International Journal of Aquatic Research and Education

Volume 2 | Number 2 Article 7

5-1-2008

Comparison of the Health Aspects of Swimming With Other Types of Physical Activity and Sedentary Lifestyle Habits

Nancy L. Chase
University of South Carolina, sealions2@yahoo.com

Xuemei Sui
University of South Carolina

Steven N. Blair
University of South Carolina

Recommended Citation
Chase, Nancy L.; Sui, Xuemei; and Blair, Steven N. (2008) "Comparison of the Health Aspects of Swimming With Other Types of Physical Activity and Sedentary Lifestyle Habits," *International Journal of Aquatic Research and Education*: Vol. 2 : No. 2 , Article 7.
DOI: 10.25035/ijare.02.02.07
Available at: https://scholarworks.bgsu.edu/ijare/vol2/iss2/7

International Journal of Aquatic Research and Education, 2008, 2, 151-161

Comparison of the Health Aspects of Swimming With Other Types of Physical Activity and Sedentary Lifestyle Habits

Nancy L. Chase, Xuemei Sui, and Steven N. Blair

Swimming, water jogging, and aqua aerobics might provide health benefits to the general population, as well as patients with chronic diseases. Research on the health benefits of aquatic exercise in comparison with activities such as running and walking is scarce, however. The goal of this study was to evaluate characteristics of participants in the Aerobics Center Longitudinal Study and to compare health habits and physiological characteristics among swimmers, runners, walkers, and sedentary women and men to evaluate the health benefits of swimming compared with other types of physical activity. Participants were 10,518 women and 35,185 men age 20–88 years who completed a health examination between 1970 and 2005. Differences in the distribution of selected characteristics between swimmers and those participating in other types of activities (sedentary, walkers, or runners) were tested using logistic regression for proportions and ANOVA for continuous variables. The principal findings of this report are that swimming, as well as walking and running, has health benefits compared with a sedentary lifestyle.

Keywords: aquatic exercise, health habits, cross-sectional study, risk factors

A sedentary lifestyle is associated with a higher risk of all-cause mortality and certain chronic diseases including cardiovascular disease, diabetes, and osteoporosis (Haskell et al., 2007). In 2005, 23.7% of adults were sedentary, and only 49.1% of adults met the American College of Sports Medicine recommendations (Centers for Disease Control and Prevention, 2005). Physical activity decreases the risk of Type 2 diabetes, obesity, cardiovascular disease, stroke, hypertension, colon cancer, breast cancer, osteoporosis, anxiety, and depression (Kesaniemi et al., 2001). It also improves health through enhanced weight management and better control of blood glucose and insulin in diabetes (Kesaniemi et al.). Exercise might also decrease total cholesterol and low-density lipoprotein cholesterol while increasing high-density lipoprotein (HDL) cholesterol levels (Halverstadt, Phares, Wilund, Goldberg, & Hagberg, 2007). Regular physical activity is associated with decreased depression and anxiety, improved stress management, and improved overall mood state (Nieman, Custer, Butterworth, Utter, & Henson, 2000).

The authors are with the Dept. of Exercise Science, University of South Carolina, Columbia, SC 29208.

The American College of Sports Medicine and American Heart Association recommend that adults perform 30 min of moderate-intensity physical activity at least 5 days a week or a minimum of 20 min of vigorous-intensity physical activity 3 days a week to achieve health benefits (Haskell et al., 2007; Nelson et al., 2007). People can combine moderate and vigorous physical activity to achieve these recommendations (Haskell et al.). Those who achieve the recommended physical activity guidelines have a risk of all-cause mortality 30% lower than that of sedentary individuals (Williams, 2003). The greatest reduction in all-cause mortality risk occurs in previously sedentary individuals who become moderately active (Williams). People who exceed the basic physical activity recommendation further decrease their risk of chronic diseases, attain higher fitness levels, and increase health benefits (Haskell et al.).

