International Journal of Aquatic Research and Education

Volume 5 | Number 4 Article 5

11-1-2011

The Impact of an Aquatic Exercise Protocol on Physiologic Measures Within an Asthmatic Population

Kasee Hildenbrand
Washington State University, khildenbrand@wsu.edu

Timothy S. Freson
Washington State University

Celestina Barbosa-Leiker
Washington State University

Sara Nordio
Washington State University

Bruce E. Becker
Washington State University

See next page for additional authors

Recommended Citation

Hildenbrand, Kasee; Freson, Timothy S.; Barbosa-Leiker, Celestina; Nordio, Sara; Becker, Bruce E.; and Miller, Ashley J. (2011) "The Impact of an Aquatic Exercise Protocol on Physiologic Measures Within an Asthmatic Population," *International Journal of Aquatic Research and Education*: Vol. 5 : No. 4 , Article 5.
DOI: 10.25035/ijare.05.04.05
Available at: https://scholarworks.bgsu.edu/ijare/vol5/iss4/5

The Impact of an Aquatic Exercise Protocol on Physiologic Measures Within an Asthmatic Population

Authors
Kasee Hildenbrand, Timothy S. Freson, Celestina Barbosa-Leiker, Sara Nordio, Bruce E. Becker, and Ashley J. Miller

RESEARCH

International Journal of Aquatic Research and Education, 2011, 5, 378-388

The Impact of an Aquatic Exercise Protocol on Physiologic Measures Within an Asthmatic Population

Kasee Hildenbrand, Timothy S. Freson, Celestina Barbosa-Leiker, Sara Nordio, Bruce E. Becker, and Ashley J. Miller

Individuals suffering from asthma typically have subnormal exercise tolerance and poor physical fitness. The purpose of this case series study was to examine the impact of a new aquatic exercise protocol on physiological variables in a group of asthmatics. Participants were medically diagnosed and managed asthmatics in a rural community. A total of 8 males and 12 females were accepted into the study with 7 males and 9 females completing the 12-week study. Physiological measures were taken pre- and posttreatment with paired t-tests used for analyses. Increases in VO_2max, pretreatment mean (M) = 31.244 SD = 9.772; post-treatment M = 33.431, SD = 10.387; partial ç^2 = 0.257, $p < 0.038$; lean body muscle mass, pretreatment M = 119.606, SD = 28.210; posttreatment M = 122.012, SD = 30.475; partial ç^2 = 0.237, $p < 0.047$; and blood glucose, pretreatment M = 83.937, SD = 7.584; post-treatment M = 89.812, SD = 7.799; partial ç^2 = 0.603, $p < 0.000$, were seen from pre- to posttreatment. The exercise protocol was successful as seen by the increase in VO_2max and lean body mass. The protocol was well tolerated and enjoyed by the participants suggesting it is useful in the asthmatic population. Our results predicted a need for larger sample sizes in future research ranging from 8 to 218 participants depending upon the dependent measure.

Approximately 40.6 million Americans have been diagnosed with asthma at some point during their lives, with 16.2 million being affected by asthma symptoms on a daily basis (Ram, Robinson, Black, & Picot, 2005). Asthma burdens our nation with an annual economic cost of $14.7 billion in direct health care costs, with indirect costs adding another $5 billion (American Lung Association, 2007). Furthermore, coronary heart disease (CHD), peripheral artery disease, metabolic syndrome (MetS), and muscluoskeletal problems have been reported in individuals suffering from chronic asthma (Durstine, Moore, Painter, & Roberts, 2009).

