HIGH-INTENSITY INTERVAL TRAINING ON AN AQUATIC TREADMILL IN ADULTS WITH OSTEOARTHRITIS: EFFECT ON PAIN, BALANCE, FUNCTION, AND MOBILITY

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ABSTRACT

Bressel, E, Wing, JE, Miller, AI, and Dolny, DG. High-intensity interval training on an aquatic treadmill in adults with osteoarthritis: effect on pain, balance, function, and mobility. *J Strength Cond Res* 28(8): 2088–2096, 2014—Although aquatic exercise is considered a potentially effective treatment intervention for people with osteoarthritis (OA), previous research has focused primarily on calisthenics in a shallow pool with the inherent limitations on regulating exercise intensity. The purpose of this study was to quantify the efficacy of a 6-week aquatic treadmill exercise program on measures of pain, balance, function, and mobility. Eighteen participants (age = 64.5 ± 10.2 years) with knee OA completed a non-exercise control period followed by a 6-week exercise period. Outcome measures included visual analog scales for pain, posturography for balance, sit-to-stand test for function, and a 10-m walk test for mobility. The exercise protocol included balance training and high-intensity interval training (HIT) in an aquatic treadmill using water jets to destabilize while standing and achieve high ratings of perceived exertion (14–19) while walking. In comparison with pretests, participants displayed reduced joint pain (pre = 50.3 ± 24.8 mm vs. post = 15.8 ± 10.6 mm), improved balance (equilibrium pre = 66.6 ± 11.0 vs. post = 73.5 ± 7.1), function (rising index pre = 0.49 ± 0.19% vs. post = 0.33 ± 0.11%), and mobility (walk pre = 8.6 ± 1.4 s vs. post = 7.8 ± 1.1 s) after participating in the exercise protocol ($p = 0.03$–0.001). The same benefits were not observed after the non-exercise control period. Adherence to the exercise protocol was exceptional and no participants reported adverse effects, suggesting that aquatic treadmill exercise that incorporates balance and HIT training was well tolerated by patients with OA and may be effective at managing symptoms of OA.

KEY WORDS rehabilitation, hydrotherapy, aquatic exercise

INTRODUCTION

Although no gold standards of exercise exist for treatment of osteoarthritis (OA), there is the contention that patients with OA who are unable to perform exercises on land, because of load-elicited pain and poor balance, should begin exercise therapy in an aquatic environment. The research on aquatic exercise generally suggests that there are some short-term benefits for reducing symptoms of OA, including joint pain reduction and improved mobility; however, the results are mixed (2).

Previous researchers have postulated that the mixed results observed between aquatic and land-based exercise modes for patients with OA were possibly because of the lack of control over exercise intensity (2,11). The only form of aquatic exercise that allows for a high level of control over exercise intensity is aquatic treadmill exercise where water depth, belt speed, and water current flow rate can be adjusted in some models to produce equivalent energy demands between aquatic and land treadmill exercise (8,11,18).

Denning et al. (11) compared the effectiveness of a matched dose exercise intervention comparing aquatic and land treadmill exercise for patients with OA. A key observation from their research was that after just three 20-minute exercise bouts at a moderate intensity, participants displayed significantly less ($p = 0.01$) perceived pain and improved Timed Up & Go scores after aquatic than land treadmill exercise (effect size [ES] = 0.49 and 1.12, respectively). Their results justify the need to examine a longer multi-week aquatic treadmill training protocol using more robust outcome measures.

In terms of developing a multi-week aquatic treadmill protocol for patients with OA, it would seem imperative to include a balance training component because many patients with OA display inferior balance compared with aged-matched controls (19,29). Inferior balance combined with the older age of many patients with OA likely increases

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This study was completed in the John Worley Sports Medicine Research Center at Utah State University.

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the risk of falls in this population (26). Researchers examining optimal training techniques for improved balance in the elderly argue the need for "perturbation-based" training (25) and exercises that promote muscle power production (17). The basis for these recommendations is that a person's ability to recover from a perturbation (e.g., destabilizing push or pull) is more related to one's ability to generate a rapid rate of muscle force production (power) and not necessarily greater maximal muscle force. In this view, inclusion of a perturbation and power-based training component in a multiweek aquatic treadmill protocol designed for patients with OA seems warranted.