Swimming, water jogging, and aqua aerobics are excellent aerobic activities that might provide health benefits to the general population, as well as patients with chronic disease such as heart failure (Schmid et al., 2007). Aquatic exercises might be preferred over other forms of aerobic activity for people who have arthritis, diabetes, disabilities, or excess weight (Lin, Davey, & Cochrane, 2004). Most studies on physical activity and health have included aerobic activities such as walking, jogging, and aerobics classes, but few such studies have included swimming as an exposure. It is important to understand how or if swimming and other types of physical activity are related and how they relate to health outcomes. Therefore, the goal of this study was to evaluate the characteristics of participants in the Aerobics Center Longitudinal Study (ACLS) and to compare the health habits and physiological characteristics of swimmers, runners, walkers, and sedentary women and men. Our principal purpose was to evaluate whether regular swimming is comparable to other aerobic activities in terms of beneficial health outcomes.

Methods

Participants

Data were obtained from a population of adults selected from patients of the Cooper Clinic, a preventive-medicine clinic in Dallas, TX. Participants were self- or employer- referred to the clinic for various services such as preventive medical examinations and health, nutrition, and exercise counseling. Participants for the current analysis were 10,518 women and 35,185 men age 20–88 years who completed a health examination during 1970–2005. Most participants were White and from middle and upper socioeconomic strata. All participants provided written consent to participate in the examination and in research. The Cooper Institute Institutional Review Board annually reviewed and approved the study protocol.

Clinical Examination

The physician examination and clinical measurements were completed after an overnight fast of at least 12 hr (Blair, Kampert, Kohl, Barlow, Macera, & Paffenbarger, 1996; Blair, Kohl, Paffenbarger, Clark, Cooper, & Gibbons, 1989). The examination consisted of the following: a personal and family health-history questionnaire, a physical examination by a clinic physician, anthropometric measurements, blood analyses, and a graded exercise test on a treadmill. Body-mass index (BMI, kg/m^2) was computed from measured height and weight and classified as normal (<25.0), overweight (25.0–29.9), or obese (30.0+). After a brief period of quiet sitting, blood pressure was recorded as the first and fifth Korotkoff sounds using auscultation methods (Pickering et al., 2005). Serum samples were analyzed for lipids and glucose using standardized automated bioassays. The clinical laboratory participated in and met quality-control criteria of the Centers for Disease Control and Prevention lipid-standardization program. Hypertension was defined as systolic blood pressure of 140 mm Hg or greater, diastolic blood pressure of 90 mm Hg or greater, or a history of physician diagnosis of the disease. Diabetes mellitus was defined as fasting plasma glucose concentration of 7.0 mmol/L or greater, a history of physician diagnosis, or insulin use. Hypercholesterolemia was defined as total cholesterol of 6.20 mmol/L or greater. Personal history of cardiovascular disease (myocardial infarction or stroke) and information on smoking habits (current smoker or not), alcohol intake (drinks per week), and physical activity habits (sedentary, walker, runner, or swimmer) were obtained from a standardized questionnaire.

Physical Activity

Physical activity status was categorized into four mutually exclusive groups according to the usual type of physical activity reported during the preceding 3 months (Hootman et al., 2001, 2002). Sedentary participants reported no participation in a run/walk/jog program, strenuous sports, racket sports, bicycling, or swimming. Walkers reported participation in a run/walk/jog program with an average pace of 15 min/mile or slower. Runners participated in a run/walk/jog program and reported an average pace of less than 15 min/mile. For run/walk/jog participants who did not report information about their pace (4–5% of the sample), walking and running status were determined by a question that asked how much time participants spent walking during their run/walk/jog program. Walkers were those who reported walking for at least 75% of their run/walk/jog program, and runners walked less than 25% of their run/walk/jog program. Run/walk/jog participants with missing information on pace and who reported walking 25–75% of their run/walk/jog program could not be clearly classified as runners or walkers and were excluded from this analysis. Swimmers were those who exclusively engaged in swimming and did not participate in a run/walk/jog program or other physical activities.