Asthma can reduce the opportunity for an active lifestyle and increase the risk of CHD and MetS (American Lung Association, 2007; Cochrane & Clark, 1990; Haskell et al., 2007; Lucas & Platts-Mills, 2005; Pedersen & Saltin, 2006; Ram

---

Kasee Hildenbrand, Sara Nordio, and Bruce Becker are with the National Aquatic and Sports Medicine Institute; Timothy Freson, Celestina Barbosa-Leiker, and Ashley Miller are with the Health and Wellness Services, all with Washington State University in Pullman.

et al., 2005). Between 8%–9% of all deaths in adults can be attributed to physical inactivity (Goodarz et al., 2009). In addition, physical inactivity is strongly correlated with morbidity and mortatility rates associated CHD. Exercise has been shown to have extensive health benefits, both in normally functioning adults as well as in adults with asthma (Lucas & Platts-Mills, 2005; Pedersen & Saltin, 2006). The value of maintaining a physically active lifestyle for health preservation and disease prevention has been well recognized (Haskell et al., 2007; Nelson et al., 2007). Individuals suffering from asthma typically have subnormal exercise tolerance (Pedersen & Saltin, 2006) and poor physical fitness (Cochrane & Clark, 1990). Higher exercise intensities, typically above 75% of age-predicted maximal heart rate, are likely to initiate an asthma attack (Durstine et al., 2009). Unfortunately, exercise intensities generally above 60% of age-predicted maximal heart rate are necessary to improve exercise tolerance and reduce risk factors for CHD (ACSM, 2006; LaMonte, Durstine, Addy, Irwin, & Ainsworth, 2001). Therefore, because asthmatics may have difficulties exercising at higher intensities, they are at a distinct disadvantage for improving exercise tolerance and physical fitness level while reducing risk for CHD.

Aquatic programs focusing on respiratory endurance have significantly improved athletic performance in the general population, and activity in the pool has been shown to allow asthmatics to breathe easier due in part to the warm, humid, pollen-free air over the water (Weisel et al., 2009). Neck depth immersion has been reported to increase the work of breathing at rest by approximately 60% (Hong, Cerretelli, Cruz, & Rahn, 1969). These increased workloads imposed on muscles assisting in respiration during aquatic exercise may improve efficiency of inspiratory muscles if the respiratory effort is prolonged enough to produce a conditioning stimulus. The overall result may produce a reduction in respiratory fatigue during vigorous exertion. Performing exercise in an aquatic environment also offers the benefits of reduced stress to the joints of the body, improved breathing, and can produce less asthmatic events.

To date, no studies have examined the effect of a vertical water exercise program on risk factors for long-term health issues in an asthmatic population. Therefore, the purpose of this study was to examine the impact of a new aquatic exercise protocol on variables associated with CHD, type 2 diabetes, and MetS in asthmatics.

Method

Participants

Approval was obtained through the university's Institutional Review Board prior to recruitment (#10460) and informed consent was gained during the initial meeting and screening. Recruitment was done through public forums within a rural community in the Pacific Northwest. Individuals were screened for health/behavior issues and a history of asthma. Participants were required to have physician-diagnosed asthma that was being medically managed "daily or on an as needed" basis. Potential participants were eliminated if they reported a history of cardiovascular disease, metabolic disorders, cancer, arthritis, hyperthyroidism, hepatitis, cirrhosis, epilepsy, eating disorders, and alcoholism. Current smokers and those individuals who were afraid of the water were also eliminated.

DOI: 10.25035/ijare.05.04.05

A total of 8 males and 12 females were accepted into the study with 7 males and 9 females completing the 12-week study. Participants were excused from the study if they missed more than three consecutive exercise sessions (80% compliance). The average age of participants who completed the study was 22 years (SD = 5.27). The 16 participants who completed the study were primarily Caucasian (75%) and reported an average of 195 minutes of moderate physical activity/week for the four weeks prior to the study (SD = 143.73). All participants suffered from either exercise-induced asthma, asthma symptoms related to allergies, intrinsic asthma, or a combination of asthma types. Four of the sixteen participants who completed the 12-week exercise protocol reported taking medications on a daily basis to manage their asthma symptoms (two took Singular Tab, 10mg/day; one took Symbicort 160/4.5 each day; and one used Flovent 100 mcg inhaler each day). All 16 subjects used an Albuterol Inhaler as needed. Inhaler utilization ranged from one time per day up to four times per day.

