ABSTRACT

ANTHONY, R.M. Is fast walking an adequate aerobic training stimulus for male and female cardiac patients? MS in Adult Fitness/Cardiac Rehabilitation, December 1998, 32pp. (J. Porcari)

Walking is the most common form of aerobic activity in most cardiac rehabilitation programs. Many physiological health benefits have been associated with low to moderate exercise intensities. On the other hand, cardiac patients are older and have a variety of cardiovascular and musculoskeletal limitations that may hinder the ability to achieve a training heart rate (THR). The purpose of this study was to determine whether or not male and female cardiac rehabilitation (CR) patients can walk fast enough to achieve their individualized THR, defined as $\geq$ 70% heart rate max (HRmax). Each subject was instructed to walk as brisk as possible, trying to maintain a steady pace, for 1 mile. All walks were performed individually and not paced in any manner. Heart rates were measured every minute using a heart rate monitor. The heart rates between the 0.50 and 0.75 mile points were used as an average for each walk and an overall rating of perceived exertion was recorded at the end of the test. It was found that 87.5% of the male and 100% of the female subjects were able to achieve $\geq$ 70% of their individualized THR. The combined mean actual percent achieved by both genders was 80.4% HRmax. It is concluded that fast walking is an adequate aerobic training stimulus for most cardiac patients.

IS FAST WALKING AN ADEQUATE AEROBIC TRAINING STIMULUS FOR MALE AND FEMALE CARDIAC PATIENTS?

A MANUSCRIPT STYLE THESIS PRESENTED

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RYAN M. ANTHONY

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THESIS FINAL ORAL DEFENSE FORM

Candidate: Ryan Matthew Anthony

We recommend acceptance of this thesis in partial fulfillment of this candidate's requirements for the degree:

Master of Science in Adult Fitness/Cardiac Rehabilitation

The candidate has successfully completed the thesis final oral defense.

Thesis Committee Chairperson Signature — Date: 7/2/98

Thesis Committee Member Signature — Date: 7/2/98

Thesis Committee Member Signature — Date: 7/2/98

This thesis is approved by the College of Health, Physical Education, and Recreation.

Associate Dean, College of Health, Physical Education, and Recreation — Date: 7-8-98

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INTRODUCTION

It has been well established that walking as a form of exercise is associated with many physiological health benefits. Walking has been shown to improve cholesterol levels and aid in weight loss,[1] control hypertension and relieve anxiety,[2] and slow the rate of osteoporosis.[3] A major question is whether or not walking provides a sufficient training stimulus to increase cardiovascular respiratory endurance.

According to the American College of Sports Medicine (ACSM), cardiovascular fitness is related to achieving and maintaining a prescribed exercise intensity for 20 to 60 minutes.[4] The recommended intensity level for increasing cardiorespiratory endurance corresponds to 60% to 90% of heart rate max (HRmax), or 50% to 85% of maximal oxygen consumption (VO_2max).

Porcari et al.[5] studied the question as to whether or not walking was an intense enough activity to elicit a training level heart rate, defined as $\geq$ 70% of HRmax, for men and women between the ages of 20 and 70 years old. It was found that 91% of the women and 67% of the men could achieve a training heart rate (THR) with brisk walking. A recent study by Spelman, Pate, Macera, and Ward[6] agreed with these findings and found that healthy, habitual exercise walkers were able to attain 70% HRmax by self-selecting a walking intensity.

Walking is the most common form of aerobic activity in most cardiac rehabilitation programs. Many cardiac rehabilitation patients are older and have a variety of

cardiovascular and musculoskeletal limitations that may restrict walking capabilities. Thus the question arises as to whether or not heart disease patients can walk fast enough to achieve their individualized THR. As the aging process evolves, there is a general decline in physiological function, which results in a decrease in walking speed. Researchers have found that the decline in walking speed is due to decreased strength in both the plantar flexor muscles of the calf[7] and the quadriceps,[8] which contribute significantly to changes in gait.[9] In addition, many cardiac rehabilitation patients may have orthopedic problems, which may limit their walking speed.

Another factor to consider when prescribing exercise is that some older individuals or cardiac rehabilitation patients still feel that they need to run in order to achieve a training effect. Previous studies[10,11] have shown that brisk walking, if carried out at the same intensity, results in similar changes in endurance capacity compared to running. Also, because of the lower impact of walking, the incidence of injuries is much lower.

To the author's knowledge, there has not been a study that has validated walking as a beneficial training modality in patients with coronary heart disease. Previous studies utilized apparently healthy middle aged and elderly adults. The purpose of this study was to determine whether or not brisk walking is an adequate enough stimulus to elicit a training heart rate in subjects with coronary heart disease.

METHODS

Subjects

Patients were recruited from the Phase III and IV Cardiac Rehabilitation unit of the La Crosse Exercise and Health Program. Each subject had documented heart disease, as indicated by past medical events listed in Table 1.