Cardiorespiratory Fitness

Cardiorespiratory fitness (CRF) was quantified as the duration of a symptom-limited maximal treadmill exercise test using a modified Balke protocol (Balke & Ware, 1959; Blair et al., 1989). The treadmill test began with the participant walking 88 m/min at 0% grade. At the end of the first minute, incline was increased to 2% and thereafter increased 1%/min until the 25th minute. For those who were able to continue past 25 min, the treadmill speed was increased by 5.4 m/min for each minute after the 25th. Exercise duration in this protocol is highly correlated with measured maximal oxygen uptake ($r > .90$; Pollock et al., 1976; Pollock et al., 1982). The test endpoint was volitional exhaustion or termination by the supervising physician. Maximal metabolic equivalents (METs, 1 MET = oxygen uptake of 3.5 ml · kg^{-1} · min^{-1}) were estimated from the final treadmill speed and grade

(American College of Sports Medicine, 2000). Previous ACLS reports have shown that low CRF is an independent predictor of mortality and nonfatal disease (Blair et al., 1989, 1996; Sui, LaMonte, & Blair, 2007). We defined low, moderate, and high CRF exposures according to the lowest 20%, the next 40%, and upper 40%, respectively, of the age- and sex-specific distribution of treadmill duration in the overall ACLS population (Sui et al.). We used this approach to maintain consistency in our study methods and because there is no widely accepted clinical categorization of CRF. Abnormal resting and exercise electrocardiogram (ECG) responses were broadly defined as rhythm and conduction disturbances, and ischemic ST-T wave abnormalities, as described in detail elsewhere (Gibbons, Mitchell, Wei, Blair, & Cooper, 2000). We have found 90% agreement between the ECG interpretation recorded in our database and that of a group of three physicians who read a random sample of 357 patient records (Gibbons et al.).

Statistical Analysis

Descriptive information is presented for men and women separately by different types of physical activities. Differences in the distribution of selected characteristics between swimming and other types of activities (sedentary, walkers, or runners) were tested using logistic regression for proportions and ANOVA for continuous variables. We performed an overall *F* test for one-way ANOVA and then compared three pairs of groups, which had been planned in advance, with the least-squares means procedure if the overall *F* test was statistically significant. For all statistical tests, α level adopted for significance was two-tailed, with $p < .05$. Statistical analyses were performed with SAS version 9.1 (SAS Institute, Cary, NC).

Results

Applying the physical activity categories described earlier, 1.0% of participants were swimmers, 42.5% were sedentary, 9.7% were walkers, and 46.8% were runners. Among the women, 1.1% were swimmers, 40.1% were sedentary, 14.5% were walkers, and 44.3% were runners. Among the men, 0.9% were swimmers, 43.2% were sedentary, 8.3% were walkers, and 47.6% were runners.

Characteristics of Physical Activity Groups in Women

The characteristics of female swimmers, walkers, and runners and sedentary women are shown in Table 1. There was no age difference among the four groups of participants. Walkers and runners had significantly lower BMI than swimmers. No significant differences were observed for total cholesterol or triglyceride level. Sedentary women had significantly lower HDL cholesterol levels than swimmers. Runners had significantly lower fasting blood glucose than swimmers. Sedentary women had significantly higher resting heart rates than swimmers, and runners had lower resting heart rates. Systolic and diastolic blood pressures were similar among the four physical activity groups. Significantly more sedentary women and walkers than swimmers were current smokers. Swimmers had the lowest alcohol intake among the four groups. Abnormal exercise and resting ECGs, as well as the prevalence of cardiovascular disease, hypertension, diabetes, and hypercholesterolemia, were similar among the four groups.