Fitness Assessment

Pre- and postexercise measurements for the following variables were taken the week before the exercise treatment began and then again the week after the exercise treatment concluded. Fitness assessments were scheduled on the same week day and time for pre- and posttraining measurements. Resting measurements of heart rate and blood pressure were taken using a standard automated plethysmometer (OMRON HEM-755, Omron Healthcare, Inc, Bannnockburn IL) after participants sat in a quiet room for 5 minutes. Body composition was assessed using the Body Composition Tracking System (BOD POD; Life Measurement, Inc., Concord, CA). Maximal oxygen consumption was assessed using a graded exercise test on a Monark 181E cycle ergometer because it mimics many of the exercise movements within the deep water portion of the program (Varburg, Sweden). Participants began with a warm-up for two minutes at 25 watts and then moved through stages every two minutes, progressively increasing resistance levels by 25 watts until maximum tolerance. There was a two-minute cool-down/recovery period after termination of the exercise protocol at 50 watts. Data on continuous gas exchange measures and spirometry were collected using the TrueMax 2400 computerized metabolic system (ParvoMedics, Salt Lake City, UT). Heart rate variability (HRV) was assessed using a BioPac™ biologic monitoring system (BioPac Systems Inc., Goleta, CA).

Blood Measurements

Fasting blood samples were collected from a forearm vein between 7 a.m. and 9 a.m. and analyzed by regional laboratories (Pathology Associates Medical Laboratories, Spokane, WA). Blood draws were scheduled on the same week day/time for the pre- and posttraining measurements. Total cholesterol, low-density lipoprotein (LDL), and high-density lipoprotein (HDL) were measured by the ADVIA® 2400 Chemistry system with a coefficient of variance (CV) ranging from 1.0%–1.5%. Fasting blood glucose and insulin concentrations were assessed using the Glucose Hexokinase II (ADVIA® Chemistry, CV = 1.3%) and radioimmunoassays (Immulite® 2000, CV = 7.5%–12%), respectively. High sensitivity C-reactive protein (CRP) concentrations were measured by nephelometry. The CV ranged from 1.4% to 10.8%.

Aquatic Exercise Protocol

Guidelines from the Aquatic Exercise Association (AEA) and the American College of Sports Medicine (ACSM) were used in the development of the aquatic training protocol. The protocol included three exercise sessions per week, increasing from 30 minutes to 45 minutes per session over the 12-week training (see Table 1). This protocol was designed to assist sedentary asthmatics in beginning an exercise program, progressing them from low to high intensity conditioning phases. For details on the aquatic exercise protocol refer to previously published work (Hildenbrand, Nordio, Freson, & Becker, 2010).

Monitoring Exercise Intensity

Exercise intensities during the training sessions were monitored using the modified Borg Rate of Perceived Exertion Scale (RPE) with a range from 1 to 10. RPE is the preferred method for monitoring intensities during aquatic exercise because of known reductions in heart rate during cool water immersion (Durstine et al., 2009; Robertson & Noble, 1997). In addition, asthmatics are often taking medication known to alter heart rates at rest and during exercise, which hinders the effectiveness of using heart rate in monitoring exercise intensities.

Experimental Design

A quasi-experimental approach with a single group pre-post test design was utilized in this study. Initially, the study had been developed with a completely randomized design containing a treatment and control group. Because of difficulties with recruiting asthmatics for a 12-week exercise study and the small participant numbers, all interested individuals were assigned to the treatment group. Obviously, the lack of a control group and use of the quasi-experimental design limits to a certain degree the confidence and scope of conclusions from the current study.