Intuitively, water jet application while standing may serve as a perturbation-based training technique in an aquatic environment. Water jet application while walking may also serve as an effective method for increasing exercise intensity and training power (8). Recent evidence supports the use of short-duration high-intensity interval training (HIT) as a method for improving health-related physical fitness and neuromuscular power (21,31,40). High-intensity interval training may be particularly beneficial for patients with OA because, not only does it emphasize muscle power production but it can also be completed in a relatively short period, which may help with exercise adherence (39).

In view of the previous research, aquatic treadmill exercise may be an effective exercise mode for managing symptoms of OA (e.g., joint pain, compromised balance, and mobility) despite limited understanding regarding its use over a multiweek training period (11). Additionally, aquatic treadmill exercise with jet applications may be effective at challenging balance and applying HIT in people with OA; however, this assertion has not been tested previously. Accordingly, the purpose of this current study was to quantify the efficacy of a multi-week aquatic treadmill exercise program that includes balance training and HIT on measures of pain, balance, function, and mobility in patients with OA. We hypothesized that dependent measures will improve after the 6-week training protocol and that it will be well tolerated as measured through adherence.

METHODS

Experimental Approach to the Problem

The design of the study was a single-group double pretest posttest design whereby participants completed a 4-week non-exercise control period followed by a 6-week aquatic exercise intervention period. Dependent measurements were evaluated before the control period (pretest 1), after the control period (pretest 2), and after the exercise period (posttest). The single-group double pretest (i.e., time series) is considered a strong quasi-experimental research design with high internal validly as it controls for learning effects on repeated tests (38). All dependent measurements were made within 48 hours of the control and exercise intervention periods, with each test and training session controlled for day and time. The dependent measures included visual analog scales and questionnaires for pain, posturography for balance, sit-to-stand and lunge tests for function, and a 10-m walk test for mobility. These dependent measures were chosen as they are often considered gold standard measurements for their respective constructs (10,34,43).

Subjects

Potential participants for this study were recruited from the local community through flyers and informational sheets distributed through primary care physician offices. Before participating in the study, all participants read and signed an informed consent form. The informed consent form and procedures of the study were approved by the University Institutional Review Board (protocol # 2915). To be included in the study, participants had to be previously diagnosed with knee or hip OA through clinical history, physical examination, and radiographic analysis. All diagnoses were made by a local rheumatologist and were confirmed for "definite" OA in our laboratory using a diagnostic algorithm (28). Additionally, participants had to be older than 35 years, able to walk a city block, and walk upstairs in a reciprocal manner without the use of ambulatory assistive devices. Participants were excluded if they currently exercised on an underwater treadmill, had intra-articular corticosteroid injections in the past month, reported any neuromuscular disease such as Parkinson's disease, stroke, cardiovascular disorders, or surgeries to the lower limb (except for exploratory arthroscopy), lavage of knee joint or partial meniscetomy at least 1 year before entry into study. Use of medications for treating symptoms of OA was not an exclusion criterion. Instead, participants were asked to keep taking any current medications and to not start taking new medications for the duration of the study. Eighteen participants (Table 1) who responded to the request for subjects met these criteria. This number exceeded the sample size recommendation calculated using GPower 3.1 (13), which was based on ES computed from pain scores in the study by Denning et al. (11) with an alpha level of 0.05 and power at 0.80.

TABLE 1. Physical characteristics for all participants (n = 18, 2 men and 16 women).

Characteristic	Mean	*SD*	Range
Age (y)	64.5	10.2	52–78
Height (m)	1.66	0.08	1.55–1.85
Mass (kg)	79.7	11.6	52–90
Involved limb	1 or both knees = 100%; knee and hip = 42%		
Duration of OA* (y)	6.8	7.4	1–30

*OA = osteoarthritis.

Procedures

During the 4-week control period, participants were asked to maintain their typical activities of daily living and to not begin any new treatment therapy, including therapeutic exercise interventions. A descriptive overview of the 6-week aquatic training program is in Table 2 and detailed template is reported in the Supplemental Digital Content 1 Microsoft Excel file (http://links.lww.com/JSCR/A5). Participants attended up to 3 exercise sessions each week with each session lasting 30 minutes or less. Important to each exercise session was the perturbation (balance) and HIT training components (Figure 1) using water jets to achieve brief repeated bouts of exercise at an intensity of 14–19 on the rating of perceived exertion (RPE) scale (7). It is important to note that optimal exercise training duration, frequency, and intensity guidelines for patients with OA are not well understood (5), particularly regarding the use of HIT for this population. For example, HIT intervention times have ranged from 2 to 12 weeks, with positive health-related outcomes being reported at each end of the range (21,40). Exercise duration and frequency parameters in the current study were based on guidelines presented by the American Geriatric Society for patients with OA (32), whereas exercise intensities were based on current HIT research for special populations (40). The intervention duration of 6 weeks fit within the aforementioned range used by previous HIT studies (21,40) and was a feasible request of subjects given the infancy of HIT use in people with OA.