Table 1. Events Leading to Enrollment into the Cardiac Rehabilitation Program

Event	Occurrence
Myocardial Infarction	19
CABG	7
PTCA	3
CABG + PTCA	5
CABG	14
PTCA	5
CABG + PTCA	5
CAD	3
Cardiomyopathy	1
Angina	2
Silent Ischemia	1

CABG = coronary artery bypass graft; PTCA = percutaneous transluminal coronary angioplasty; CAD = coronary artery disease

Prior to testing, each subject was asked to sign an informed consent form (see Appendix A) approved by the University of Wisconsin-LaCrosse Human Subjects Review Board. Subjects also could not have had a change in heart rate altering medications since their last symptom-limited graded exercise test (GXT).

Subjects were eligible for the study as long as they had symptom-limited GXT within the past year. Information from the subject's last symptom-limited GXT is summarized in Table 2. These data were used to calculate the subject's individualized training heart rate used for the 1 mile walking test. Drugs taken by the subjects included beta blockers, calcium channel blockers, aspirin, anticoagulants, and cholesterol lowering medications.

Table 2. Maximal Data From Last Symptom Limited Graded Exercise Test

	Mean ± SD	Range
HR (bpm)	131 ± 25.0	83 – 187
SBP (mm Hg)	174 ± 23.7	130 – 234
DBP (mm Hg)	78 ± 13.9	50 – 110
RPE	16.5 ± 1.5	13 – 20
METS	9.5 ± 2.8	4.1 – 15

Testing Procedures

The purpose of the study, the procedures, and the time commitment were discussed individually with each subject. Each eligible subject given the option to participate was assured that their confidentially would be protected. It was clearly explained to each subject that the risks involved were minimal, but if at any time during the test any pain or unusual discomfort occurred the test would be terminated.

Each subject performed a 5 to 10 minute warm up that included a walk around the track at a comfortable pace and stretching of all the major muscle groups. Following the 1 mile walking test, each subject performed a cool down walk around the track until HR was within 10 beats per minute (bpm) of resting heart rate.

Track Walks

Each subject performed the 1 mile walk (8 laps) on a measured track. All walks were performed individually and not paced in any manner. The subjects were simply instructed to walk as briskly as possible, trying to maintain a steady pace. Heart rates were monitored using the Polar Vantage XL heart rate monitor. The Polar heart rate monitor was set to memory mode and heart rates recorded every minute.

Since the heart rates at the 0.25 mile point reflects a transition from rest to exercise and the heart rates during the last quarter mile may be influenced by fatigue or a last minute surge, the heart rates from the middle ½ mile were used to represent the steady state exercise period.[5] The heart rates at the 0.50 and 0.75 mile points were used as an

average for each walk and included in the final analysis. An overall rating of perceived exertion (RPE) was asked at the conclusion of the test.

Data Analysis

The goal of the analysis was to determine what percentage of cardiac rehabilitation patients can achieve a THR, defined as ≥ 70% HRmax, while walking briskly. The percentages of those who did and did not elicit a THR were measured between subjects based on mean comparisons of different variables (gender, height, weight, age, and walking time). Alpha was set at .05 to achieve statistical significance.

RESULTS

Fifty patients (40 males and 10 females) were recruited to perform the 1 mile walking test. The descriptive characteristics of the subjects are described in Table 3. The results attained during the 1 mile walk test are presented in Table 4.

Table 3. Descriptive Characteristics of the Subjects

Variable	Age (yr) x ± SD (range)	Height (cm) x ± SD (range)	Weight (kg) x ± SD (range)
Males (40)	67.4 ± 9.9 (48 – 83)	177.5 ± 7.2 (165.1 – 198.1)	84.7 ± 14.5 (50 – 113.6)
Females (10)	64.7 ± 8.7 (49 – 75)	161.3 ± 4.7 (154.9 – 167.6)	69.6 ± 18.1 (54.5 – 115.9)

Table 4. Results Attained During the 1 Mile Wali Test

	Sex	Mean ± SD	Range
Achieved HR (bpm)	M	103 ± 16	65 – 146
	F	107 ± 19	83 – 144
% of HRmax	M	78 ± 1*	59 – 100
	F	88 ± 7*	74 – 96
RPE	M	12.5 ± 1.7*	9 – 17
	F	14.5 ± 2.4*	11 – 17
Walkingtime (min:sec)	M	17:20 ± 3:22*	12:15 – 26:25
	F	19:56 ± 4:27*	14:27 – 28:25

* indicates significant difference between gender ($p < 0.05$).

Actual heart rates achieved during the walk ranged from 65 – 146 bpm, with the average being 103 and 107 bpm for the males and females, respectively. Measured as a percentage of HR max, females achieved a significantly higher ($p < 0.05$) percentage than males (88% vs. 78%). Females also perceived the 1 mile walk to be significantly ($p < 0.05$) more difficult than the males (14.5 vs. 12.5) and took significantly ($p < 0.05$) longer to walk the 1 mile than the males (19:56 vs. 17:20). Overall, 88% (35 of 40) of the men and all of the women achieved a THR. The maximal MET capacity of the five men who did not achieve a THR was significantly ($p < 0.05$) greater then the men who did attain a THR (11.4 vs. 9.7 METS). Lastly, only one of the subjects with stable angina experienced a mild case of chest discomfort during the 1 mile walk.

