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Development of an Aquatic Exercise Training Protocol for the Asthmatic Population

Kasee Hildenbrand, Sara Nordio, Timothy S. Freson, and Bruce E. Becker

The purpose of this article is to propose creation of a consistent, measureable 12-week aquatic exercise progression for individuals diagnosed with asthma. An aquatic exercise option not requiring swim skills may offer real value, but no previous literature explicitly describes a standardized nonswimming aquatic exercise progression. Participants were diagnosed: medically managed asthmatics in a rural community. Guidelines set forth by AEA and ACSM were used in the development of the exercise program and progression. By the end of the 12 weeks, instructors were challenging participants with multilevel travel sets and complex timed sequences, meeting programmatic goals for exercise intensity progression. In conclusion, this 12-week aquatic exercise protocol could effectively be prescribed by aquatic exercise specialists to increase physical activity in an asthmatic population. The design may be used in research studies as a consistent and measurable treatment protocol.

According to the National Health Interview Study, in 2007 approximately 40.6 million Americans have been diagnosed with asthma at some point during their life. Approximately 16.2 million are affected by asthma symptoms daily. Asthma ranks within the most prevalent conditions causing limitation of activity, which can make asthmatics more likely to suffer from cardiovascular and metabolic conditions resulting from a sedentary lifestyle. Physical activity 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).

Aquatic exercise programs focusing on respiratory endurance have significantly improved athletic performance in the general population (Romer, McConnell, & Jones, 2002a, 2002b). Researchers have also reported that individuals suffering from asthma typically have subnormal exercise tolerance (Pedersen & Saltin, 2006) and poor physical fitness (Clark & Cochrane, 1988; Cochrane & Clark, 1990; Malkia & Impivaara, 1998). Physical activity in an aquatic environment can improve exercise tolerance by allowing asthmatics to breathe easier due in part to the warm humid pollen-free air over the water (de Araujo & Bar-Or, 1994; Soares

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de Araujo & Bar-Or, 1997). As breathing becomes easier, both an improvement in general conditioning and a reduced incidence of exertionally-induced asthma (EIA) can be achieved.

Another cause for the reduction in exercise tolerance is respiratory fatigue, or specifically diaphragmatic fatigue (Sheel, Derchak, Pegelow, & Dempsey, 2002). Improvement in respiratory function is largely dependent upon diaphragm function. Neck-depth immersion in water places the diaphragm at an increased length, which allows the diaphragm to work through its entire length, resulting in an improvement of fatigue tolerance (Banzett, Lansing, & Reid, 1985; McCool & Mead, 1989; Reid, Banzett, Feldman, & Mead, 1985; Roussos, 1984). Improvement in respiratory muscular and cardiorespiratory endurance is proposed as the reason for clinical improvement seen in asthmatics, since no significant lung function changes are found (Ram, Robinson, Black, & Picot, 2005).

Neck-depth immersion has been reported to increase the work of breathing at rest by approximately 60% (Craig & Ware, 1967; Hong, Cerretelli, Cruz, & Rahn, 1969). The cause of this increased workload is primarily from two factors: hydrostatic pressure on the chest wall, which accounts for 1/3 of the increased workload, while the remainder is due to the dramatic increase in central blood volume (Hong et al., 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.

Improvements in respiratory muscular and cardiorespiratory endurance are more likely to occur in response to aquatic exercise that is vertical and not horizontal (swimming) due to the immersion factors. Since this is a critical issue for exercise tolerance in the asthmatic population, an aquatic exercise protocol using vertical immersion may be more beneficial than horizontal stroke swimming. To date, most research examining the relationships among aquatic exercise and physiological variables in asthmatics has used horizontal swimming, not vertical water immersion activity, as the form of aquatic exercise (Arandelovic, Stankovic, & Nikolic, 2007; Bar-Or & Inbar, 1992; Emtner, Herala, & Stalenheim, 1996; Fitch, Morton, & Blanksby, 1976; Huang, Veiga, Sila, Reed, & Hines, 1989; Kennedy, 1971; Matsumoto et al., 1999; Rosimini, 2003; Schnall, Ford, Gillam, & Landau, 1982; Soares de Araujo & Bar-Or, 1997; Szentagothai, Gyene, Szocska, & Osvath, 1987; Wardell & Isbister, 2000). In addition, no standard protocol (time, duration, mode, intensity) has been used across the studies, which makes it difficult to replicate or compare.

Huang et al. (1989) reported decreased emergency room visits and hospitalizations for asthmatic children (*n* = 45, age range = 6–12 years) in a swimming program, even though the exercise protocol did not completely eliminate wheezing and drug requirements. The exercise protocol was two months in length, where participants swam 3 times per week for an hour in each session. Program design, intensity monitoring and progression, and types of activities during the swimming sessions were not outlined in the study, which makes it difficult to use the Huang protocol in future research or for asthmatics in the general population who may lack swimming skill.

Wardell and Isbister (2000) reported general improvements in psychological and physical well-being for asthmatic children (*n* = 73) enrolled in a community swim program (average of 2.4 years of participation). In this study, peak flowmeter readings were taken at the beginning of each session as a guide for preswim medication needs, but no significant changes in this variable were reported over time. No details were provided about the swimming program, making it difficult to replicate the study protocols. It was unclear as to the types of swimming activities, intensity, duration, and progression in the exercise program over time. In addition, it was uncertain as to the training state or skill levels of the children in the study, making it difficult to determine the appropriate exercise protocol for the sample group.