All aquatic exercise sessions were performed in a sports medicine clinic using an underwater treadmill (HydroWorx 2000, Middletown, PA, USA) with no shoes at a water depth equal to the xiphoid process. The temperature of the water was 30° C and the air temperature was 24° C. All treadmill adjustments during the protocol were administered by the same research assistant who also gave verbal encouragement during the HIT phase of each session. A description of the dependent measures used in the study follows.

Knee Injury and Osteoarthritis Outcome Score. The Knee Injury and Osteoarthritis Outcome Score (KOOS) is a self-completed questionnaire to assess participant's opinion regarding their primary joint symptoms and associated problems (35). Participants completed the KOOS questionnaire upon arrival to the clinic. Key outcomes from the questionnaire included measures of joint pain, other symptoms (SPT), function in daily living (ADL), function in sport and recreation (SAR) and knee-related quality of life (QOL). Generally, test-retest reliability is high for the KOOS subscales (pain Intraclass Correlation Coefficient = 0.85–0.93) (10). We analyzed the questionnaire using the scoring guide and Microsoft Excel files that are freely available at www.koos.nu. For the present study, scores were computed for pretests and posttest evaluations.

Pain Scale Assessment. Participant's perception of immediate and usual joint pain was assessed using a continuous visual analog scale described previously (11). The scale was 12 cm in length, with the left end of the scale labeled "no pain" and the right end labeled "very severe pain." The pain scales were analyzed by measuring the distance from the left of the scale to the vertical mark drawn by each subject. For the immediate pain scale, all pre-exercise pain scores were averaged and all post-exercise pain scores were averaged, to yield a single mean pain score before and after each exercise bout. For the usual pain scale, all pretest and posttest values were averaged separately to yield a pain score to represent average pain felt the week before assessment. Visual analog scales, such as the one used in this study, are reported to be reliable assessments of pain perceptions and are more precise than ordinal scales that rank responses (16).

TABLE 2. Aquatic treadmill exercise protocol progression.*†

Week	Frequency and duration (min) of exercise	Warm-up/ recovery speed ($m \cdot s^{-1}$) and RPE	Interval speed and recovery speed ($m \cdot s^{-1}$)	Interval jet intensity (%)	Interval frequency, duration, and rest duration (min)	Interval RPE and rest RPE	Balance RPE and jet intensity (%)
1	2/18	1.3/10	1.3/1.3	50	3/0.5/1	13/10	11/53
2	2/20	1.5/10	1.5/1.5	56	4/0.8/1	14/10	13/58
3	2/20	1.6/10	1.7/1.6	63	4/1.5/1.5	16/10	13/63
4	2/30	1.6/10	1.8/1.6	69	4/2.5/2.5	17/10	15/67
5	3/30	1.7/10	2.0/1.7	75	6/1.3/1.3	18/10	17/70
6	3/30	1.8/10	2.1/1.8	80	6/1.2/1.2	19/10	18/74

*RPE = rating of perceived exertion.
†Values are means for all subjects.