DISCUSSION

The purpose of this study was to determine whether or not male and female cardiac rehabilitation (CR) patients can walk fast enough to achieve their individualized THR, defined as ≥ 70% HR max. It seemed appropriate to consider 70% HR max a reasonable criterion, since this corresponds to approximately 56% of VO_2max and is above the minimum guidelines to improving cardiorespiratory endurance recommended by ACSM.[4] Patients on beta-blocking medication were included in this study based on studies that have concluded exercise guidelines for patients taking or not taking beta-blockers are similar[12] and does not influence the HR and RPE relationship.[13]

In the current study, it was found that 90% of the subjects were able to achieve 70% of their individual THR. Overall, an average HR corresponding to 80% HR max was achieved. The results of this study are comparable to studies by Porcari et al.,[5] Spelman et al.,[6] and Murphy and Hardman,[14] which found that walking at a self-selected intensity elicited exercise heart rates corresponding to 73%, 75%, and 81% of HR max, respectively. According to the research investigating factors affecting the ability to elicit THR, the most significant influences on heart rate were due to age, VO_2max, gender, and the relationship between height and walking speed.

Overall, 88% of the men and all of the women were able to reach their THR. When compared to Porcari et al.,[5] they found that 67% of the men and 91% of the women were able to achieve 70% of HRmax. A possible explanation for the higher percentage of subjects in this study who achieved a THR might be due to the difference in age.

The subjects in this study were older as compared to the subjects used in the study by Porcari et al.[5] (66 vs. 49 years). Consistent with this finding is that in the study by Porcari et al.,[5] 83% of males over the age of 50 elicited a THR, which is similar to the percentage (88%) found in the current study. A further explanation would be that as age increases, VO_2max decreases, and the percentage of subjects who can attain a THR increases. This is of no surprise due to a relatively lower functional capacity reflected in this population.

This explanation agrees with Porcari et al.,[5] who found a significant VO_2max effect with age in regards to attaining a THR. In their study, a higher percentage of those who elicited a THR were associated with having a lower VO_2max across all ages. This VO_2max effect was most evident in the 30 to 39 year old men, among whom 87% of those with low, 44% of those with medium, and only 37% of those with high VO_2max achieved THR. However, no consistent pattern was observed in the women, since 93% of the 30 to 39 year old with high VO_2max achieved THR. The same trend was evident in the present study comparing those who did versus those who did not achieve a THR.

When comparing the males who were able to achieve a THR to the males who did not, the males who attained a THR were older (68 vs. 61years) and had a lower maximal MET capacity (9.7 vs. 11.4 METS) than those who did not achieve a THR. However, it is of interest to point out that three of the five subjects who did not attain THR achieved a %HR max of 65%, 66%, and 67%, respectively. Even though those patients did not achieve a THR, they were found to have a faster walking pace then

those who did (3.5 vs. 3.7 mph). According to Porcari et al.,[5] this result seems appropriate because they found that men with a high VO_2max walked at a relatively faster pace (5.3 mph) in order to achieve a THR.

When divided by gender, the males finished the mile faster (17:20) than the females (19:56) and had a higher MET capacity (10.0 vs. 7.5 METS), whereas the females reached a higher percentage of HR max (88% vs. 78%) and perceived the mile walk to be harder (14.5 vs. 12.5) when compared of males. These gender differences are similar to those found by Porcari et al.,[5] where females walked slower, had a lower VO_2max, and reached a higher percentage of HR max. The ability for a greater percentage of females to achieve a THR is associated with having a lower MET capacity, which also explains the higher RPE.

Another possible reason why the females took longer to finish the mile walk, yet achieved higher heart rates, may be due to the differences in height. The women in this study were significantly shorter then the men (63 vs. 70 inches). Shorter legged individuals tend to have a faster pace frequency causing increased work from the leg muscles, which could well increase energy expenditure, heart rate, and perceived exertion.

Overall, it appears that brisk walking is a safe and effective means to elicit a training level heart rate defined as $\geq$ 70% HRmax in the majority of Phase III/IV cardiac rehabilitation patients. This study showed that 88% of the men and all of the women

were able to achieve a THR. Thus, brisk walking may be sufficient for most stable cardiac rehabilitation patients, except for highly fit patients, to achieve a training benefit.

REFERENCES

1. Rippe JM, Ward A, Porcari JP, Freedson PS: Walking for health and fitness. *JAMA* 1988;259(18):2720-2724.

2. Porcari JP, Ward A, Morgan W, et al: Effects of walking on state anxiety and blood pressure. *Med Sci Sports Exerc* 1988;20:S85.

3. Blumental JA, Emery CF, Madden DJ, et al: Effects of exercise training on bone density in older men and women. *J Am Geriatr Soc* 1991;39(11):1065-1070.

4. American College of Sports Medicine. *Guidelines for Exercise Testing and Prescription (5th ed.)*. Philadelphia, PA: Lea and Febiger, 1995:158.

5. Porcari J, McCarron R, Kline G, et al: Is fast walking an adequate aerobic training stimulus for 30-69 year old men and women? *Phys Sportsmed* 1987;15(2):119-129.