Table 1 Training Progression for Asthmatic Participants

Stage	Week	Exercise Frequency (times/week)	Aquatic RPE	Conditioning Duration (min)
Initial	1	3	4	15
	2	3	4	20
	3	3	5-6	20
	4	3	5-6	25
Improvement	5-7	3	6-7	25
	8-10	3	6-7	30
	11-12	3	7-8	30

DOI: 10.25035/ijare.05.04.05

Statistical Analyses

Two-tailed paired sample *t*-tests were performed in order to examine differences across variables from pretest to posttest (14 weeks apart). In order to maintain the family wise error rate for the multiple comparisons, differences were considered significant at $p < .003$ (Bonferroni correction; $p = 0.05/15$ *t*-tests); however, comparisons significant at the $p < .05$ level also are discussed. One-way Analysis of Variance (ANOVA) was utilized to obtain observed power (fixed-effects assumption, using $\alpha = 0.05$) and effect sizes (partial η^2) in order to assess sample size adequacy and clinical meaningfulness. Effect sizes were interpreted as follows: 0.01 for small effects, 0.10 for medium effects, and 0.25 for large effects (equivalent to Cohen's *d* of 0.20, 0.50, and 0.80). CRP was log-transformed to approximate normality. A priori power analyses were not conducted due to the novel approach taken with this study (i.e., previous effect sizes were unavailable). Thus, post hoc observed power is reported and discussed.

Results

The exercise protocol stimulated a significant increase in glucose from pretreatment to posttreatment with a $p < 0.0001$ (pretreatment M = 83.937, SD = 7.584; posttreatment M = 89.812, SD = 7.799; partial $\eta^2 = 0.603$). This was the only significant difference at the a priori specified $p < 0.003$ level, as well as the only effect that had sufficient statistical power to be detected (observed power = 99.4%). Large effect sizes warranted closer inspection of differences found at the $p < 0.05$ level. The exercise protocol produced an increase in lean muscle over the 12-week period of time with a $p < 0.047$ (pretreatment M = 119.606, SD = 28.210; posttreatment M = 122.012, SD = 30.475; partial $\eta^2 = 0.237$); however, there was no significant change in the total body weight or body fat percentage with a $p < 0.117$. A significant increase in VO_{2max} was seen posttreatment when compared to pretreatment measures with a $p < 0.038$ (pretreatment M = 31.244, SD = 9.772; posttreatment M = 33.431, SD = 10.387; partial $\eta^2 = 0.257$). There were no significant changes in resting heart rate, resting systolic blood pressure, resting diastolic blood pressure, measures of lung function ($FEV_{1.0}$/FVC), CRP, insulin, HDL, LDL, VLF, HF, or Sympathovagal Bal over the course of the study**.** See Table 2 for complete results. Observed power indicates that the sample size was too small to detect statistically significant differences for those variables, but the effect sizes indicate that small effects exist, with the exception of CRP. See Tables 3 and 4 for complete results.

Discussion

A program of regular aquatic exercise may provide distinct benefits in the asthmatic population because of improvements in aerobic capacity (Arandelovic, Stankovic, & Nikolic, 2007) and the unique value of immersion-produced improvements in respiratory endurance and cardiac output (Becker, 2009; Hong et al., 1969). For the physiological variables assessed during the study, there were significant increases in blood glucose levels between pre- and posttreatment measurements, although both values remained within normal limits. This was the only cardiovascular disease

Table 2 Pool Conditions

Factor	Value
Free Chlorine	1.5 -2.0 ppm
Total Chlorine	1.7 ppm - 2.3 ppm
pH	7.5 - 7.8
Total Alkalinity	90-120 ppm
Calcium Carbonate	100-150 ppm
Air temperature	78° F (doors closed)
Pool water temp	84° F - 86° F
Humidity	57% - 60%

ppm, parts per million; F, Fahrenheit

Table 3 Means for Physiological Variables pre- and Posttreatment

	Pretreatment		Posttreatment	
Variable	Mean	S.D.	Mean	S.D.
Body Fat %	29.844	10.762	29.131	11.468
Lean Mass	119.606	28.210	122.012	30.475
$FEV_{1.0}$/FVC	98	8.914	98.5	8.710
HR – Rest	71.062	9.848	69.687	11.881
SBP	117.375	13.865	118.062	16.377
DBP	74.562	7.924	76.562	11.069
VO_{2max}, ml O_2/ kg/min	31.244	9.772	33.431	10.387
lnCRP	0.85	1.22	0.81	1.02
Glucose	83.937	7.584	89.812	7.799
Insulin	8	5.933	7.062	4.358
HDL	52.562	12.591	51.062	11.544
LDL	117.125	58.608	119.437	56.213
VLF	7.843	2.397	8.192	3.531
HF	0.800	0.476	0.866	0.412
VB	3.807	0.680	3.877	0.549