A 6-week swimming program has been shown to improve aerobic capacity for children (n = 16, mean age = 10 years) with moderate/severe asthma (Matsumoto et al., 1999). The exercise protocol included swimming six days a week for six weeks. Each exercise session included two 15-min bouts of swimming with a 10 min rest period between bouts. The training intensity for exercise bouts was 125% of their lactate threshold, which was measured once a week after the first 15 min training bout to ensure adequate training intensity. The researchers monitored lactate concentrations during the exercise protocol in an attempt to control the intensity; however, this technique isn't used during daily exercise in the general population to monitor intensity. Furthermore, the lactate assays are simply snapshots and not a consistent monitoring of exercise intensity throughout the session.

A five-month training protocol was reported to improve a 9-min swimming distance with a group of young asthmatics (n = 46, mean age = 12.5 years; Fitch et al., 1976). Participants were assigned to a professional coach at each site and began the exercise protocol with three sessions per week. The exercise intensities, durations, and frequencies were increased until the participant met a weekly goal of five 1-hr long sessions where training continued for five months. Each participant kept a diary for 6 weeks before training began to track wheezing and medication usage. Swimming tests for distance covered in nine minutes were performed at the completion of the one, three, and five months. Researchers reported significant reductions in asthma disability, medication usage, and percent body fat. Improved posture and increased work capacities (measured at a heart rate of 170 beats/min) were also reported in the study. One of the limitations for this study was the inability to determine whether improvements in the 9-min swim test were due to an increase in aerobic capacity or an improvement in swimming technique. In addition, the exercise protocol was unclear, since there was no report of exercise type, intensity, duration, and progression.

Research has shown that swimming appears to be beneficial for individuals with asthma, but inconsistent exercise protocols make comparisons across studies difficult. Furthermore, even with a significant number of studies using swimming as the therapeutic modality, little has been done to assess the effectiveness of other modes of aquatic exercise. Few studies have examined the impact of vertical aquatic aerobic exercise programs on variables such as maximal oxygen consumption, percent body fat, quality of life, and respiratory function in a generally healthy population, with no studies reported for the asthmatic population.

The issue of program adherence is also critical in predicting long-term maintenance of physical activity in the asthmatic population. Technical skills, exercise tolerance, and social support issues are important to address for adherence to any exercise program. There are many biomechanical differences between swimming and vertical aquatic exercise programs. Swimming is a technical skill that takes extensive practice and instruction to achieve even intermediate levels of proficiency. Because of individual differences in skill levels between swimmers, energy consumption and training effectiveness are difficult to regulate, and these effects have been found to vary widely across individuals with different skill levels. In contrast, vertical aquatic exercise using a floatation belt and aquatic exercise equipment can easily be monitored and regulated, decreasing the variance in energy consumption and training effectiveness, while being fun for the individual. Tolerance of exercise-induced discomfort can be a significant predictor of adherence for regular moderate-to-vigorous exercise programs (Annesi, 2004). As mentioned earlier, vertical aquatic exercise with neck-depth immersion can improve fatigue tolerance, which could sustain exercise adherence (Banzett et al., 1985; McCool & Mead, 1989; Reid et al., 1985; Roussos, 1984). Finally, the social impact of group aquatic exercise should not be ignored. Social support can be a strong predictor of long-term maintenance of physical activity in some populations (Annesi, 2004; Edmunds, Ntoumanis, & Duda, 2007; McAuley, Jerome, Elavsky, Marquez, & Ramsey, 2003; Sarrazin, Vallerand, Guillet, Pelletier, & Cury, 2002). The group aquatic exercise program has the social support component, while lap swimming is largely a solitary activity, even when done in groups.

A program of regular aquatic exercise may have distinct benefits in the asthmatic population because of improvements in aerobic capacity (Arandelovic et al., 2007) and the unique value of immersion-produced improvements in respiratory endurance and cardiac output (Arborelius, Balldin, Lila, & Lundgren, 1972; Arborelius, Balldin, Lilja, & Lundgren, 1972; Becker, 2004; Hong et al., 1969). The purpose of this article is to develop an exercise curriculum as part of a larger study that examined a 12-week aquatic exercise regimen for a group of asthmatics. The first goal in developing the curriculum was to create a comprehensive exercise program frequency, intensities, durations, types of exercises, and program progressions described that could be prescribed by health care providers and aquatic professionals and used by asthmatic individuals with varying fitness levels. The second goal in creating the curriculum was to develop a consistent aquatic exercise protocol that could be used for research, examining the impact of exercise in an asthmatic population.

Method

Participants

Recruitment was done through public forums (e.g., classified advertisements in local newspapers, press releases, flyers, Facebook ad, local electronic list serves) with a rural community in the Pacific Northwest during the fall of 2008. Individuals interested in participating in the study completed a screening session with health/behavior questionnaires, a physiological measure of lung function, and signed an informed consent form approved by the institution's Institutional Review Board. Information collected in the health/behavior questionnaires included demographic and behavioral/lifestyle variables (e.g., sex, race, age, smoking status, and medical history). Using a spirometer, forced expiratory volume in 1 s ($FEV_{1.0}$) and forced vital capacity (FVC) were measured during this session (SB Office, SDI Diagnostic, Easton, MA). The average of three trials was calculated.

Participants were required to have diagnosed asthma, which was being medically managed daily or in an "as needed" basis. Letters from the participant's supervising physician were requested to support the diagnosis and give medical clearance for participation in the study. 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. Participants were screened for their physical fitness levels and instructed not to modify their activity levels throughout the study with the exception of the study protocol. Participants filled out monthly activity logs to monitor their fitness activity during the exercise sessions.