https://scholarworks.bgsu.edu/ijare/vol2/iss2/7
DOI: 10.25035/ijare.02.02.07

Table 1 Characterization of Different Types of Activities in Women

Characteristic	Swimmers (*n* = 118)	Sedentary (*n* = 4,218)	Walkers (*n* = 1,522)	Runners| (*n* = 4,660)
Age (years)	44.4 ± 10.8	43.4 ± 10.3	44.7 ± 10.9	43.2 ± 10.6
Body-mass index (kg/m^2)	24.1 ± 4.9	23.6 ± 4.5	23.2 ± 4.5*	22.5 ± 3.4*
Blood lipids (mmol/L)				
total cholesterol	5.21 ± 0.91	5.32 ± 1.04	5.24 ± 1.02	5.11 ± 0.98
HDL-C	1.66 ± 0.36	1.54 ± 0.38*	1.60 ± 0.40	1.63 ± 0.40
triglycerides	1.06 ± 0.58	1.11 ± 0.78	1.07 ± 0.67	0.98 ± 0.60
Fasting blood glucose (mmol/L)	5.36 ± 1.41	5.28 ± 0.76	5.24 ± 0.82	5.18 ± 0.72*
Resting heart rate	64 ± 11	67 ± 11*	64 ± 10	62 ± 11*
Resting blood pressure (mm Hg)				
systolic	113 ± 12	114 ± 15	112 ± 15	112 ± 14
diastolic	75 ± 9	76 ± 10	76 ± 10	75 ± 9
Current smoker (%)	3 (2.5)	612 (14.5)*	145 (9.5)*	296 (6.4)
Alcohol intake ≥5 drinks per week (%)	2 (1.7)	733 (17.4)*	286 (18.8)*	805 (17.3)*
Abnormal exercise ECG (%)	3 (2.5)	214 (5.1)	82 (5.4)	200 (4.3)
Abnormal resting ECG (%)	1 (0.9)	89 (2.1)	32 (2.1)	84 (1.8)
Prevalent diseases (%)				
cardiovascular disease[a]	0 (0)	20 (0.5)	11 (0.7)	16 (0.3)
diabetes mellitus	7 (5.9)	121 (2.9)	57 (3.8)	155 (3.3)
hypertension	16 (13.6)	790 (18.7)	261 (17.2)	709 (15.2)
hypercholesterolemia	15 (12.7)	715 (17.0)	222 (14.6)	507 (10.9)

Note. Data shown as *M* ± *SD* unless otherwise specified. HDL-C = high-density lipoprotein cholesterol; ECG = electrocardiogram.

[a]Myocardial infarction or stroke.

*Significantly different from swimmers ($p < .05$).

Characteristics of Physical Activity Groups in Men

The characteristics of male swimmers, walkers, and runners and sedentary men are shown in Table 2. Sedentary men, walkers, and runners were significantly younger than swimmers. Sedentary men had significantly higher BMI than swimmers, and runners had lower BMI than swimmers. Sedentary men, walkers, and runners had significantly higher levels of total cholesterol than swimmers, and swimmers had significantly higher HDL cholesterol and significantly lower triglycerides than sedentary men and walkers. Sedentary men had higher fasting blood glucose levels than swimmers. Sedentary men and walkers had higher resting heart rates than swimmers. Systolic blood pressure was lower in walkers and runners than in swimmers, and diastolic blood pressure was lower in runners than in swimmers. Significantly more sedentary men than swimmers were current smokers. Alcohol intake was the lowest in swimmers. Abnormal exercise and resting ECGs and the prevalence of cardiovascular disease were similar among the four groups. Runners had lower rates of diabetes mellitus and hypertension than swimmers. The prevalence of hypercholesterolemia was significantly higher in sedentary men than in swimmers.

Table 2 Characterization of Different Types of Activities in Men

Characteristic	Swimmers (*n* = 322)	Sedentary (*n* = 15,206)	Walkers (*n* = 2,928)	Runners (*n* = 16,729)
Age (years)	46.5 ± 10.6	43.8 ± 9.6*	45.4 ± 10.5*	43.9 ± 9.7*
Body-mass index (kg/m²)	26.4 ± 3.8	27.0 ± 4.1*	26.5 ± 3.7	25.7 ± 3.2*
Blood lipids (mmol/L)				
total cholesterol	5.21 ± 1.01	5.64 ± 1.07*	5.47 ± 1.04*	5.34 ± 1.07*
HDL-C	1.24 ± 0.33	1.12 ± 0.31*	1.15 ± 0.29*	1.22 ± 0.32
triglycerides	1.35 ± 0.92	1.77 ± 1.54*	1.59 ± 1.25*	1.36 ± 0.98
Fasting blood glucose (mmol/L)	5.57 ± 1.06	5.69 ± 1.16*	5.61 ± 1.03	5.52 ± 0.88
Resting heart rate	57 ± 9	64 ± 11*	62 ± 11*	58 ± 10
Resting blood pressure (mm Hg)				
systolic	124± 14	122 ± 14	122 ± 14*	121 ± 14*
diastolic	82 ± 9	82 ± 10	81 ± 10	80 ± 9*
Current smoker (%)	42 (13.0)	3,532 (23.2)*	496 (16.9)	1,872 (11.2)
Alcohol intake ≥5 drinks per week (%)	63 (19.6)	5,147 (33.9)*	1,102 (37.6)*	6,523 (39.0)*
Abnormal exercise ECG (%)	13 (4.0)	886 (5.8)	170 (5.8)	874 (5.2)
Abnormal resting ECG (%)	13 (4.0)	492 (3.2)	104 (3.6)	573 (3.4)
Prevalent diseases (%)				
cardiovascular disease[a]	3 (0.9)	153 (1.0)	45 (1.5)	298 (1.8)
diabetes mellitus	22 (6.8)	942 (6.2)	162 (5.5)	704 (4.2)*
hypertension	118 (36.7)	5,221 (34.3)	926 (31.6)	4,846 (29.0)*
hypercholesterolemia	53 (16.5)	3,790 (24.9)*	606 (18.7)	2,784 (16.6)