Body Fat %: percent body fat; Lean Mass: lean body mass in pounds; $FEV_{1.0}$/FVC: percentage of forced expiratory volume in one second/forced vital capacity; HR: Rest, resting heart rate in beats per minute; SBP: systolic blood pressure at rest, mm Hg; DBP: diastolic blood pressure at rest, mm Hg; VO_{2max}: maximum oxygen uptake in; ln CRP: log transformed high sensitivity C-reactive protein; HDL: high density lipoprotein; LDL: low density lipoprotein; VLF PSD: very low frequency; HF PSD: high frequency; VB: Sympathetic Vagal Balance; SD: standard deviation.

DOI: 10.25035/ijare.05.04.05

Table 4 T-Tests for Physiological Variables pre- and Posttreatment

Variable	t	p	95% CI	Effect Size	Power
Body Fat %	1.300	0.213	–0.456 to 1.881	0.101	0.230
Lean Mass	–2.161	0.047*	–4.780 to -0.033	0.237	0.525
$FEV_{1.0}$/FVC	–0.375	0.713	–3.340 to 2.340	0.009	0.064
HR – Rest	0.457	0.654	–5.043 to 7.793	0.014	0.071
Systolic BP	–0.202	0.843	–7.936 to 6.561	0.003	0.054
Diastolic BP	–0.783	0.446	–7.445 to 3.445	0.039	0.114
VO_{2max}, ml O_2/kg/min	–2.276	0.038*	–4.236 to -0.139	0.257	0.567
lnCRP	0.150	0.883	–0.544 to 0.626	0.001	0.052
Glucose	–4.772	0.000*	–8.499 to -3.251	0.603	0.994
Insulin	1.111	0.284	–0.861 to 2.736	0.076	0.180
HDL	1.006	0.331	–1.679 to 4.679	0.063	0.156
LDL	–0.416	0.683	–14.168 to 9.543	0.011	0.068
VLF	–0.512	0.616	–1.805 to 1.106	0.017	0.616
HF	–0.812	0.430	–0.240 to 0.108	0.042	0.430
VB	–0.571	0.576	0.192 to -0.571	0.021	0.083

Body Fat %: percent body fat; Lean Mass: lean body mass in pounds; $FEV_{1.0}$/FVC: percentage of forced expiratory volume in one second/forced vital capacity; HR: Rest, resting heart rate in beats per minute; Systolic BP: systolic blood pressure at rest; Diastolic BP: diastolic blood pressure at rest; VO_{2max}, maximum oxygen uptake in ml O_2/kg/min; ln CRP: log transformed high sensitivity C-reactive protein; HDL: high density lipoprotein; LDL: low density lipoprotein; VLF PSD: very low frequency; HF PSD: high frequency; VB: Sympathetic Vagal Balance; SD: standard deviation.

*significant at the $p < 0.05$ level (2-tailed)

risk factor (e.g., blood pressure, CRP, glucose, insulin, HDL, LDL) with significant differences over the 12-week aquatic exercise protocol. The significant increases in glucose over time were small but unexpected since exercise training has been shown to decrease glucose concentrations in healthy and disease populations (Hansen et al., 2009; Pescatello et al., 2008).