6. Spelman CC, Pate RR, Macera CA, Ward DS: Self-selected exercise intensity of habitual walkers. *Med Sci Sports Exerc* 1993;25:1174-1179.

7. Bendall MJ, Bassey EJ, Pearson MB: Factors affecting walking speed of elderly people. *Age Ageing* 1989;18:327-332.

8. Gibbs J, Hughes S, Dunlop D, et al: Predictors of change in walking velocity in older adults. *J Am Geriatr Soc* 1996;44:126-132.

9. Imms FJ, Edholm OG: Studies of gait and mobility in the elderly. *Age Ageing* 1981;10:147-156.

10. Suter E, Marti B, Gutzwiller F: Jogging or walking: Comparison of health effects. *Ann Epidemiol* 1994;4:375-381.

11. Pollock ML, Carroll JF, Graves JE, et al: Injuries and adherence to walk/jog and resistance training programs in the elderly. *Med Sci Sports Exerc* 991;23(10): 1194-1200.

12. Pollock ML, Lowenthal DT, Foster C, et al: Acute and chronic responses to exercise in patients treated with beta blockers. *J Cardiopulm Rehabil* 1991;11: 132-144.

13. Pollock ML, Foster C, Rod JL, Wible G: Comparison of methods for determining exercise training intensity of cardiac patients and healthy adults. *Adv Cardiol* 1982;31:129-133.

14. Murphy MH, Hardman AE: Training effects of short and long bouts of brisk walking in sedentary women. *Med Sci Sports Exerc* 1998;30(1):152-157.

APPENDIX A

INFORMED CONSENT

IS FAST WALKING AN ADEQUATE AEROBIC TRAINING STIMULUS FOR FOR MALE AND FEMALE CARDIAC REHABILITATION PATIENTS?
INFORMED CONSENT

I,_____, would like to volunteer to participate in a study to determine the percentage of cardiac rehabilitation patients who can achieve a training heart rate while walking one mile. My target heart rate is defined as a minimum of 70% of maximal heart rate determined from my symptom-limited maximal graded exercise test within the past year. This study will require the measurement of my heart rate during the entire one mile walk. I am eligible for this study because of my documented heart disease and have had a symptom limited maximal graded exercise test within the past year. In addition I have not had a change in any heart rate altering medications since my last graded exercise test as explained by the researcher.

I agree that I have the ability to walk at least one mile continuously. After a 5 to 10 minute warm up walking around the track at a comfortable pace, the researcher and I will stretch all of the necessary muscle groups in an attempt to avoid any unnecessary injury that may occur during the test. The test will be conducted on the indoor track located in Mitchell Hall at the University of Wisconsin-La Crosse. I will be instructed to walk one mile as briskly as possible trying to maintain a steady pace throughout the walk. During the test, my heart rate will be monitored continuously with a heart rate monitor strapped to my chest. Although this test will require submaximal effort I understand that I can stop the test anytime I feel unable to complete the one mile walk. As with any exercise, there exists the possibility of adverse changes occurring (i.e., dizziness, difficulty in breathing, etc.) during the test procedure. In addition, I will probably feel tired at the end of the walking test. If any abnormal conditions are to occur at any time, the test will be immediately terminated.

After the one mile walk test has been completed, the researcher will lead in a cool down period until I have fully recovered. I will be closely monitored after the test since there is a chance some individuals may experience nausea or become light headed immediately following the test.

A resting heart rate and blood pressure will be taken before the warm up begins. Heart rate will be measured at every minute of the walk until I have finished the one mile duration using the monitor strapped around my chest. Other than the possible discomfort of this strap there should be no interference with my ability to participate in this test.

All testing sessions will be scheduled at my convenience. The testing sessions will be supervised and conducted by Ryan Anthony, a graduate student enrolled in the Adult Fitness/Cardiac Rehabilitation graduate program under the direction of John Porcari, Ph.D.

I consider myself functional enough to complete the one mile walk test to the best of my ability. To my knowledge I am not infected with a contagious disease or have any limiting physical conditioning or disability, that would preclude my participation in the test as described above. I have read the foregoing material and I understand what is expected from me. Any questions which may have occurred to me have been answered to my satisfaction. I, therefore, voluntarily consent to participate in this test although I may withdraw at any time without any type of penalty. Furthermore I understand that participation is voluntary and that neither the refusal to participate nor the decision to discontinue participation (at any time) will involve no penalty or loss of benefits to which the I am entitled. Lastly, I consent to presentation and publication or other dissemination of study results so long as the information is anonymous and disguised so that no identification can be made.

Concerns about any aspects of this study or project may be referred to the principal researcher, Ryan Anthony (785-7195), and thesis advisor, John Porcari, Ph.D (785-8684).