Note. Data shown as *M* ± *SD* unless otherwise specified. HDL-C = high-density lipoprotein cholesterol; ECG = electrocardiogram.

[a]Myocardial infarction or stroke.

*Significantly different from swimmers ($p < .05$).

CRF

Table 3 shows the physical activity and CRF levels of women and men in the study. Women swimmers had significantly longer treadmill-test durations and higher maximal MET levels than sedentary women and walkers. The treadmill time and maximal MET levels for swimmers were significantly less than for women runners, however. A significantly higher percentage of sedentary women than of swimmers were in the low- and moderate-CRF groups. The pattern across CRF groups was similar for the swimmers and runners, and these two groups had significantly more women in the high-fitness category.

Men who were swimmers had significantly longer treadmill-test durations and higher maximal MET levels than men who were sedentary or walkers. Runners had longer treadmill-test durations and higher maximal MET levels than swimmers. A higher percentage of sedentary men and walkers than of swimmers were in the low- and moderate-CRF groups and also were significantly less likely to be in the

DOI: 10.25035/ijare.02.02.07

Table 3 Characterization of Physical Activity and Cardiorespiratory Fitness (CRF) in Women and Men

	Swimmers	Sedentary	Walkers	Runners
Women				
treadmill-test duration (min)	14.3 ± 4.3	11.0 ± 3.8*	13.3 ± 3.9*	15.8 ± 4.7*
maximal METs	10.0 ± 2.0	8.4 ± 1.8*	9.4 ± 1.8*	10.6 ± 2.2*
CRF group (%)				
low	8 (6.8)	1,136 (26.9)*	129 (8.5)	169 (3.6)
moderate	26 (22.0)	1,966 (46.6)*	579 (38.0)*	1,056 (22.7)
high	84 (71.2)	1,116 (26.5)*	814 (53.5)*	3,435 (73.7)
Men				
treadmill-test duration (min)	19.1 ± 4.7	15.2 ± 4.3*	17.0 ± 4.5*	20.5 ± 4.8*
maximal METs	12.2 ± 2.4	10.4 ± 2*	11.2 ± 2.1*	12.9 ± 2.4*
CRF group (%)				
low	13 (4.0)	4,873 (32.1)*	447 (15.3)*	778 (4.7)
moderate	112 (34.8)	7,399 (48.7)*	1,386 (47.3)*	4,576 (27.4)*
high	197 (61.2)	2,934 (19.3)*	1,095 (37.4)*	11,375 (68.0)*

Note. METs = maximal metabolic equivalents from treadmill test.

*Significantly different from swimmers ($p < .05$).

high-fitness category. As with the women, the distribution of fitness categories was similar in swimmers and runners.

Overall, swimmers had better activity and fitness profiles than those who were sedentary and those who walked for exercise, and the results were comparable for women and men. Both women and men runners were the most fit of any of the activity groups, but the general pattern of fitness distributions was similar for swimmers and runners.

Characterization of Physical Activity and BMI Groups in Women and Men

Data on normal-weight, overweight, and obese categories among swimmers, sedentary individuals, walkers, and runners are shown in Table 4. A significantly lower percentage of women who swam were in the normal-weight group, and a significantly higher percentage of swimmers were overweight than in the other three groups. A significantly lower percentage of women runners than of swimmers were obese, and obesity rates were similar among swimmers, walkers, and sedentary women. Among the men, the normal-weight group contained a significantly lower percentage of sedentary individuals and a higher percentage of runners than swimmers. The prevalence of overweight was similar for all four activity groups. A significantly higher percentage of sedentary men were obese and a lower percentage of runners were obese than men in the swimming group.