Currently, there is no clear explanation for the slight increases in blood glucose concentrations. These changes could in part be due to the small sample size; however, this was the only physiological variable that was significantly different from pre- to posttreatment with familywise error rate for the multiple comparisons (significant at $p < .003$). Even though there were significant increases in glucose concentration across the study, the mean difference is less than 6 mg/dl. Furthermore, both pre- and posttreatment values are within normal ranges of 70 mg/dl to 99 mg/dl (ACSM, 2006). This is an area that ought to be closely evaluated in future studies with larger numbers of participants.

Lean muscle mass and VO_{2max} were also significantly different with large effect sizes. Significant increases in lean muscle mass were observed on both the lower and upper body extremities (Volaklis, Spassis, & Tokmakidis, 2007). A small but significant increase in VO_{2max} (2.187 ml/kg/min) was seen posttreatment when compared to pretreatment measures. Even so, these results are important since the sample size was small and physically active. Furthermore, the protocol initially had shorter exercise sessions at lower intensities to reduce the chances of initiating asthmatic events and improve exercise tolerance gradually. Because the sample was more physically fit, we were less likely to see a significant response to the low impact aquatic exercise protocol. Therefore, a significant increase in VO_{2max} from pretreatment to posttreatment with a small group of fairly active healthy college aged asthmatics suggests that this protocol will be very effective in increasing cardiovascular fitness for a more severe asthmatic population. In addition, as asthmatics are able to tolerate higher intensities for longer periods of time there will be even larger increases in VO_{2max} regardless of severity.

There were no significant changes in measures of lung function ($FEV_{1.0}$/FVC) over the course of the study. Typically, we would expect lung function to improve in both healthy and diseased populations with aquatic exercise (Ide, Belini, & Caromano, 2005; Silvers, Rutledge, & Dolny, 2007). In this study, values for $FEV_{1.0}$/FVC were at the upper limits of the healthy ranges (Durstine & Moore, 2003). There was a mean increase of 0.5% in pre- to posttreatment $FEV_{1.0}$/FVC value but lack of significant differences in this study could be due to a ceiling effect since values are near the possible upper limit. From a functional perspective, there were no increases in asthmatic events or medication usage throughout the study even as the exercise intensities increased to an RPE of 7-8 for 30 minutes in the conditioning phase (Hildenbrand et al., 2010).

No significant changes in any of the HRV variables (e.g., very low frequency, high frequency, sympathovagal balance) were observed in this study's participants. Mixed results have been reported in previous studies examining the effect of exercise on HRV. Variations in exercise doses and intensity of exercise may be responsible for the mixed results across the studies (Borghi-Silva et al., 2009; Carter, Banister, & Blaber, 2003; Okazaki et al., 2005; Sloan et al., 2009). The quantities of work and exercise intensities completed by the participants in the current study were lower than in other research reporting changes in HRV (Carter et al., 2003; Okazaki et al., 2005; Sloan et al., 2009). Perhaps, as asthmatics can tolerate exercise for longer periods of time at higher intensities, significant changes in HRV may be reported. The protocol utilized in the current study can prepare asthmatics for increased exercise tolerance without stimulating asthmatic events.

One of the most important findings of this study was the determination of power and effect sizes. No study to date has addressed power or effect sizes for the variables measured in this study, making it difficult to determine the appropriate number of participants needed for statistical analyses. The calculated power and effect sizes now make it possible for researchers in this area to design future studies with participation numbers necessary to determine significant differences in variable relationships. This study and previous studies which quantitatively measure the impact of exercise on asthmatics have used low participant numbers in part due to recruitment issues and the large quantity of resources necessary to do these types of studies. Based on the statistical power and effect sizes observed in our study for $FEV_{1.0}$/FVC and VO_{2max}, our key variables of interest, we offer the following sample size recommendations when employing a within-subjects design: significant differences from pre- to posttreatment for VO_{2max} may be found for a

DOI: 10.25035/ijare.05.04.05

sample as small as eight participants; however, a sample of 218 would be needed to find statistical differences from pre- to posttreatment for $FEV_{1.0}$/FVC and is thus not recommended based on lack of clinical or practical significance.