Investigator or Researcher	Date	Participant	Date

APPENDIX B

REVIEW OF RELATED LITERATURE

REVIEW OF RELATED LITERATURE

Introduction

It has been well established that walking as a form of exercise is associated with many physiological health benefits. A major question is whether or not walking provides a sufficient stimulus to increase cardiovascular fitness. According to the American College of Sports Medicine (ACSM), the recommended intensity level for increasing cardiovascular fitness corresponds to 60% to 90% of maximum heart rate (HRmax), or 50% to 85% of maximal oxygen uptake (VO_2max) or HR reserve.[1] Both methods are associated with a rating of perceived exertion of 12 to 16 on the original Borg scale. This prescribed intensity should be sustained for 20 to 60 minutes.[1]

Walking is the most common form of aerobic activity in most cardiac rehabilitation programs. Many cardiac rehabilitation patients are older and have a variety of cardiovascular and musculoskeletal limitations that may restrict their walking capabilities. Thus the question arises as to whether or not heart disease patients can walk fast enough to achieve their individualized training heart rate.

This review of literature will focus on studies that have evaluated factors affecting the ability to walk at an increased rate in elderly individuals, thus influencing heart rate. The majority of the literature has used healthy adults as subjects. These studies have concentrated on only the factors affecting walking speed and heart rate. To the researchers knowledge there have been no studies looking at whether individuals with

heart disease are able to achieve a training heart rate while walking. This review of literature will also help the reader understand the physiological and cardiovascular health benefits of walking, some of the limiting factors that may affect the ability achieve a training heart rate, and some of the associated risks of brisk walking and jogging at varied intensities in the elderly.

The Importance of Walking

It has been documented well over the past few decades that physical activity plays an important role in improving physiological health. The importance of walking as a form of activity has also been shown to be associated with many of these benefits. In 1988, Rippe, Ward, Porcari, and Freedson[2] concluded that even low to moderate intensity exercise, such as walking, is associated with reduced anxiety and tension, aids in weight loss, improves cholesterol levels, helps to control high blood pressure, and slows the process of osteoporosis. As the aging process evolves, the elderly become more frail, which affects mobility. According to Barry, Rich, and Carlson,[3] walking is probably the single most important form of physical activity for the elderly who are still ambulatory. Walking programs, along with flexibility and strength training, can prevent muscle weakness, impaired gait, and loss of balance, which all increase with age. This will result in greater independence and an improved quality of life.

Cardiovascular Benefits of Walking

Many important epidemiological studies have linked physical activity with decreased risk of developing coronary heart disease (CHD). Studies by Leon and

colleagues,[4] and Paffenbarger, Hyde, and Wing,[5] and the recent Surgeon General's Report on Physical Fitness[6] released in 1996 all conclude that self-selected moderate intensity activity will lower mortality rates and the development of CHD compared to a sedentary lifestyle. Most of these studies, however, analyzed data from subjects who were less then 65 years of age. LaCroix, Leveille, Hecht, Grothaus, and Wagner[7] recognized the fact that little research has been done on the benefits of physical activity in adults aged 65 and older. The purpose of their study was to determine whether walking is associated with a reduced risk of CHD, hospitalization, and death in community dwelling older men and women over the age of 65. The 4.2 year study was based on 1645 older adults without severe disability and without a prior history of heart disease. Subjects who walked more than 4 hours per week were approximately 30% less likely to be hospitalized for CHD during the follow-up period as compared to those who walked less than 1 hour per week. This association was present in both sexes, all ages, among those with or without physical limitations, and among those who did or did not participate in more vigorous physical activities (e.g., jogging, aerobics, and basketball). Walking more than 1 hour per week was also associated with a 30% reduction in mortality.

The debate over whether or not the duration of exercise can effect improvements in cardiovascular health has recently been studied by Murphy and Hardman,[8] who compared the effects of short versus long bouts of brisk walking in sedentary women. Forty-seven middle aged women were assigned to either, three 10 minute walks per day

or one 30 minute walk per day. Brisk walking was done 5 days a week, at 70 to 80% of maximal heart rate for 10 weeks. It was found that heart rate during brisk walking did not differ significantly between groups. Short bout and long bout walkers achieved 131 bpm and 136 bpm, respectively, which corresponded to 73% and 75% of maximal heart rate. Improvements in VO_2max of about 8% were observed for both short and long bout walkers. This reconfirms the recommendation by ACSM that an accumulation of short bouts of exercise that are approximately 10 minutes in length throughout the day are just as beneficial as longer, continuous aerobic exercise.[1] These findings provide much stronger evidence than previously available for advising older adults to start or continue an exercise program of walking to prevent cardiac related events.

Walking and Cardiovascular Fitness

A number of studies have been done on the cardiovascular fitness benefits associated with walking. A round table discussion of six experts[9] were posed the question as to whether or not cardiac patients and the elderly could realize a training benifit from walking. They concluded that many people, particularly elderly individuals or cardiac patients, are able to improve their aerobic capacity with walking. It was pointed out that intensities of 4 METS often fall within 50%-60% of the VO_2max in these populations, which falls within the range recommended by ACSM for the development and maintenance of cardiovascular fitness. In other words, it is almost impossible not to get some cardiovascular benefit from walking.

In 1971, Pollock et al.[10] studied the effects of walking on cardiovascular function. Sixteen sedentary middle aged males volunteered to train for 20 weeks, 4 times a week for 40 minutes per session. It was found that maximal oxygen uptake increased by 28%. They concluded that vigorous walking has a significant training effect on cardiovascular fitness.