Table 4 Characterization of Physical Activity and Body-Mass Index in Women and Men

Body-mass index	Swimmers *n* (%)	Sedentary *n* (%)	Walkers *n* (%)	Runners *n* (%)
Women				
normal weight	73 (61.9)	3,064 (72.6)*	1,153 (75.8)*	3,821 (82.0)*
overweight	35 (29.7)	779 (18.5)*	264 (17.4)*	658 (14.1)*
obese	10 (8.5)	375 (8.9)	105 (6.9)	181 (3.9)*
Men				
normal weight	124 (38.5)	4,991 (32.8)*	1,067 (36.4)	7,788 (46.6)*
overweight	156 (48.5)	7,440 (48.9)	1,428 (48.8)	7,376 (44.1)
obese	42 (13.0)	2,775 (18.3)*	433 (14.8)	1,565 (9.4)*

*Significantly different from swimmers ($p < .05$).

Discussion

The principal findings of this report are that all types of physical activity have similar health benefits compared with a sedentary lifestyle. Swimming and running had similar health benefits even though there were a few differences between swimmers and runners. Runners had the lowest obesity rates among the four groups. The prevalence of chronic diseases was similar among women who were swimmers and runners, but fewer male runners than swimmers had diabetes mellitus and hypertension. Treadmill-test durations and maximal MET levels were the highest among the runners in both men and women. The distribution of CRF categories of swimmers and runners was comparable in women, but more men runners than swimmers were in the high-CRF group.

Aerobic and endurance training help maintain and improve various aspects of cardiovascular function and health, as well as improve quality of life. We found that regular swimmers had higher CRF levels than sedentary people and walkers. Runners had significantly higher CRF levels than swimmers. This might, however, be a result of specificity of their activity, because the test performed was similar to their normal physical activity (i.e., running task). Most of the participants in the low-CRF category were sedentary.

Swimming is a lifetime activity that appears to produce healthy levels of CRF, flexibility, endurance, aerobic capacity, muscle mass, body composition, cholesterol, and quality of life (Westby, 2001). Aquatic exercises can be enjoyed by the general population and by patients suffering from chronic diseases. Physical therapy and cardiac rehabilitation clinics use hydrotherapy to improve muscle function, stamina, balance, agility, range of motion, and coordination, as well as increase fitness (Lin et al., 2004). Furthermore, aquatic exercise is a preferred mode of exercise for older people with osteoarthritis because it has less impact on the joints than running, walking, and other weight-bearing activities (Westby).

Participation in the Arthritis Foundation Aquatic Program improves muscle strength and function (Lin et al., 2004) and increases static and dynamic postural stability in women with arthritis (Lin et al.). Water aerobics increases aerobic capacity by 24%, endurance by 24%, and exercise tolerance by 26% (Minor, Hewett, Webel, Anderson, & Kay, 1989). Minor et al. showed that aquatic exercise at 60–80% of maximum heart rate three times a week for 12 weeks significantly improved aerobic capacity and endurance while it decreased disease complications.

Our results are consistent with those of previous studies on the effects of swimming and other water exercise on lipids, body composition, and triglyceride levels. The Manhattan Stroke Study found that low-intensity sports such as swimming and walking decrease the risk of stroke in middle-aged and older men (Sacco et al., 1998). Middle-aged and elderly men who begin moderate to vigorous activities such as swimming, jogging, or brisk walking have a 23–29% lower overall death rate than sedentary individuals and up to a 41% lower risk of coronary artery disease (Paffenbarger et al., 1993). Exercise tends to decrease total cholesterol and low-density lipoprotein cholesterol and increase HDL cholesterol (Trejo-Gutierrez & Fletcher, 2007). For every 1% increase in HDL cholesterol, there is a 3% reduction in death or myocardial infarction (Boden, 2000). Most studies investigating the effect of exercise on HDL cholesterol involve land-based exercise such as running (Durstine et al., 2001). Takeshima et al. (2002) reported that a 12-week water-based exercise program in older women significantly decreased skinfold thickness (8%), total cholesterol (11%), and triglycerides (9%) in comparison with sedentary controls.