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 dropped from the study if they missed more than 3 consecutive exercise sessions. The average age of participants who completed the study was 22 years old (SD = 5.27), and those who dropped out had an average age of 20 (SD = 1.26). The 16 participants who completed the study were primarily Caucasian (75%) and reported an average of 195 min of moderate physical activity/week for the 4 weeks before the study (SD = 143.73). Participants who dropped out of the study reported 85 min of moderate physical activity for the 4 weeks before the start of the study (SD = 84.26). Four of the participants who completed the 12-week exercise protocol reported taking medications on a daily basis to manage their asthma symptoms. Due to the nature of the study, participants were financially compensated for their time in the screening and exercise sessions.

Facilities

Facilities used in the study met all university and national requirements. The pool was indoors, water temperature held between 28.9°–30 °C with the air temperature at 25.6 °C while doors to the pool were closed. Pool length was 25 yards and depth was from four feet to nine feet. Side ladders were used for entry and exit into the pool with portable stairs available if needed. Locker rooms were located within the building and were accessible from the pool area via a ramp with hand rails and nonskid flooring. All safety equipment (e.g., backboard, life preserver, first aid kit) was readily available in case of an emergency (Table 1).

Staffing & Equipment

Two instructors with similar teaching backgrounds, professional education, and knowledge conducted this study. This allowed for consistent class formats, techniques, questions, and corrections across all exercise sessions. These instructors held certifications from the Aquatic Exercise Association, Arthritis Foundation Water Exercise program, and American Red Cross Water Safety programs. Equipment for the study included flotation/buoyancy belts (Sprint Aquatics; San Luis Obispo, CA), Hydro-fit cuffs (Hydro-Fit, Inc.; Eugene, Oregon), hand buoys/dumbbells (Hydro-Fit, Inc.; Eugene, Oregon), and webbed gloves (Sprint Aquatics; San Luis Obispo, CA).

Table 1 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

Monitoring Exercise Intensity

Exercise intensities during the training sessions were monitored using the modified Borg Rating of Perceived Exertion Scale (RPE). The RPE scale was recommended for the asthmatic population since familiarization with it can ameliorate fear associated with difficulty in breathing (Dishman, 1994; Durstine, Moore, Painter, & Roberts, 2009). Heart rate ranges were not used in this study because of the known reduction in heart rate during cool water immersion and because medications treating asthmatic symptoms may alter heart rates at rest and during exercise. RPE has been reported as a better estimate of VO_2 peak when compared with heart rate (Dishman, 1994). Furthermore, heart rate was not used to monitor intensity since reliance on heart rate can lead to large over-/under- estimates of exercise intensity (Dishman, 1994; Durstine et al., 2009). During exercise sessions, RPE checks were useful for participants to continually gauge their intensities during the different stages and for the instructors to continually monitor the status of the participants.

Guidelines for Program Development

Guidelines from the Aquatic Exercise Association (AEA) and the American College of Sports Medicine (ACSM) were used in the development of the exercise program. AEA and ACSM have recommended that an aquatic fitness program should be balanced between cardiorespiratory endurance, muscular conditioning, and flexibility (ACSM, 2006; AEA, 2006). In this study, the exercise program goal for the cardiorespiratory endurance section was to increase the participants peak work (maximal oxygen consumption, VO_2max), improve breathing patterns, delay ventilator threshold, and improve breathing efficiency. For muscular conditioning, the exercise program goals were to increase force generation through repetitions, improve core stabilization, and increase lean body mass. Finally, the goal for the flexibility portion of the exercise program was to increase overall range of motion that could improve gait and balance. The exercise protocol for the study was

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reviewed and approved by the Institutional Review Board for Human Subjects at a land grant institution in the Pacific Northwest.

Each session had a warm up component, conditioning phase and a cool down period (ACSM, 2006; AEA, 2006; Durstine et al., 2009; Joint American College of Chest Physicians/American Association of Cardiovascular and Pulmonary Rehabilitation, 2007). According to the ACSM's Management for Persons with Chronic Diseases and Disabilities, improving fitness for asthmatics requires participation in an aerobic training program similar to sedentary nonasthmatic subjects, where intensity, frequency, duration, and longevity of the program follow ACSM recommendations (Durstine et al., 2009). The AEA and ACSM standards and guidelines were combined to produce an aquatic training program with 3 exercise sessions per week for 12 weeks. Table 2 outlines the progression for the exercise program, with durations of conditioning phase as well as perceived exertion goals for each week. For each exercise session, a 10 min warm up and 5 min cool down period were included. Total time for exercise sessions increased from 30 min to 45 min over the 12 week aquatic training program.

There were several special considerations taken into account as the exercise protocol was developed for the asthmatic population. First, more time may be needed during warm up to reduce the possibility of initiating an asthmatic event (Durstine et al., 2009; Joint American College of Chest Physicians/American Association of Cardiovascular and Pulmonary Rehabilitation, 2007; Rundell, Wilber, & Lemanske Jr., 2002). The primary focus of the warm up component was to gradually elevate core temperature and heart rate using large, lower impact, rhythmic movements. In addition, the maximal amount of time recommended by the ACSM, 10 min, was used during the exercise sessions before moving into the conditioning portion of the protocol.

The second special consideration was that asthmatics often reduce their physical activity over time as a consequence of the asthma and may be extremely deconditioned. This could cause an increased possibility of ventilatory, cardiovascular, and muscular impairments in the participants, which could ultimately increase hypoxia, stimulate angina, and increase the chances of a myocardial infarction during the exercise sessions. As mentioned above, the protocol was similar to

Table 2 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

sedentary nonasthmatic subjects as recommended by ACSM, which reduced the potential for stimulating an asthmatic or cardiac event (Durstine et al., 2009). The staff on-site were also certified in CPR-PR and trained to handle emergency situations related to this special population.