In 1987, Porcari et al.[11] conducted a study to determine if fast walking was intense enough to elicit an adequate aerobic stimulus for 30 to 69 year old men and women. The target training heart rate was defined as greater than or equal to 70% of a person's age predicted maximal heart rate. Three hundred and forty three subjects (165 men and 178 women) walked a mile as fast as possible. Ninety-one percent of the women and 83% of the men reached a heart rate greater than or equal to 70% of their individual maximum.

In a related study, Spelman et al.[12] assessed self-selected exercise intensity of habitual walkers. Twenty-nine healthy middle aged subjects (22 females and 7 males) performed a typical exercise walk, while walking speed was measured by an unseen observer. The mean percent of HRmax and the average rating of perceived exertion during the walk were 70% and 10.9, respectively. These results were similar to that of the findings by Porcari et al.,[11] mentioned earlier, who reported a mean RPE of 11.7 by similar aged subjects while walking at a self-selected pace that was almost identical in speed (3.98 vs. 3.87 mph).

The results of these three studies seem to show that fast walking is adequate enough to elicit an aerobic training stimulus in healthy middle aged men and women according to ACSM recommendations. To the knowledge of the current researcher, there have not been any studies to date that have tested this conclusion specifically in cardiac patients. The studies utilizing these patients have only examined factors limiting walking speed and gait. This raises the question as to whether these factors would limit the elderly from achieving a training heart rate while walking.

Limiting Factors Affecting HR while Walking

As the aging process evolves, there is a general decline in physiological function, which results in a decrease in walking speed. It seems logical to think that the reduction in the speed of walking would effect the ability of the elderly to walk at higher intensities, thus effecting the ability to achieve a training heart rate. Researchers have found that a decline in walking speed is due to a decrease in strength in both the plantar flexor muscles of the calf[13] and the quadriceps,[14] which contribute significantly to changes in gait.[15] Many cardiac rehabilitation patients may also have orthopedic problems, which may limit their walking speed.

A study by Bendall et al.[13] investigated the association between a number of variables and walking speed in a group of 67 women and 58 men aged 65 to 90 years. Walking speed was assessed by measuring the time subjects took to walk around a 100 meter paved outdoor course, having been given standard instructions to walk steadily at a pace which was right for them. In men, 44% of the variance in walking speed was

accounted for by height, calf strength, and weight. In women, 42% of the variance was accounted for by height, calf strength, and the presence of leg pain limiting mobility. As expected, a similar decline in walking speed was observed with age in both men and women. Lastly, it was reported that walking speed was affected mostly by leg pain, not by chest pain or breathlessness. This explains the association between walking speed and the reduced strength of the plantar flexor muscles of the calf in the elderly.

Quadriceps strength has also been identified as another limiting factor to walking speed. A recent study[14] found that quadriceps strength, along with joint impairment and age, contributed significantly to the decline in walking velocity. The mean age of subjects (n = 588) was 77 years. Walking velocity was determined by testing the time required to walk 50 feet. Over a 4 year period, median walking velocity declined from 2.3 to 1.9 mph. A minimum walking speed 0.5 mph was used to predict long term hospital care versus independent living. The proportion of subjects above this speed declined from 95.3% to 80.4% during the 4 year study. Lastly, only 28.3% of the subjects with walking velocities greater than 2.6 mph at baseline, an approximate normal walking speed for older adults, exceeded this speed after 4 years. It is clearly apparent that the importance of exercise to maintain muscular development and growth in the elderly is essential for independent living. These two studies have mainly associated the decline in walking speed to a reduction in calf and quadriceps strength in the elderly. Hence, the disturbances of gait are likely to be more prevalent.

Imms and Edholm[15] studied the gait and mobility of 71 subjects aged 60-99 years. The subjects were measured using metal contacts on the heel and sole of each shoe to evaluate the velocity of walking and stride length. If was found that the variation in stride lengths within this population is greater than that of stride frequency. It seems likely, therefore, that the variation in walking speeds is due rather more to the changes in stride length than to alterations of frequency. The results of this study agree with the previous studies in that the decline of walking speed is highly correlated with an increase in age. With age, the disease processes may also lead to shortening of the stride length, thus decreasing the speed of walking.

Bassey, Macdonald, and Patrick[16] investigated whether or not the relationship between freely chosen walking speeds and heart rate are effected by body composition, sex, and age. Two hundred and seventy-seven healthy subjects ranging from 20 to 65 years performed a self-paced walking test. The subjects walked approximately 200 meters at three different personally chosen speeds (slow, normal, or rather fast). Height, weight, and sex were significant factors influencing walking speed, which thus affected heart rate. Age was a significant factor affecting walking speed, but not heart rate. The influence of both height and age were more marked at the faster speed and explained more of the variance.

