pressure and ratings of perceived exertion will be measured every 2 minutes during exercise. I will be connected to a 12-lead electrocardiogram which will be monitored continuously on an oscilloscope.

As with any exercise, there exists the possibility of adverse cardiovascular changes (i.e., dizziness, shortness of breath, heart attack, and stroke). However, if abnormal physical responses occur at any time during testing, medical personnel on standby will be informed and the test will be terminated immediately. I also may stop testing at any time. In addition, I may feel tired or sore at the end of each testing session.

I, the undersigned, agree to hold harmless and indemnify the State of Wisconsin, the Board of Regents of the University of Wisconsin System, and the University of Wisconsin-La Crosse, their officers, agents and employees, from any and all liability, loss, damages, costs, or expenses which are sustained or incurred while I am being tested. In case of emergency, appropriate emergency care will be provided for me. All other care must be provided and covered by my insurance carrier.

All testing sessions will be scheduled at my convenience. The tests will be conducted by Patrick R. Walter, a graduate student enrolled in the Adult Fitness/Cardiac Rehabilitation Graduate Program under the direction of John Porcari, Ph.D. The results of all tests will be thoroughly explained upon completion of the test and all data will be confidential. I do, however, give permission for the data to be used for research purposes.

I have read the foregoing and I understand what is expected of me. Any questions which may have occurred to me have been answered to my complete satisfaction. I therefore voluntarily consent to be a subject in this study. Furthermore, I know I may withdraw at any time without any type of penalty.

SIGNATURE OF SUBJECT \_\_\_\_\_ DATE \_\_\_\_\_

SIGNATURE OF WITNESS \_\_\_\_\_ DATE \_\_\_\_\_

**APPENDIX B**  
**PHYSICIAN APPROVAL FORM**

University of Wisconsin-La Crosse  
La Crosse, WI 54601

TITLE: The Acute Physiological Responses to Walking With  
and Without Power Poles in Patients with Cardiac  
Disease

Principle Investigator: Patrick R. Walter

Dear Dr. \_\_\_\_\_,

I would like your permission to perform a series of submaximal exercise tests on one of your patients, \_\_\_\_\_ . The patient will not be asked to perform at an exercise intensity any greater than what he normally performs during the cardiac rehabilitation program he currently participates in. The study to be conducted will be my master's thesis for the Adult Fitness/Cardiac Rehabilitation program. The purpose of this study is to determine the physiological responses to walking with and without Power Poles in patients with cardiac disease. Power Poles are specially constructed, rubber-tipped walking poles designed to be incorporated during walking exercise by mimicking the arm action of cross-country skiing.

Two exercise sessions of 8 minutes in duration will be performed on a treadmill. A speed and grade will be chosen

which will elicit a heart rate response in the lower portion of the subject's current exercise range, determined by their latest symptom-limited GXT. An active recovery and rest period will occur between each of the trials. I would like to reiterate that the subject will not be asked to perform at an exercise intensity any greater than what he normally performs during the cardiac rehabilitation program he currently participates in. The subject may terminate the testing at any time.

During all sessions, subjects will be constantly monitored using a standard 12-lead ECG system, and blood pressure will be measured every 2 minutes during exercise. During the testing sessions, subjects will also be connected to a Quinton Q-Plex metabolic cart to determine respiratory values. Testing will occur only during the Cardiac Rehabilitation hours of the La Crosse Exercise and Health Program, where advanced cardiac life support equipment and a crash cart will be on site.

A recent study measuring the acute physiological benefits of walking with poles in apparently healthy adults found  $VO_2$  and heart rate to be increased by approximately 1.5 METs and 15 beats per minute, respectively. There were no significant differences in oxygen pulse values measured between the two conditions, therefore indicating the changes

were due to an increase in muscle mass involved, not due to a pressor response mechanism. No abnormal responses occurred during the testing.

Physician Approval

I find the following patient \_\_\_\_\_  
to be an acceptable candidate for the previously mentioned  
study.

Physician \_\_\_\_\_

Date \_\_\_\_\_

Please return page 3 in the SASE as soon as possible.  
Thank You!

APPENDIX C  
REVIEW OF LITERATURE

## REVIEW OF LITERATURE

### Introduction

Today, with the fitness revolution upon us, there is a bombardment of new types of fitness equipment hitting the market. Some of these new innovative pieces of equipment are legitimate cardiovascular health aids, while others are just fads that seem to have no merit to their claims of increasing cardiovascular fitness. The more recent pieces of equipment being developed and marketed have begun to put an emphasis on the need for a combined, simultaneous upper body and lower body cardiovascular workout. An example of this type of equipment is the Power Pole, built and designed by NordicTrack.

The Power Pole is similar to a rubber-tipped cross-country ski pole. Its purpose is to incorporate the upper body during walking exercise, thus enhancing cardiovascular benefits. The arm movement is the same as the arm movement used in diagonal striding while cross-country skiing. This increase in arm movement can increase exercise intensity. Since the concept of using poles for walking exercise is relatively new, a review of literature is needed for arm work and adding arm work to leg work.