Practical Application

The protocol used in this study was shown to increase fitness levels and improve body composition, which are risk factors for CHD and MetS without increasing asthmatic events. If asthmatics can maintain their physical activity, then their risk of these types of diseases in later life may be decreased. Adherence to an exercise protocol is essential for physiological improvements and risk reduction. Hildenbrand and colleagues (2010) reported that participants enjoyed the aquatic exercise program and experienced improvements in activities of daily living. Ease of activities in the exercise protocol, increased ability to tolerate higher exercise intensities, and increased social support seen in the group exercise environment are all additive factors that improve the potential for adherence to any exercise program (McAuley, Jerome, Elavsky, Marquez, & Ramsey, 2003). In addition, many communities have access to public pools, and the water offers a way for participants to increase their exercise tolerance gradually. This study showed that a consistent reproducible exercise program can be prescribed by health care providers and aquatic professionals for asthmatic individuals with varying fitness levels to reduce disease risk factors.

Limitations

The quasi-experimental time-series approach utilized in this study was a limitation, since we were unable to assess normal fluctuations in our variables over the time period of the exercise protocol; however, this study may represent what is seen by clinicians in the field. Another limitation to the study was that participants represented a younger, more physically active subgroup of asthmatics. This college aged adult sample reported being more active than the ACSM sedentary population guidelines. Finally, since many of the participants were on “as needed” medication regimes, their asthmatic status may have been less severe than other asthmatic populations.

References

ACSM (2006). *American College of Sports Medicine’s guidelines for exercise testing and prescription* (7th ed.). Baltimore: Lippincott Williams and Wilkins.

American Lung Association (2007). Trends *in asthma morbidity and mortality. Epidemiology and statistics unit, 1 and 8*. Washington, DC: Author.

Arandelovic, M., Stankovic, I., & Nikolic, M. (2007). Swimming and persons with mild persistent asthma. *Scientific World Journal, 7*, 1182-1188.

Becker, B.E. (2009). Aquatic therapy: Scientific foundations and clinical rehabilitation applications. *PMR, 1*(9), 859-871.

Borghi-Silva, A., Arena, R., Castello, V., Simoes, R.P., Martins, L.E.B., Catai, A.M., et al. (2009). Aerobic exercise training improves autonomic nervous control in patients with COPD. *Respiratory Medicine, 103*, 1503-1510.

Carter, J., Banister, E., & Blaber, A. (2003). The effect of age and gender on heart rate variability after endurance training. *Medicine & Science in Sports & Exercise, 35*(8), 1333-1340.

Cochrane, L.M., & Clark, C.J. (1990). Benefits and problems of a physical training programme for asthmatic patients. *Thorax, 45*(5), 345-351.

Durstine, J., Moore, E., Painter, P., & Roberts, S. (2009). *ACSM's exercise management for persons with chronic diseases and disabilities* (3rd ed.). Champaign, IL: Human Kinetics.

Durstine, J., & Moore, G. (2003). ACSM's exercise management for persons with chronic diseases and disabilities (2nd ed.). Champaign, IL: Human Kinetics.

Goodarz, D., Ding, E.L., Mozaffarian, D., Taylor, B., Rehm, J., Murray, C.J.L., et al. (2009). The preventable causes of death in the United States: Comparative risk assessment of dietary, lifestyle and metabolic risk factors. *PLoS Medicine, 6*(4), 1-23.

Hansen, D., Dendale, P., Jonkers, R., Beelen, M., Manders, R., Corluy, L., et al. (2009). Continuous low- to moderate-intensity exercise training is as effective as moderate-to high-intensity exercise training at lowering blood HbA1c in obese type 2 diabetes patients. *Diabetologia, 52,* 1789-1797.

Haskell, W.L., Lee, I.M., Pate, R.R., Powell, K.E., Blair, S.N., Franklin, B.A., et al. (2007). Physical activity and public health: Updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. *Circulation, 116*, 1081-1093.