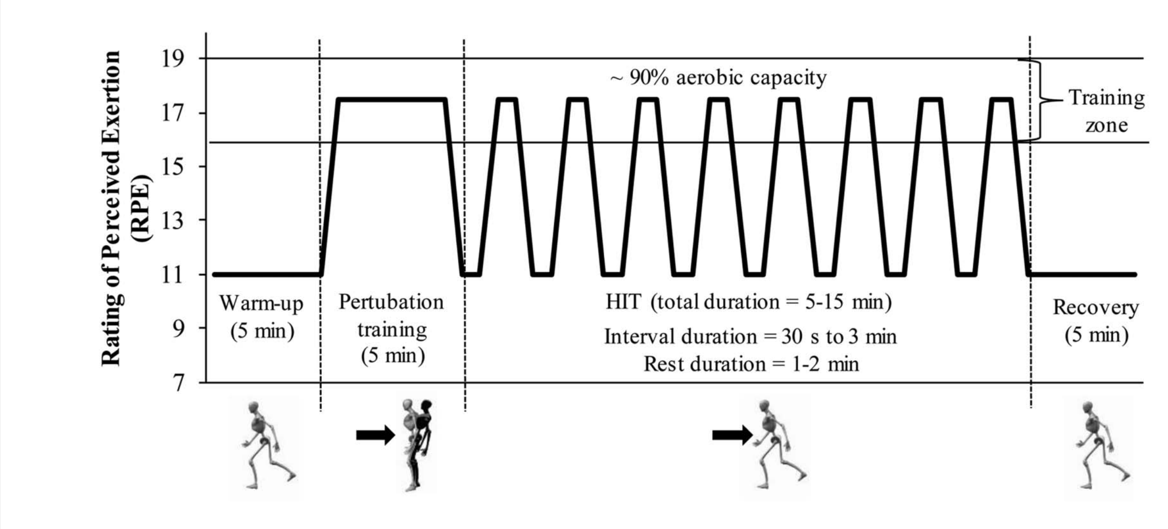

Figure 1. Illustration of the exercise components included in each exercise session. Key features included the perturbation-based balance training and the short-duration high-intensity interval training (HIT). For the perturbation training, participants were asked to stand as still as possible while water jets (→) were applied for 1-minute intervals each to the abdomen, side, lower back, and side. For the treadmill exercise component, water jets were directed horizontally to the abdominal region while participants walked centered and 1 m from the jets.

Computerized Dynamic Posturography. After participants completed the questionnaires, they performed standardized protocols for balance and motor function using the SMART EquiTest system (NeuroCom, a division of Natus, Clackamas, OR, USA). Specifically, participants were objectively assessed using the sensory organization test (SOT), motor control test (MCT), and limits of stability test (LOS). For balance, this system is arguably the gold standard (43) and has been evaluated extensively with good reliability (12,14,22). In-depth descriptions of the test protocols and measures have been described previously (23,41). Table 3 provides a brief description of each test and the specific measures used in the present study.

Function and Mobility. Participants performed standardized protocols for a sit-to-stand test (STS), forward lunge test (FLT), and 10-m walk test. The STS and FLT were assessed during pretest and posttest evaluations using the Balance Master System and manufacturer guidelines (NeuroCom). A description of the testing procedures is in Table 3. The 10-m walk test was assessed by having participants walk at a "comfortable speed" over a flat straight walkway. Walking speed is one of the most widely accepted measures of lower limb recovery (34), and test-retest reliability of this measure has revealed ICCs of 0.94 (37). The time average of 3 walking trials for pretests and posttest evaluation was used for subsequent statistical analyses.

Statistical Analyses

The independent variable in this study was the time variable, and the dependent variables were KOOS scores, visual analog pain scores, computerized dynamic posturography (CDP) scores, function, and mobility scores. Statistical analyses were conducted using SPSS version 20 (IBM Corp., Somers, NY, USA).

All data were first pre-analyzed for violations of normalcy using the Shapiro-Wilk test, which revealed that the normality assumption was met for all data sets ($p = 0.12–0.98$). Repeated-measures analysis of variance (ANOVA) was then used to assess the effect of time (pretest 1, pretest 2, and posttest) on each dependent variable. Follow-up multiple comparisons (LSD) were conducted when necessary using a Holm's corrected alpha level of 0.05 to determine significance for all tests. Effect sizes were also quantified to appreciate the meaningfulness of any statistical differences in the results, and Cohen's (9) convention for ES interpretation was used (<0.41 = small, 0.41–0.70 = medium, and >0.70 = large). Any unsolicited comments about the participants' perception of the exercise training, including any adverse effects, were recorded.

Results

All participants ($n = 18$) underwent the 6-week training program as planned (100% exercise adherence). Accordingly, 18 participants were included in the statistical analyses. The results of the ANOVA tests were significant for each dependent measure ($p = 0.01–0.001$). Results of the multiple comparisons revealed that there were no differences between pretest 1 and pretest 2 ($p = 0.10–0.96$), with the exception of 2 LOS measures. The LOS maximal and endpoint excursion values for pretest 2 were 7 and 9% greater than pretest 1 values, respectively ($p = 0.02–0.007$; ES = 0.39–0.45). Comparisons between pretest 2 and posttest follow.