The third special consideration during the development of the exercise protocol was the time of day for the exercise sessions. Asthmatic events and difficulty with breathing are more often seen in the early morning; therefore, it was recommended that exercise sessions and fitness testing occur during the late morning or afternoon (Durstine et al., 2009). For this study, exercise sessions were offered in the afternoon with some morning exercise sessions due to facility availability and participants' schedules.

The final special consideration taken into account during the development of the exercise protocol was that participants were taking medications to manage their asthma, whether on a daily basis or as needed. Medications were taken as prescribed throughout the study, including during the exercise sessions and fitness assessments. These medications may have reduced dyspnea and improved exercise capacities throughout the 12-week exercise protocol despite the potential side effects such as tachycardia. Medication usage was monitored on a weekly basis and during each exercise session. Ventilatory impairments were monitored during each exercise session by the instructors and also through RPE checks to watch for asthmatic events.

Fitness Assessment

Pre- and postexercise measurements for VO_2max were taken the week before the exercise treatment began and again the week after the exercise treatment concluded. Fitness assessments were scheduled on the same week day and time for pre- and posttraining measurements. Cardiorespiratory fitness was assessed using a graded exercise test on a Monark 181E cycle ergometer (Varburg, Sweden). Participants began with a warm-up for 2 min at 25 W and then moved through stages every two minutes, progressively increasing resistance levels by 25 W until maximum tolerance (Robertson, Simkins, O'Hickey, Freeman, & Cayton, 1994). There was a 2 min cool-down/recovery period after termination of the exercise protocol at 50 W. Data on continuous gas exchange measures and spirometry were collected using the TrueMax 2400 computerized metabolic system (ParvoMedics, Salt Lake City, UT; Hodges, Brodie, & Bromley, 2005). The TrueMax 2400 was also used to collect the FEV1.0/FVC data. Each participant was instructed to breathe normally for a couple of breaths, then to inhale maximally, then to exhale as fast and completely as possible. A total of 3 trials were conducted with the best value being reported.

Psychological Assessment

Perceived stress was measured using the 10 question version of the Perceived Stress Scale (PSS10; Cohen & Williamson, 1988). The PSS10 consists of 6 "stress" and 4 "counter-stress" items rated on a 0–4 response scale, 0 = *never*; 4 = *very often*. Scores range from 0 to 40 with higher scores on the PSS10, indicating greater feelings of stress. Depression was evaluated using the Center for Epidemiological Studies—Depression scale (CES-D). The CES-D is a 20 question survey assessing depression symptoms on a four point scale where 0 = *rarely or none of the time* (less than 1 day) and 3 = *most or all of the time* (5–7 days; Radloff, 1977). Scores range from 0 to 60 with higher scores on the CES-D indicating greater depressive symptoms.

Quality of life was assessed using the Asthma Impact Survey (AIS) and a 7-question phone survey. The AIS contains 6 questions on a 5-point scale (i.e., *not at all*, *a little*, *moderately*, *quite a lot*, *extremely*). Scoring for AIS used a norm-based method. Scores range from 36 to 78 with an average score of 48 for asthmatics (Schatz et al., 2007). Data were collected on psychological parameters PSS10, CES-D, and AIS at the beginning of the fitness assessments pre- and postexercise treatment. Participants two months posttreatment participants were also contacted by phone to complete a 7-question survey assessing perceptions about the exercise program and its impact on their daily lives (e.g., "While participating in the weekly aquatic exercise program, did you notice any changes in your daily living skills or energy level in regards to your breathing?" "Did you enjoy the aquatic exercise programs?"). Questions were developed by the research team to gather subjective data.

Statistical Analyses

Two-tailed paired sample *t* tests were performed to examine differences across variables from pretest to posttest (14 weeks apart). Chi square statistics were calculated to examine the differences in asthmatic events across the study. To maintain the familywise error rate for the multiple comparisons, differences were considered significant at $p < .003$ (Bonferroni correction; $p = .05/15$ *t* tests); however, comparisons significant at the $p < .05$ level also are discussed.

Results

The exercise protocol stimulated a significant increase in VO_2max that was seen posttreatment when compared with pretreatment measures at the $p < .05$ level (pretreatment M = 31.244, *SD* = 9.772; posttreatment M = 33.431, *SD* = 10.387; partial $\eta^2 = 0.257$); however, note that the significance level did not meet the a priori specified $p < .003$ level so there is a possibility that this difference might not be repeatable (Table 3). There were no significant changes in measures of lung function ($FEV_{1.0}$/FVC), perceived stress, depression, and quality of life. There were also no differences in reported asthmatic events across the study, χ^2 (1) = 0.76, $p = 0.383$. In a posttreatment phone survey, participants reported it was easier to get out of bed in the morning, they had more overall energy, and climbing stairs was less taxing on breathing effort. Despite the lack of significant changes as a group in stress, depression, or quality of life, some participants also reported that the aquatic exercise program reduced their anxiety about exercising and that they planned to remain physically active.