A similar study by Himann, Cunningham, Rechnitzer, and Paterson[17] investigated the effect of height and age on the speed of walking and heart rate. One hundred and forty-nine females (aged 22 to 95 years) and 289 males (aged 19 to 102 years) were

asked to walk 80 meters at three different personally chosen speeds (slow, normal, or fast). It was found that the differences in speed, step length, and frequency between the three different paces, became smaller with increasing age. Age was not a significant independent variable before age 62; however, after age 62, age accounted for 31, 37, and 34% of the variance for slow, normal, and fast walking paces, respectively. Also, heart rates at each walking pace were similar in both sexes, and decreased slightly with age. The assumption that speed of walking is positively correlated with height was prevalent in the study, which is in agreement with the three previously mentioned studies.[13-15]

The fact that height was found to be the most significant influence on heart rate in these studies[13-17] may be because taller individuals have longer legs, which enables them to walk with a longer stride and lower stride frequency at a given speed. This produces a lower heart rate as compared to shorter individuals. Shorter legged individuals tend to have a faster pace frequency at any speed causing increased work from the leg muscles, which could well increase energy expenditure and heart rate.

Other factors influencing walking speed also become apparent with age. An unmotivated sedentary lifestyle will eventually lead to weight gain and loss of muscle strength which will influence the pace of walking,[13-15] hence eliciting a lower heart rate. Thus, that is why it was concluded that the strain of walking rather fast (at more than 3.0 mph) for some people would be harder and may even produce higher heart rate levels compared to other individuals dependent upon these factors.

Risk of Injury with Varied Intensities

As the aging possess evolves, the body is not as compliant to the vigorous pounding to the joints and ligaments as it once was due to some of the limiting factors mentioned earlier. Thus, the greater chance of having an injury with high impact activities is more likely. Some members of the older population still have the youthful mentality that they need to run in order to achieve a training effect. A number of studies have looked at the risk of injury between jogging and walking.

An early study by Koplan, Powell, Sikes, Shirley, and Campbell[18] investigated the risks of recreational running in 693 males and 730 females by way of questionnaire following a 10-km road race. The mean age of the males was 33.4 years and 29.9 years for the females. In the year after the race, more than 35% of the men and women incurred a musculoskeletal injury attributed to running that was severe enough to require a decrease in weekly mileage. The knee was the most common site of injury for both sexes. Injuries were not found to be correlated with age, speed, body mass index, or number of prior years running.

A more recent study by Suter, Marti, and Gutzwiller[19] also investigated the frequency of running injuries, but looked at the exercise adherence rate and training intensity associated with them. Seventy-five sedentary male volunteers (mean age 41.2 years) who were free of cardiovascular disease were randomly allocated to a control, jogging, or walking group. Exercisers were encouraged to adhere to a home-based training program of either 4 days of 30 minutes of jogging per week at a

heart rate corresponding to 75% of VO_2max, or 6 days of 30 minutes of walking per week at a heart rate corresponding to 50% of VO_2max. Both groups trained for 6 months. Over the duration of the study, a total of 49 injuries occurred. In relating the frequency of injuries to training modality, joggers suffered about 33% more injuries than walkers. The joggers also suffered more often from muscle soreness than walkers. In regards to adherence rate, results showed that lower training intensity did not increase adherence rate, but walkers trained somewhat more frequently than joggers (3 vs. 2.4 times/wk). This study indicates that brisk walking seems to be as effective as high intensity training with respect to similar changes in endurance capacity and body fat. This is in agreement with another study[2] which suggest that brisk walking provides strenuous enough exercise for cardiovascular benefits in most adults.

Two studies investigated the incidence of exercise related injuries during training in the elderly. The first study by Pollock, Carroll, Graves, Leggett, Braith, Limacher, and Hagberg[20] evaluated the effects of 26 weeks of aerobic training on the incidence of injury in 70 to 79 year old men and women (25 males and 32 females). During the first 13 weeks, subjects walked for 30 to 45 minutes, 3 days a week at 40 to 70% of heart rate reserve (HRmax reserve). Rating of perceived exertion during these sessions averaged 11-12 (light) initially and progressed to 12-13 (somewhat hard) on the Borg Scale. For weeks 14-26 subjects increased the intensity to 75% to 85% of HRmax reserve. This increase in intensity was accomplished by alternating

moderate and fast-paced walking intervals or walk/jog intervals. The RPE for the last 13 weeks averaged 14-15 (hard). Nine of the 21 subjects in the walk/jog training group sustained in injury (42.9%). Only one of these nine injuries occurred during the first 13 weeks of low to moderate intensity walking. The other eight injuries occurred during the last 13 weeks of training higher intensities. Two of the eight males were injured (25%) while all six of the females (100%) were injured. All of the injuries involved the lower extremity, were new, and were not related to previously known orthopedic conditions.

A follow-up study conducted a year later by Carroll, Pollock, Graves, Leggett, Spitler, and Lowenthal[21] concentrated on the incidence of injury with just walking. Sixty-eight healthy elderly volunteers (31 men and 37 women) aged 60-79 years of age were assigned to moderate or high intensity walking for 26 weeks. The moderate intensity group of subjects gradually increased their training to 65%-70% of HRmax reserve for 45 minutes and the high intensity group gradually increased their training to 80%-85% of HRmax reserve for 35 minutes for the final 12 weeks of training. Seven injuries occurred during the study. Five of the training injuries occurred while subjects were training on a gymnasium floor at walking speeds of approximately 3.5 to 4.0 mph. Three of these subjects were training at a moderate intensity while the other two were training at higher intensities. Again, all of the injuries took place in the lower extremity and only one appeared to be related to any previously known orthopedic problem.