Table 3. Description of the computerized dynamic posturography and functional assessments.*

Assessment	Description	Variable
Sensory organization test	Participants stand as still as possible under 6 conditions designed to separate the sensory effect of vision, proprioception, and vestibular inputs	Composite equilibrium score (0–100): 0 = least stable; 100 = most stable Strategy score: 0 = hip; 100 = ankle
Motor control test	Participants stand as still as possible and respond to unexpected platform translations in a forward and backward direction	Weight symmetry score (0–200): 0 = left leg; 200 = right leg Latency score (ms): time between translation and participant force response
Limits of stability test	Participants attempt to move their COG as quick as possible away from their base of support without stepping	Movement velocity ($°\cdot s^{-1}$) Maximum excursion = % of max Endpoint excursion = % of max during primary attempt Directional control = intended movement − extraneous movement (%)
Sit-to-stand test	On prompt, participants rise from seated position then stand as still as possible	Weight transfer = time (s) to shift weight from seated to standing position Rising index = force (% body weight) exerted by legs during rising phase COG sway velocity ($°\cdot s^{-1}$) during rise and stance period
Forward lunge test	Participants stand still feet together then steps (lunges) forward onto one leg, then pushes back with that leg to return to a standing position	Lunge distance (% of height) Impact index = maximum vertical force of lunging leg (% body weight) Contact time (s) = duration of contact with lunging leg Force impulse = work of lunging leg (% body weight × contact time)

*COG = center of gravity.

Knee Injury and Osteoarthritis Outcome Score

All subscales were different between pretest 2 and posttest (p = 0.03–0.005). Pain, SPT, ADL, SAR, and QOL scores were 30–49% greater at posttest than pretest 2 (ES = 0.46–0.80) (Figure 2).

Pain Scale Assessment

Usual pain values for pretest 2 and posttest were significantly different (p = 0.001). That is, usual pain values for the posttest were 213% lower than pretest 2 (ES = 0.64). Immediate pain scores were 56% lower after the exercise bout compared with before exercise commenced (p = 0.001; ES = 1.39) (Table 4).

Computerized Dynamic Posturography Assessments

The SOT equilibrium and strategy scores for the posttest were 10 and 2.5% greater, respectively, than pretest 2 scores (p = 0.03–0.008; ES = 0.22–0.64), whereas MCT latency scores decreased by 4% (p = 0.006; ES = 0.75). For the LOS test, all posttest values were greater than pretest 2 values (p = 0.04–0.01; ES = 0.50–0.54) except for the LOS directional score (p = 0.64) (Table 4).

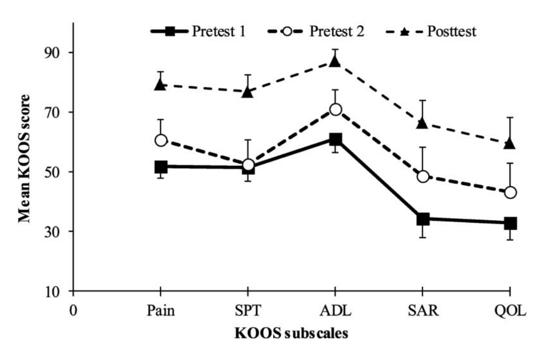

Figure 2. Knee Injury and Osteoarthritis Outcome Score (KOOS) subscale scores for the 2 pretests and posttest. Scores for each subscale range between 0 and 100, where 100 indicates no problems and 0 indicates extreme problems. Subscales include measures of joint pain, other symptoms (SPT), function in daily living (ADL), function in sport and recreation (SAR), and knee-related quality of life (QOL). All subscale scores improved for the posttest versus pretest 2 (p = 0.03–0.005).

TABLE 4. Usual pain, computerized dynamic posturography, functional task, and timed walking values (mean ± *SD*) for pretest 1, pretest 2, and posttest evaluations.*

Measured variable	Pretest 1	Pretest 2	Posttest
Usual pain (mm)	57.1 (26.9)	50.3 (24.8)	15.8 (10.6)†
SOT equilibrium (0–100)	62.6 (13.0)	66.6 (11.0)	73.5 (7.1)†
SOT strategy (0–100)	81.5 (12.1)	79.6 (9.0)	82.5 (6.8)†
MCT symmetry (0–200)	103.5 (8.8)	100.7 (10.9)	100.4 (9.1)
MCT latency (ms)	144.2 (11.1)	145.4 (7.3)	139.1 (8.4)†
LOS velocity (°·s^{-1})	2.5 (1.1)	2.7 (1.0)	3.4 (1.3)†
LOS max excursion (%)	73.6 (11.2)	79.4 (10.6)‡	84.9 (6.2)†
LOS end pt. excursion (%)	56.8 (14.2)	62.8 (14.0)‡	69.9 (11.3)†
LOS direction control (%)	80.2 (6.5)	81.9 (7.1)	81.4 (5.8)
STS transfer time (s)	0.54 (0.60)	0.49 (0.19)	0.33 (0.11)†
STS rising index (%)	13.8 (5.4)	12.5 (5.4)	14.4 (5.0)†
STS sway velocity (°·s^{-1})	4.7 (1.4)	4.4 (1.2)	4.5 (0.9)
FLT distance (%) left leg	31.3 (9.1)	31.3 (9.1)	32.9 (8.1)
FLT distance (%) right leg	34.6 (9.5)	34.5 (9.5)	35.2 (7.2)
FLT impact index (%) left leg	13.9 (6.0)	14.9 (5.2)	15.9 (4.2)
FLT impact index (%) right leg	15.6 (4.6)	14.7 (4.9)	16.6 (4.2)
FLT contact time (s) left leg	2.7 (1.5)	2.9 (1.8)	1.9 (0.7)†
FLT contact time (s) right leg	2.4 (1.7)	2.7 (1.4)	1.7 (0.6)†
Timed 10-m walk test (s)	9.3 (2.1)	8.6 (1.4)	7.8 (1.1)†