Discussion

A significant increase in VO_2max was seen posttreatment when compared with pretreatment measures at $p < .05$ but not at $p < .003$. Participants were more physically fit, which is why we were less likely to see a significant response to the low impact aquatic exercise protocol. The current study is the first to directly measure

Table 3 Physiological Adaptations to the Exercise Protocol

	Pre-Treatment		Post-Treatment		*t* Test		
Variable	Mean	SD	Mean	SD	Mean Dif	*t*	Sig
VO_{2max}	31.244	9.772	33.431	10.387	–2.187	–2.276	0.038*
$FEV_{1.0}$/FVC	98	8.914	98.5	8.710	–0.500	–0.375	0.713
CES-D	8.437	3.386	7.375	4.689	1.062	1.314	0.209
PSS10	12	4.619	11.125	5.976	0.875	0.778	0.449
AIS	42.687	4.643	42.062	5.026	0.625	0.470	0.645
Medication	2.5	1.225	2	0.816	0.437	1.331	0.203

VO_{2max}, maximum oxygen uptake in ml O_2/kg/min; $FEV_{1.0}$/FVC, percentage of forced expiratory volume in one second/forced vital capacity; CES-D, Center for Epidemiological Studies—Depression scale; PSS10, Perceived Stress Scale 10-item version; AIS, Asthma Impact Survey; Medication, Asthma Medication Usage per week; S.D., standard deviation; Mean Dif, mean difference; Sig, significance

*significant at the $p < .05$ level (2-tailed)

VO_2max, using a documented and reproducible aquatic exercise protocol with the asthmatic population. The increase in VO_2max from pretreatment to posttreatment with this small group of fairly active healthy college-aged asthmatics suggests that the protocol could be effective in increasing cardiovascular fitness for a more severely-afflicted asthmatic population.

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; Wardell & Isbister, 2000). Participants within the current study had a baseline $FEV_{1.0}$/FVC value of 98% (SD = 8.91%), and a postexercise value of 98.5% (SD = 8.7%). Participant values were within the upper limits of healthy ranges and therefore improving on this fairly high baseline was difficult. No values occurred below medical demarcations, which is not typical for individuals in the asthmatic population (Durstine et al., 2009). There was a mean increase of 0.5% in pre- to posttreatment $FEV_{1.0}$/FVC values but the lack of significant differences in this study was most likely due to a ceiling effect, but also may have related to the small sample size and low statistical power.

Analysis showed no significant changes in the psychological factors, as measured by PSS10, CES-D, and AIS, related to the aquatic exercise program. This could be due to low values for participants initially. For PSS10 scores could range from 0 to as high as 40. With this sample, the means pre- to posttreatment were 12 and 11.125, respectively, which are on the lower end of the score range. The same is seen with CES-D, where participants reported mean scores at the low end of the scale. AIS participants scored at the lower end of the scale and below levels typically seen for asthmatics. These data suggest that participants were psychologically well before entering the study, which may be why we did not see significant differences in psychological variables. Qualitative data were also collected and seem to capture the subjective thoughts and feelings of participants about the aquatic exercise program. Participants reported that they felt they used medication to manage their asthma, had more energy, experienced less fear about exercise, and had an easier time walking up stairs. These anecdotal feelings of increased well-being reported in the phone survey might be more important in examining effects of the protocol because of the potential floor effects for the other psychological measures.

Overall feedback from the participants and instructors was positive. Based on interactions with participants during the study and the follow-up phone survey, participants indicated the curriculum was able to hit the target RPE goals each week, and the conditioning portion of the curriculum was able to adapt to the changing RPEs and durations. Instructors were able to create a curriculum that was challenging and evolving from week to week to keep participants motivated. During the protocol, instructors were able to observe that the participants' skills and fitness levels progressed throughout the program, and feedback from participants during the follow-up survey confirmed this observation. The participants' efficiency in the water improved and they were able to maintain high RPE goals without appearing to work as hard as they did initially.

Several special considerations outlined by AEA and ACSM were taken into consideration as the exercise protocol was developed. First, longer times in the warm-up stage were recommended to reduce exercise-induced asthmatic events. The warm-up segments were 10 min in length, which was standard for most aquatic exercise programs. This time was used for the participants to acclimate to the indoor pool environment through a combination of thermal warm up (i.e., water walking, marching, varying arm movements) as well as prestretching and cardio respiratory exercises. None of the participants experienced asthmatic symptoms or an event during the warm-up. The second special consideration was that the participants may have reduced cardiovascular fitness levels because of their asthma. Within the initial screening, participants reported that they were involved in moderate intensity exercise or physical activity 195 min/week (SD = 143.73). Participants were not sedentary and did not experience issues such as cyanotic hypoxia, angina, or myocardial infarction. The time of day for the exercise sessions was the third special consideration since asthmatic events have been reported more often during the early morning. Exercise sessions were offered during the early morning (8:00–9:00 a.m.), midmorning (10:00–11:00 a.m.), and a mid afternoon (3:00–4:00 p.m.) to accommodate facility availability and the participants' schedules. One participant dropped out of the early morning session due to time constraints, but no differences were seen in asthmatic symptoms across exercise times. Medication management was the final special consideration while developing the exercise protocol. There were no asthmatic events during the exercise sessions, and participants reported no changes in medication usage during the 12 weeks, suggesting that aquatic exercise programs that have slow progressive intensity increasing over time may not initiate increases in asthmatic events.

Before the exercise program was initiated, participants completed RPE training; however, during the follow-up survey, it was indicated they would have preferred more training on the use of the RPE scale before beginning the exercise program. More specific instruction may have given participants a greater ability to compare the RPE scale to actual exercise intensities. A large poster sized RPE scale would have allowed for better visual cueing throughout the exercise sessions.