The similarity in these two studies is that it was not the intensity that caused the injuries, but rather the high impact forces associated with jogging and faster walking speeds. Although the second study found fewer injuries (14% vs. 57%), both studies found the impact of both modalities to be a factor in lower limb injuries. Lastly, the 1992 study also pointed out that nearly all of the subjects in the high intensity group required the use of graded treadmill walking to reach their target intensity.

Summary

Walking has become an extremely effective and practical means to improve physiological and cardiovascular health, and is the mainstay of many exercise programs. Several studies have concluded that brisk walking of over 70% of HRmax is sufficient enough to develop and sustain physical fitness in apparently healthy middle aged adults.[8,10-12] However, only a few studies have recognized that the elderly, particularly cardiac patients, can produce a training effect and benefit from brisk walking.[3,9,11] Walking is a low impact activity that provides enough aerobic stimulus to maintain musculoskeletal development and reduces the risk of further developing CVD[7] at a low incidence of injury.[19-21] It is clear that walking improves well being and independence in both primary and secondary prevention.

REFERENCES

1. American College of Sports Medicine: *Guidelines for Exercise Testing and Prescription (5th ed.)*. Philadelphia, PA: Lea and Febiger, 1995:158-162,186.

2. Rippe J, Ward A, Porcari J, Freedson P: Walking for health and fitness. *JAMA* 1988;259(18):2720-2724.

3. Barry HC, Rich BS, Carlson RT: How exercise can benefit older patients. *Phys Sportsmed* 1993;21(2):124-140.

4. Leon A, Connett J, Jacobs D, Rauramaa R: Leisure-time physical activity levels and risk of coronary heart disease and death, the multiple risk factor intervention trial. *JAMA* 1987;258:2388-2395.

5. Paffenberger R, Hyde R, Wing A: Physical activity, all-cause mortality, and longevity of college alumni. *N Eng J Med* 1986;314(10):605-613.

6. U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, President's Council of Physical Fitness and Sports: *Physical activity and health: A report of the Surgeon General*. Atlanta, GA., 1996;xvii:278.

7. LaCroix AZ, Leveille SG, Hecht JA, Grothaus LC, Wagner EH: Does walking decrease the risk of cardiovascular disease hospitalizations and death in older adults? *J Am Geriatr Soc* 1996;44:113-120.

8. Murphy MH, Hardman AE: Training effects of short and long bouts of brisk walking in sedentary women. *Med Sci Sports Exerc* 1998;30(1):152-157.

9. Rippe J, Ward A, Kaskell W, Freedson P, Franklin B, Campbell K: Walking for fitness. *Phys Sportsmed* 1986;14(10):144-159.

10. Pollock M, Miller H, Janeway R, Linnerud A, Robertson B, Valentino R: Effects of walking on body composition and cardiovascular function of middle-aged men. *J Appl Physiol* 1971; 30(1):126-130.

11. Porcari J, McCarron R, Kline G, et al: Is fast walking an adequate aerobic training stimulus for 30-69 year old men and women? *Phys Sportsmed* 1987;15(2):119-129.

12. Spelman CC, Pate RR, Macera CA, Ward DS: Self-selected exercise intensity of habitual walkers. *Med Sci Sports Exerc* 1993;25:1174-1179.

13. Bendall MJ, Bassey EJ, Pearson MB: Factors affecting walking speed of elderly people. *Age Aging* 1989;18:327-332.

14. Gibbs J, Hughes S, Dunlop D, Singer R, Chang RW: Predictors of change in walking velocity in older adults. *J Am Geriatr Soc* 1996;44:126-132.

15. Imms FJ, Edholm OG: Studies of gait and mobility in the elderly. *Age Aging* 1981;10:147-156.

16. Bassey EJ, Macdonald IA, Patrick JM: Factors affecting heart rate during self-paced walking. *Eur J Appl Physiol* 1982;48:105-115.

17. Himann JE, Cunningham DA, Rechnitzer PA, Paterson DH: Age-related changes in speed of walking. *Med Sci Sports Exerc* 1988;20(2):161-166.

18. Koplan JP, Powell KE, Sikes RK, Shirley RW, Campbell CC: An epidemiologic study of the benefits and risks of running. *JAMA* 1982;248(23):3118-3121.

19. Suter E, Marti B, Gutzwiller F: Jogging or walking: Comparison of health effects. *Ann Epidemiol* 1994;4:375-381.

20. Pollock ML, Carroll JF, Graves JE, et al: Injuries and adherence to walk/jog and resistance training programs in the elderly. *Med Sci Sports Exerc* 1991;23(10): 1194-1200

21. Carroll JF, Pollock ML, Graves JE, Leggett SH, Spitler DL, Lowenthal DT: Incidence of injury during moderate and high intensity walking training in the elderly. *J Gerontol* 1992;47(3):M61-66.