### Benefits of Walking Exercise

Supervised walking programs serve as the main form of exercise for virtually every cardiac rehabilitation program

in the world. Walking is popular for the cardiac patient because the risk of orthopedic injury is minimal. The primary cause of running injuries is from the force of impact when the feet hit the ground after the airborne phase.<sup>1</sup> Walking, however, results in lower forces because there is no airborne phase. Not only is walking safer for the musculoskeletal system, but it has also been shown to be effective in reducing anxiety and tension, aid in weight loss, help improve cholesterol profile, help control hypertension, slow the process of osteoporosis,<sup>2</sup> and increase cardiovascular endurance.<sup>2,5</sup>

#### Benefits of Arm Exercise

Cardiovascular function can be improved when arm pedaling is used for training,<sup>6,9</sup> but some questions remain as to whether arm exercise alone should be used for cardiac rehabilitation.<sup>10</sup> Cardiac patients need to be cautious since exercise that uses smaller muscles can cause blood pressure (BP) to rise higher than exercise that uses larger muscles.<sup>11</sup> Also, the rate pressure product (HR x SBP), which is a correlate of myocardial oxygen demand,<sup>12-14</sup> has been shown to be significantly higher during arm ergometry compared with other modalities.<sup>15</sup> Other studies have indicated that arm exercise, when carefully monitored, can be safe and effective for cardiac patients.<sup>7,16-19</sup>

### Incorporating Leg and Arm Work

In 1991, the American College of Sports Medicine<sup>20</sup> (ACSM) recommended that Phase III cardiac patients should exercise 3-4 times a week at 50-80% of functional capacity for up to 45 minutes. Although walking may provide sufficient stimulus for some individuals to reach a training threshold, others may need an added stimulus to reach their target HR zone. The most popular method to increase HR while walking is to involve arm movement during exercise.

Exercise training using both arms and legs has been found to be more beneficial than using either the arms or legs alone. Mostardi, Gandee, and Norris<sup>21</sup> studied arm and leg training versus leg training. Two groups of subjects trained 3 times per week for 6 weeks, with one group using both arms and legs while the other exercised the legs alone. The subjects covered a distance of 3 miles per session while riding a bike ergometer. Results indicated that the arm and leg subjects were able to do more work at a lower HR, thus showing an increase in aerobic power. A similar study by Clausen, Trap-Jensen, and Lassen<sup>22</sup> found a significant reduction in HR during training using arms and legs, but no significant reduction occurred during legwork alone. Since arm and leg conditioning provides higher levels of improvement in aerobic power with less demand on the

cardiovascular system, it is suggested that arm and leg exercise be incorporated in the rehabilitation of cardiac patients.

#### Other Adjuncts to Walking

Hand-held and wrist weights, the two most popular adjuncts for the arms, have been shown to increase the energy cost of walking. Auble, Schwartz, and Robertson<sup>23</sup> studied the effect of 1, 2, and 3 pound (lb) hand-held weights on oxygen consumption during normal walking. The addition of 3-lb hand-held weights while pumping the arms increased the  $VO_2$  requirements of their subjects 113 to 255% above normal walking at any given speed. A similar study found that HR,  $VO_2$ , RER,  $V_B$ , SBP, DBP, RPP, and RPE were significantly greater when 3-lb hand weights were added to walking exercise at a constant treadmill grade and speed.<sup>24</sup> The data indicated that 3-lb hand weights can increase the metabolic costs of exercise by approximately 1 MET and HR by 7 to 13 beats per minute. These increases indicate the addition of 3-lb weights to the arms during walking is sufficient to improve aerobic fitness. However, without a constant pumping of the arms while walking, or when using weights that are 2.27 kg or less, no increase in HR or oxygen consumption will occur.<sup>25</sup>

In 1990, Abadie<sup>26</sup> tested the physiological responses associated with adding wrist and hand-held weights to graded walking. In this study, 11 male and 8 female volunteers ranging in age from 20 to 35 years were recruited to participate as subjects. All subjects were apparently healthy and free of coronary artery disease. The subjects performed 3 submaximal exercise tests with at least 2 days separating each testing session. The protocol for each testing session consisted of walking 3 mph at 8% grade for 6 minutes. The 3 testing conditions consisted of walking with hand weights, walking with wrist weights, and walking with no weights. The results indicated that both the use of 6-lb wrist weights and 6-lb hand weights increased the energy requirements of walking by approximately 18%. This finding, along with findings of the other aforementioned studies, not only has practical applications for those populations that are limited to walking, but may be useful in exercise prescription for individuals who do not want to run or are orthopedically limited in the speed at which they can walk.