The first few weeks of the study were important in creating a comfortable, fun, and safe environment within the exercise sessions. The goal for the first week of training was to introduce general aquatic exercise terminology through verbal instruction and visual demonstration and determine overall participant comfort levels with equipment in shallow and deep water areas of pool (Table 4). Everyone in the classes used buoyancy belts with five participants adding Hydro-Fit cuffs to the ankles to keep them at chest level in the deep water. In addition, the use of hand buoys was introduced with a variety of arm movements, as well as leg/arm combinations to enhance the exercise segments. One participant needed to add hydro-fit cuffs on arms, in addition to a belt to remain at chest level. The additional equipment did not change the established protocol. Addressing these buoyancy

Table 4 Aquatic Exercise Program—Week 1

Program Phase	Exercise Session Description
Warm-up	Duration: 10 min Pool location: Shallow water Exercises: • Deep breathing • Shoulder shrugs • Shoulder rolls forward/back • Stretch arms overhead • Triceps stretch • Shoulder stretch (arm across chest) • Pelvic Tilt (suck & tuck, abs & gluts) • Beach ball stretch
Conditioning	Duration: 15 min Intensity: RPE = 4 Pool location: Deep water Equipment: Belts, no hand buoys Exercises: • Gentle bicycling + add breast stroke or scissor arms • Cross country ski + arms move forward & back • Jog in place + arm movement + Talk Test • Jumping jacks + arms at sides • Bicycle to slow down + Talk Test • Knee to elbow stretch
Cool Down	Duration: 5 min Pool location: Shallow water, next to wall Equipment: belts removed Exercises: • Face wall & do lunges side to side • Face wall & raise heel toward buttocks to stretch quad • Toe raises & rock back onto heels • Deep breathing

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issues during the first week was very important so that participants could maintain core muscle stabilization and correct body position.

The goals for week two were to review and reinforce target RPE for the training week in relation to the participant response and confirm participant understanding of aquatic exercise terminology. At the beginning of week two, several participants verbalized concerns about exercising in the deep and middle area of the pool. The instructors emphasized the buoyancy equipment, asked the participants to stay approximately arms length from the edge of the pool, and alerted lifeguards to the participants concerns for their safety.

The goal for weeks three and four was to emphasize increases in RPE while adding more challenging exercises within conditioning segments thus encouraging participants to meet the RPE goal (Table 5). During week four of the study, instructors began to report that participants had adapted to the aquatic exercise protocol requiring more advanced activities. Instructors added at least one timed or fast-paced sequence to assist participants in meeting their RPE goals. For example, a pace clock was used for a 60 s knee tuck with arms out to side on the surface of the pool. Upon completing similar types of timed activities, participants stated they would like to have more challenges added to the following week's curriculum. During this phase of the study, there was one participant who consistently was not meeting the RPE goal. Upon closer observation, the instructor noticed that the participant was having difficulty remaining vertical in the deep water while wearing a buoyancy belt. Review of core muscle utilization and body positioning tips did not assist in correcting the body position so the buoyancy belt was removed and Hydro-Fit cuffs on their ankles were used for buoyancy. The participant reported being more comfortable using only Hydro-Fit cuffs, remaining vertical and at shoulder depth, and using core muscles more efficiently.

Before initiating the exercise protocol for week five, instructors met and reviewed the first four weeks of curriculum. The instructors observed that participants had become comfortable with the aquatic exercise sessions and were able to work harder, reporting lower RPE levels. To maintain intensities within the protocol, instructors implemented activities challenging participants to meet RPE goals. Warm-up in this stage used static stretching, rhythmical stretching, and/or light cardio exercises. Time sequences, along with choreographed combinations, were used to challenge participants and reach RPE goals for the conditioning segments. A variety of arm movements and/or hand shapes and positions were added to use their full range of motion and increase the effectiveness of each exercise format.

In weeks six and seven, the instructors continued to use the exercise formats developed after week four. Participants responded well to greater challenges in the aquatic exercise protocol, understanding of the aquatic exercise terminology, and responded easily to the instructor's cues. Timed sequences were one of the participant's favorite activities, along with abdominal exercises to emphasize core muscle control. In this block of time, one participant indicated having difficulty meeting the RPE goal even though visibly working at the right pace and water depth. This participant had some difficulty with body position, which was corrected with verbal cues. The RPE scale was also reviewed with this participant to ensure they understood the comparison between the exercise intensity and the actual RPE scale.

The goal for weeks eight through ten was to introduce water specific movements and combination patterns to continually challenge participants and maintain interest (Table 6). During week eight of the exercise program, pyramid choreography and

Table 5 Aquatic Exercise Program—Week 3

Program Phase	Exercise Session Description
Warm-up	Duration: 10 min Pool location: Shallow water Exercises: • Water walking forward, breaststroke arms pulling forward, ×3–4 • Side steps w/ lunges, arms move out & down, × 3–4 • Deep breathing—inhale & raise arms overhead, reach upwards, × 3 • Shoulder shrugs—up & down, × 6
Conditioning	Duration: 20 min Intensity: RPE = 5–6 Pool location: Deep water Equipment: Belts, hand buoys Exercises (approximately 2–2.5 min each): • Jog in place + arms punch forward/arms punch down (then travel over to pick-up hand buoys) • Jumping jacks + arm movement out to sides & press down + *Talk Test* • Vertical flutter kicks + hand buoys up like ice cream cones, arms move out & in • Bicycling + arms punch forward/arms punch out to sides + *Talk Test* • Cross country ski + arms at sides moving forward & back • Run through tires + arms press/punch down in front • Jog in place + do barrel rolls w/arms + *Talk Test* • Abdominal Crunches—forward/knees to chest—then knees to each shoulder + arms are out to sides on surface • Ankle to hip stretch (sit & bring ankle up to top of knee), × 1 on each leg
Cool Down	Duration: 5 min Pool location: Shallow water, next to wall Equipment: Remove all equipment Exercises: • Quad stretch (heel to buttocks), 2× on each side • Knee hug stretch (knee up toward chest), ×2 on each side • Beach ball stretch, ×2 • Deep breathing, inhale & raise arms overhead, ×3

layer techniques were added to the curriculum to gradually increase or decrease the repetitions within a variety of patterns and combination sequences. Multiple patterns and travel sets kept participants engaged in the exercise sessions. Participants verbalized their enjoyment with the multiple patterns and travel sets used during this phase of the training, even while they were being challenged to maintain intensity.