Hildenbrand, K., Nordio, S., Freson, T.S., & Becker, B.E. (2010). Development of an aquatic exercise training protocol for the asthmatic population. *International Journal of Aquatic Research & Education, 4*(3), 278-299.

Hong, S.K., Cerretelli, P., Cruz, J.C., & Rahn, H. (1969). Mechanics of respiration during submersion in water. *Journal of Applied Physiology, 27*(4), 535-538.

Ide, M., Belini, M., & Caromano, F. (2005). Effects of an aquatic versus non-aquatic respiratory exercise program on the respiratory muscle strength in healthy aged persons. *Clinics (San Paulo), 60*(2), 151-158.

LaMonte, M.J., Durstine, J.L., Addy, C.L., Irwin, M.L., & Ainsworth, B.E. (2001). Physical activity, physical fitness, and Framingham 10-year risk score: The cross cultural activity participation study. *Journal of Cardiopulmonary Rehabilitation, 21*(2), 63-70.

Lucas, S.R., & Platts-Mills, T.A. (2005). Physical activity and exercise in asthma: Relevance to etiology and treatment. *Journal of Allergy and Clinical Immunology, 115*(5), 928-934.

McAuley, E., Jerome, G.J., Elavsky, S., Marquez, D.X., & Ramsey, S.N. (2003). Predicting long-term maintenance of physical activity in older adults. *Preventive Medicine, 37*, 110-118.

Nelson, M.E., Rejeski, W.J., Blair, S.N., Duncan, P.W., Judge, J.O., King, A.C., et al. (2007). Physical activity and public health in older adults: Recommendation from the American College of Sports Medicine and the American Heart Association. *Medicine & Science in Sports & Exercise, 39*(8), 1435-1445.

Okazaki, K., Iwasaki, K., Prasad, A., Palmer, M.D., Martini, E., Arbab-Zadeh, A., et al. (2005). Dose-response relationship of endurance training for autonomic circulatory control in healthy seniors. *Journal of Applied Physiology, 99*, 1041-1049.

Pedersen, B.K., & Saltin, B. (2006). Evidence for prescribing exercise as therapy in chronic disease. *Scandinavian Journal of Medicine and Science in Sports, 16* Suppl 1, 3-63.

Pescatello, L., Blanchard, B., Van Heest, J., Maresh, C., Gordish-Dressman, H., & Thompson, P. (2008). The metabolic syndrome and the immediate antihypertensive effects of aerobic exercise: A randomized control design. *BMC Cardiovasc Disorders, 8*(12).

Ram, F., Robinson, S., Black, P.N., & Picot, J. (2005). Physical training for asthma. *Cochrane Database of Systematic Reviews*, (4), 1-24.

Robertson, R.J., & Noble, B.J. (1997). Perception of physical exertion: Methods, mediators, and applications (Perception de l'effort : methodes, mediateurs et applications). *Exercise & Sport Sciences Reviews, 25*, 407-452.

Silvers, W., Rutledge, E., & Dolny, D. (2007). Peak cardiorespiratory responses during aquatic and land treadmill exercise. *Medicine & Science in Sports & Exercise, 39*(6), 969-975.

DOI: 10.25035/ijare.05.04.05

Sloan, R.P., Shapiro, P.A., DeMeersman, R.E., Bagiella, E., Brondolo, E.N., McKinley, P. S., et al. (2009). The effect of aerobic training and cardiac autonomic regulation in young adults. *American Journal of Public Health, 99*(5), 921-928.

Volaklis, K., Spassis, A., & Tokmakidis, S. (2007). Land versus water exercise in patients with coronary artery disease: Effects on body composition, blood lipids, and physical fitness. *American Heart Journal, 154*(3), 560.e561-566.

Weisel, C.P., Richardson, S.D., Nemery, B., Aggazzotti, G., Baraldi, E., Blatchley III, E.R., et al. (2009). Childhood asthma and environmental exposures at swimming pools: State of science and research recommendations. *Environmental Health Perspectives, 117*(4), 500-507.