The principal strength of this study is the large population that we observed and the extensive database of the ACLS, which has been developed over more than 30 years. The detailed data on different types of physical activity, health outcomes, and CRF enabled us to compare swimming with other forms of physical activity and with sedentary behavior. The data collected through clinical examinations enabled us to more precisely determine health status and reduced, although it did not eliminate, the concern that undiagnosed disease might be a confounding variable in analyses. This study also has limitations. Results must be generalized with caution because the population includes few members of minority groups and comes from relatively high socioeconomic strata. Because this was a cross-sectional study, we cannot make causal inference from the results.

Conclusions

In conclusion, swimming might provide a healthful alternative to traditional modes of exercise for improving CRF for the general population, as well as for patients suffering from chronic diseases. Swimming provides a range of health benefits and is a viable alternative to other forms of physical activity. Our results show that swimming appears to have health benefits similar to those of running and generally was more beneficial than walking or a sedentary lifestyle. Future prospective research is needed to further compare the health benefits of swimming with those of other forms of physical activity.

Acknowledgments

This research was supported by a grant from the National Swimming Pool Foundation and National Institutes of Health Grants AG06945 and HL62508. We thank the Cooper Clinic physicians and technicians for collecting the baseline data, staff at the Cooper Institute for data entry and data management, and Gaye Christmus for editorial assistance. Financial Disclosures: none declared.

References

American College of Sports Medicine. (2000). *ACSM's guidelines for exercise testing and prescription* (6th ed.). Philadelphia: Lippincott Williams & Wilkins.

Balke, B., & Ware, R.W. (1959). An experimental study of physical fitness in Air Force personnel. *United States Armed Forces Medical Journal, 10,* 675–688.

Blair, S.N., Kampert, J.B., Kohl, H.W., Barlow, C.E., Macera, C.A., & Paffenbarger, R.S., Jr. (1996). Influences of cardiorespiratory fitness and other precursors on cardiovascular disease and all-cause mortality in men and women. *Journal of the American Medical Association, 276,* 205–210.

Blair, S.N., Kohl, H.W., III, Paffenbarger, R.S., Jr., Clark, D.G., Cooper, K.H., & Gibbons, L.W. (1989). Physical fitness and all-cause mortality: A prospective study of healthy men and women. *Journal of the American Medical Association, 262,* 2395–2401.

Boden, W.E. (2000). High-density lipoprotein cholesterol as an independent risk factor in cardiovascular disease: Assessing the data from Framingham to the Veterans Affairs High-Density Lipoprotein Intervention Trial. *The American Journal of Cardiology, 86,* 19L–22L.

Centers for Disease Control and Prevention. (2005). Trends in leisure-time physical inactivity by age, sex, and race/ethnicity—United States, 1994–2004. *MMWR. Morbidity and Mortality Weekly Report, 54,* 991–994.

Durstine, J.L., Grandjean, P.W., Davis, P.G., Ferguson, M.A., Alderson, N.L., & Dubose, K.D. (2001). Blood lipid and lipoprotein adaptations to exercise: A quantitative analysis. *Sports Medicine (Auckland, N.Z.), 31,* 1033–1062.

Gibbons, L.W., Mitchell, T.L., Wei, M., Blair, S.N., & Cooper, K.H. (2000). Maximal exercise test as a predictor of risk for mortality from coronary heart disease in asymptomatic men. *The American Journal of Cardiology, 86,* 53–58.

Halverstadt, A., Phares, D.A., Wilund, K.R., Goldberg, A.P., & Hagberg, J.M. (2007). Endurance exercise training raises high-density lipoprotein cholesterol and lowers small low-density lipoprotein and very low-density lipoprotein independent of body fat phenotypes in older men and women. *Metabolism: Clinical and Experimental, 56,* 444–450.

Haskell, W.L., Lee, I.M., Pate, R.R., Powell, K.E., Blair, S.N., & Franklin, B.A. (2007). Physical activity and public health: Updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. *Medicine and Science in Sports and Exercise, 39,* 1423–1434.

Hootman, J.M., Macera, C.A., Ainsworth, B.E., Addy, C.L., Martin, M., & Blair, S.N. (2002). Epidemiology of musculoskeletal injuries among sedentary and physically active adults. *Medicine and Science in Sports and Exercise, 34,* 838–844.