Table 6 Aquatic Exercise Program—Week 9

Program Phase	Exercise Session Description
Warm-up	Duration: 10 min Pool location: Shallow water Exercises: • Jog w/forward movement arms • Jog w/backward movement arms • Sidestep w/ lunge stretch arms press down at sides • Rocking horse w/ forward or backward movement arms
Conditioning	Duration: 30 min Intensity: RPE = 6–7 Pool location: Deep water Equipment: Belts, hand buoys, gloves Exercises: • Travel set Bicycle/Jog Use arm movements to get used to gloves & resistance (5 min) Thumbs up pull out Alternate sweep out White water straight arm press forward Alternate dig back &/or double dig back Breaststroke forward • Combo sets (w/ gloves)—2× (10 min) Jog in place w/ bicep curls 1 min hard—Jog w/ white water straight arm press forward Ab crunch (knees forward) Jog & travel forward w/ thumbs up pull out Stationary wide jog w/ sculling at sides (pick up buoys after second set) • Cross country hard/ flutter kick easy w/ buoys (5 min) 15 s hard 15 s easy 30 s hard 30 s easy 45 s hard 45 s easy 1 min hard 1 min easy • Bicycle w/ buoys (5 min) 1 min hard 1 min easy (punch forward w/ thumbs up) 45 s hard 45 s easy (thumbs up straight arms press out & in) 30 s hard 30 s easy (punch downward at sides) 15 s hard 15 s easy (barrel rolls in front OR in back) • Ab workout w/ buoys (Instructor's choice; 5 min) Abdominal crunches (forward tuck) +Arms out to sides or buoys under knees Oblique crunches ("side ab tucks", knees toward shoulders)

Program Phase	Exercise Session Description
	Combo (forward & to each side) Pike forward press buoys down & under thighs Pike forward scissor legs/feet Suspended Front Back Body Abs, with or w/o tuck (picture in binder) Suspended Side Side Body Abs, with or w/o tuck (picture in binder) Pike forward alternate heels over toes
Cool Down	Duration: 5 min Pool location: Shallow water, next to wall Equipment: Remove all equipment Exercises: • Hamstring stretch, face wall, lift leg to place heel on wall w/ bent knee, lean forward toward ankle, extend bent leg to stretch • Spider walk in & out, feet on wall, walk feet inward then walk feet outward • Vertical push-ups • Arm across chest, press into stretch, change arms • Deep breathing exercises **OR** • Calf stretch w/ white water palms up • Switch calf stretch w/ white water palms down • Feet wider than hips w/ wide infinity arms OR interlock hands shoulders under water reach forward, left, right • Triceps stretch overhead, both arms • Hands behind back pull down & back to squeeze shoulder blades • Deep breathing exercises

The addition of webbed gloves increased the difficulty of exercises in the aquatic enhancing participant enjoyment. Furthermore, they were able to increase their RPE easily, reaching their RPE goal more effectively. The instructors observed that utilizing a greater variety of equipment was comforting for some participants while challenging to others due to changes in buoyancy, resistance and body position.

In weeks 10 through 12, instructors increased the variety of activities to maintain adherence to the exercise protocol while increasing exercise intensity and difficulty to reach RPE goals (Table 7). The goal of this phase was to create interval training patterns for increased intensity and duration of exercise segments. Travel patterns and creating drag or turbulence in the water while wearing webbed gloves were incorporated into the program. Participants moved through the water against their own turbulence or current (e.g., circle patterns with changes in direction). These activities challenged participants to adjust their body position to maintain core muscle stabilization while completing exercises.

Table 7 Aquatic Exercise Program—Week 12

Program Phase	Exercises Session Description
Warm-up	Duration: 10 min Pool location: Shallow water Exercises: Gloves Walk &/or Jog w/forward & backward w/ arms moving Run in place—fast ×10 (palms forward, white water press forward) Frog jumps w/ hands press in front—×5 Run in place—fast ×10 (white water press out to sides) Cannon ball jumps/tucks w/ hands press under tuck—×5 Rocking horse w/ leap forward—×5 each leg forward
Conditioning	Duration: 30 min Intensity: RPE = 6–7 Pool location: Deep water Equipment: Belts, hand buoys, gloves, Nemo balls Exercises: • Cardio build (w/ gloves; 2.5 min) Straddle jog pushing diagonal down left/right Regular jog w/ white water palms front Run through tires w/ white water palms out Heel kicks w/ biceps curls OR triceps curls Regular jog w/ scarecrow arms curl forward to chest • Travel set (w/ gloves; 5 min) Bike forward w/ thumbs up sweep out Bike forward w/ alternate dig in front & pull down/back Wide bike forward w/ alternate sweep out Bike backward w/ pull wide squeeze in Bike backward w/ alternate dig reach behind & pull forward • Cardio build (w/ gloves; 2.5 min)—need Nemo Ball Jog/bike/flutter kicks/egg beater legs while keeping ball in the air Use both hands, just right, just left Volley/hot potato/name game, etc. • Cross country ski hard / Jumping jack (5 min) 15 s hard 15 s easy 30 s hard 30 s easy 45 s hard 45 s easy 1 min hard 1 min easy • Sprints from side wall to opposite wall (w/ buoys; 5 min) Bike forward w/ thumbs up sweep out Bike forward w/ paddle wheel arms Lay on one side to flutter kick OR lay back & flutter kick (buoys out in front)