Aero-belts are one of the latest types of exercise equipment being introduced into the fitness market. An aero-belt is wrapped around the waist like a belt, and has two flexible tubes hanging down on the right and left side. As the individual exercises, the tubes are pulled upon by

the arms, creating a resistance to pull against. Individual preference can allow different types of movement by the arms. For example, each arm can be raised 90 degrees (shoulder flexion) with each stride, or arm movement can simulate cross-country skiing action with each stride. Aero-belts have been shown to increase energy demands for step aerobics and jogging by approximately 54%.<sup>27,28</sup> Walking while using an aero-belt has also been shown to increase HR and  $VO_2$  by approximately 27 and 42%, respectively.<sup>29</sup>

#### Cardiac Patients

##### Adding the Upper Body While Walking

While there are numerous studies on the combination of upper body and lower body exercise with the general population, there is a lack of research in the area dealing with cardiac patients. Cardiac rehabilitation clientele are one population that may benefit from exercise modalities that include both the arms and legs.

In the cardiac rehabilitation population, walking may not incorporate a high enough workload to elicit a proper exercise intensity. Some individuals are limited in the speed at which they can walk, some are highly conditioned, and some would simply walk rather than run. According to ACSM<sup>20</sup>, patients in a Phase III program recovering from myocardial infarction or coronary artery bypass surgery

require prescribed exercise intensities of at least 5 METs. Pearce et al.<sup>30</sup> have shown that walking at self-selected paces between 2.5 and 3.5 mph produced exercise intensities of only 3 to 4 METs. This being the case, the addition of some type of upper body activity to walking may enable the cardiac population to raise their exercise intensities into the proper range.

Amos, Porcari, Bauer, and Wilson<sup>31</sup> studied the safety and effectiveness of walking with ankle and wrist weights for patients with cardiac disease. Walking with 2.5-lb weights were compared to walking with no weights while subjects walked on a treadmill. The addition of 2.5-lb ankle and wrist weights increased HR responses by 4 and 13 bpm, respectively, when compared to walking with no weights. Oxygen uptake also increased by 1.7 and 3.5 ml/kg/min, respectively. There were no abnormal ECG responses during the trials, and it was concluded that ankle weights and wrist weights can be used by patients with cardiac disease as a method to increase the intensity of walking exercise. It was also found that there was not an exaggerated BP response, as the increase in BP was related to the increase in energy demand.

The advantage of wrist and hand-held weights are that both the upper and lower body muscles are trained, while the

risk of injury is comparatively lower with walking than running.<sup>23</sup> The disadvantages include damage to elbow and shoulder tissue if the weights swing about in an uncontrolled manner. Also, if the user simply carries the weights at the side, little extra work is being done since the weights are not being used actively in the walk.

#### Special Considerations

A major area of concern associated with adding upper body activity to walking deals with BP responses. Past research has shown that adding wrist weights to walking may cause the BP response to be exaggerated due to the pressor response.<sup>24</sup> This increase in BP may be potentially dangerous, and could invalidate exercise prescription based on HR methods. For this reason,  $O_2$  pulse has been used as an indicator of the occurrence of a pressor response, as it relates to changes in HR relative to oxygen consumption ( $VO_2$ ). Numerous studies have reported that adding weight to the arms does not result in an exaggerated pressor response,<sup>26,31-33</sup> and that the increase in BP does not reflect a pressor response, but rather an increase in pressure in response to an increased metabolic demand.

Another concern with cardiac patients is the prevalence of dysrhythmias and myocardial ischemia during combined upper and lower extremity exercise. A previous study

concluded that upper extremity exercise is safe to include in exercise training programs for cardiac patients.<sup>34</sup> In recent studies, the addition of weights to the ankles or wrists produced no ischemic responses or dysrhythmias on ECGs.<sup>31,35</sup>

#### Benefits of Walking Poles

Acute physiological benefits of walking with poles include a 20% increase in  $VO_2$ , HR, and caloric expenditure when compared to walking without poles.<sup>36</sup> A similar study showed an acute increase in  $VO_2$ , HR, Kcal/min, and RER by 11, 9, 17, and 6%, respectively, during submaximal treadmill walking with walking poles.<sup>37</sup> Although the percent of increase is different between the two studies, the same general results occurred: walking poles increased the acute physiological responses to walking.

To this author's knowledge, only one training study utilizing walking poles has been completed.<sup>38</sup> The study determined the effects of 12-weeks of walking with and without walking poles in middle-aged women. It was concluded that aerobic power was increased 8% over the 12-week period in both groups. Although both groups achieved similar increases in aerobic power, the group using walking poles obtained the 8% change while walking approximately .3 mph slower. Also, the group using walking poles experienced

a small decrease in body fat percentage whereas the walking only group did not change.

Walking poles have also been shown to improve upper body muscular endurance, but not arm strength.<sup>39</sup> Endurance was measured during a 1-minute bout of alternating arm pulls on a modified isokinetic swimbench apparatus. An increase in endurance of 38% was observed following the 12-week study.

To summarize, walking poles, when used properly, can increase the acute physiological responses to walking.<sup>36,37</sup> A 12-week training study also found that walking poles can help to increase aerobic power at a slower walking speed than walkers who do not use the poles.<sup>38</sup> Other benefits include an increase in upper body muscular endurance<sup>39</sup> and a reduction in total body fat.<sup>38</sup>

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