Hootman, J.M., Macera, C.A., Ainsworth, B.E., Martin, M., Addy, C.L., & Blair, S.N. (2001). Association among physical activity level, cardiorespiratory fitness, and risk of musculoskeletal injury. *American Journal of Epidemiology, 154,* 251–258.

Kesaniemi, Y.K., Danforth, E., Jr., Jensen, M.D., Kopelman, P.G., Lefebvre, P., & Reeder, B.A. (2001). Dose-response issues concerning physical activity and health: An evidence-based symposium. *Medicine and Science in Sports and Exercise, 33,* S351–S358.

Lin, S.Y., Davey, R.C., & Cochrane, T. (2004). Community rehabilitation for older adults with osteoarthritis of the lower limb: A controlled clinical trial. *Clinical Rehabilitation, 18,* 92–101.

Minor, M.A., Hewett, J.E., Webel, R.R., Anderson, S.K., & Kay, D.R. (1989). Efficacy of physical conditioning exercise in patients with rheumatoid arthritis and osteoarthritis. *Arthritis and Rheumatism, 32,* 1396–1405.

Nelson, M.E., Rejeski, W.J., Blair, S.N., Duncan, P.W., Judge, J.O., & King, A.C. (2007). Physical activity and public health in older adults: Recommendation from the American College of Sports Medicine and the American Heart Association. *Circulation, 116,* 1094–1105.

Nieman, D.C., Custer, W.F., Butterworth, D.E., Utter, A.C., & Henson, D.A. (2000). Psychological response to exercise training and/or energy restriction in obese women. *Journal of Psychosomatic Research, 48,* 23–29.

Paffenbarger, R.S., Jr., Hyde, R.T., Wing, A.L., Lee, I.M., Jung, D.L., & Kampert, J.B. (1993). The association of changes in physical-activity level and other lifestyle characteristics with mortality among men. *The New England Journal of Medicine, 328,* 538–545.

Pickering, T.G., Hall, J.E., Appel, L.J., Falkner, B.E., Graves, J., & Hill, M.N. (2005). Recommendations for blood pressure measurement in humans and experimental animals: Part 1: Blood pressure measurement in humans: A statement for professionals from the Subcommittee of Professional and Public Education of the American Heart Association Council on High Blood Pressure Research. *Hypertension, 45,* 142–161.

Pollock, M.L., Bohannon, R.L., Cooper, K.H., Ayres, J.J., Ward, A., & White, S.R. (1976). A comparative analysis of four protocols for maximal treadmill stress testing. *American Heart Journal, 92,* 39–46.

Pollock, M.L., Foster, C., Schmidt, D., Hellman, C., Linnerud, A.C., & Ward, A. (1982). Comparative analysis of physiologic responses to three different maximal graded exercise test protocols in healthy women. *American Heart Journal, 103,* 363–373.

Sacco, R.L., Gan, R., Boden-Albala, B., Lin, I.F., Kargman, D.E., & Hauser, W.A. (1998). Leisure-time physical activity and ischemic stroke risk: The Northern Manhattan Stroke Study. *Stroke, 29,* 380–387.

Schmid, J.P., Noveanu, M., Morger, C., Gaillet, R., Capoferri, M., & Anderegg, M. (2007). Influence of water immersion, water gymnastics and swimming on cardiac output in patients with heart failure. *Heart (British Cardiac Society), 93,* 722–727.

Sui, X., LaMonte, M.J., & Blair, S.N. (2007). Cardiorespiratory fitness as a predictor of nonfatal cardiovascular events in asymptomatic women and men. *American Journal of Epidemiology, 165,* 1413–1423.

Takeshima, N., Rogers, M.E., Watanabe, E., Brechue, W.F., Okada, A., & Yamada, T. (2002). Water-based exercise improves health-related aspects of fitness in older women. *Medicine and Science in Sports and Exercise, 34,* 544–551.

Trejo-Gutierrez, J., & Fletcher, G. (2007). Impact of exercise on blood lipids and lipoproteins. *Journal of Clinical Lipidology, 1*(3), 175–181.

Westby, M.D. (2001). A health professional's guide to exercise prescription for people with arthritis: A review of aerobic fitness activities. *Arthritis and Rheumatism, 45,* 501–511.

Williams, P.T. (2003). The illusion of improved physical fitness and reduced mortality. *Medicine and Science in Sports and Exercise, 35,* 736–740.