Program Phase	Exercises Session Description
	Bike backward w/ thumbs up sweep out & squeeze in • Abs w/ buoys (Combo of instructor's choice; 4–5 min total) Straight leg kicks forward (flex at the hip, knee extended but not locked) Pike forward w/ scissor legs/feet OR alternate heels over toes Pike forward & press buoys down & under thighs OR alt press under leg Forward crunches &/or Oblique crunches Suspended Shoot through front to back w/ tuck Suspended Shoot through side to side w/ tuck
Cool Down	Duration: 5 min Pool location: Shallow water, next to wall Equipment: Remove all equipment Exercises: • Calf stretch w/ white water palms up • Switch calf stretch w/ white water palms down • Feet wider than hips w/ wide infinity arms • Interlock hands shoulders under water reach forward, left, right • Triceps stretch overhead • Hands behind back pull down & back to squeeze shoulder blades • Deep breathing exercises

By week 12, the participants' skill level had improved noticeably, where participants reported exercising within RPE ranges although they did not appear to meet the RPE goal through observation by the instructors. Participants may have increased their efficiency during the aquatic exercise sessions (e.g., improved body position, power and range of motion) so they could potentially work at the same or greater paces without increasing RPE. This could have allowed participants to work harder during the sessions without giving the instructors visible signs that the exercises were challenging. The instructors challenged the participants with timed sequences and longer travel sets to reach RPE goals. Games were added to the exercise program to maintain morale and adherence to the program. Beach balls were used to keep arms overhead while the legs worked in a jog, bike, flutter, or egg beater kick.

Two instructors facilitated all of the exercise sessions during the 12-week study. These instructors had very similar facilitation skills and met weekly to review and revise curriculum plans, ensuring the curriculum was delivered consistently throughout sessions. All fitness levels were represented in the sample group and the protocol needed to offer a challenge for each. All participants responded well and enjoyed the variety of exercises and timed segment routines. Many of the participants had increased their efficiency in the water (e.g., better body position, more power and

ROM, adjusted hand position) where they could work harder without giving the instructors as many visible signs that the exercises were a challenge. Participants had to be asked more often to ensure that they were achieving the target RPE.

The curriculum development, workout implementation, and participant feedback revealed that the protocol was able to meet study guidelines. Participants were able to successfully experience a great variety of aquatic exercises. In the beginning, teaching from the pool deck was vital to assess participation as a whole, monitor for asthma symptoms, and gain a good rapport with the participants. A change to be considered for future studies would have instructors in the water during exercise sessions during the end of the study. This may have helped with pacing the class when participants were asked to reach for higher RPE goals and to motivate participants to challenge themselves. Both instructors observed that as the study was concluding, some participants may not have given maximum effort and providing instructor motivation from the pool deck was a challenge.

Limitations

Many of the participants in this study were more active than the ACSM sedentary population guidelines, and future research will need to validate this protocol for a more severe and sedentary asthmatic population. The participants were young college-aged adults, and the larger asthmatic population in the nation includes individuals of all age groups. In addition, even though the participants were required to be medically managed for their asthma symptoms, many were on medications only as needed, so their asthmatic status may have been less severe than the general asthmatic population.

Future Considerations

Implementation of this protocol would allow researchers to examine the impact of aquatic exercise on many different populations. It will also allow the opportunity to compare and standardize results due to similar exercise treatments. In addition, depending on personal preferences, exercising in a vertical aquatic setting can greatly improve exercise adherence, whether it is in a group setting or working with a personal trainer. This protocol will also give practitioners/ aquatic personal trainers/instructors a research protocol for fitness improvements in healthy and other special populations. The curriculum was applied to a small participant number so future studies are needed to see if this curriculum is applicable and generalizable to a greater number of participants. Future investigations should examine whether this protocol can be used by individuals with more severe asthma symptoms, since our population was relatively healthy and physically active. This protocol was developed for individuals who are sedentary or active at low intensity levels as recommended by ACSM and AEA. This protocol also chose to use RPE to measure exercise intensity; however, future investigations could use waterproof heart rate monitors in conjunction with RPE to ensure accurate and redundant monitoring of exercise intensity. Future investigations should examine this protocol in an asthmatic population with higher and lower fitness levels to determine appropriate durations, frequencies, and intensities.

Conclusions

A significant goal of this project was to create the framework for a progressive structured vertical aquatic exercise protocol that includes all essential components of exercise and was descriptive and repeatable. We had not been able to find any similar protocol described in literature, and as a consequence of this gap, it is difficult to ascertain exercise dosages that may produce clinically significant results. Our protocol allows for incremental adjustment for individual improvements in exercise tolerance, despite variance in entry-level fitness as the RPE scale is based upon individual perception of effort. The exercises are based upon a common repertoire of aquatic exercise activities and should be familiar to most aquatic exercise leaders. The equipment used is widely available and in common use. This protocol should be repeatable in most aquatic exercise venues, allowing for assessment of the physiologic effects of exercise in a variety of clinical populations, despite initial fitness levels of participants.

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