*SOT = sensory organization test, MCT = motor control test, LOS = limits of stability test, STS = sit-to-stand test, and FLT = forward lunge test.

†Significantly different from pretest 2 ($p \leq 0.05$).

‡Significantly different from pretest 1 ($p \leq 0.05$).

Function and Mobility

For the STS test, weight transfer and rising index scores improved from pretest 2 ($p = 0.02–0.007$; ES = 0.20–0.89) and FLT contact scores for both legs during posttest were 53–59% less than pretest 2 ($p = 0.05–0.004$; ES = 0.56–0.73). Regarding the 10-m walk test, times were 10% lower for posttest than pretest 2 ($p = 0.008$; ES = 0.58) (Table 4).

DISCUSSION

This study quantified the effectiveness of a 6-week aquatic treadmill exercise program in patients with OA. The majority of all outcome measures improved with medium to large ES after the 6-week exercise period, which supports the research hypothesis. The improvements are likely attributable to the aquatic exercise intervention because the same group displayed no improvements after a control period, with the exception of LOS excursions that may reflect a learning effect for this measure. The present study extends previous work examining acute effects of aquatic treadmill exercise in patients with OA (11,36).

The self-completed KOOS questionnaire revealed pretest pain levels (Figure 2; 52–61) were considerably worse than normative levels (85–88) for healthy age and gender-matched controls (33). In contrast, posttest values improved (≈80) and closely matched normative values for people without OA (33), suggesting that the aquatic treadmill exercise in this study strongly influenced participants' perception of pain and other subscale components, such as function in daily living and function in sport and recreation. To put these values into perspective, a recent review for the management of OA reported that "best evidence" ES for reducing joint pain with exercise was 0.52 (44). The ES for the KOOS pain subscale in the present study was 0.74.

Further evidence that the aquatic treadmill exercise influenced participants' perception of joint pain is revealed in the immediate and usual pain scale results. These scores were substantially lower after each exercise session (ES = 1.39) and after 6 weeks of training (ES = 0.64). This observation is consistent with previous pain scale results for patients with OA who completed aquatic treadmill exercise (11,36) and aquatic calisthenics (42). Moreover, an original finding of the present study was that high-intensity gait intervals in an aquatic environment (RPE ≈ 18, equivalent to 90% $\dot{V}O_2max$) did not exacerbate joint pain, but in fact provided joint pain relief in patients with OA.

One possible benefit of joint pain relief is improved balance (20), although some researchers have suggested otherwise (4). The present study observed that CDP balance measures, such as the SOT composite score, were improved after the 6-week training program (Table 4). Healthy age-matched controls often score 68 on the SOT (30), whereas pretest scores for the patients with OA in the present study were on average 64. This pretest score provides further support to the observation that patients with OA display inferior balance compared with age-matched controls (29). A clinically relevant observation of the present study was that SOT scores after the 6-week aquatic treadmill exercise period improved (74; ES = 0.63) and exceeded normative values (30).

Aside from measures of static balance, motor function scores also improved after the aquatic training. For instance, the MCT latency score decreased after the 6-week exercise period, suggesting improved motor control responses to a sudden unexpected perturbation. A lower latency score may lead to improved recovery from sudden slips to avoid possible falls (24). From a functional and mobility standpoint, the participants with OA displayed an improved ability to stand from a seated position, lunge more quickly on 1 leg, and walk 10 m with greater speed (Table 4; gait times/10 m). For example, before training, the participants with OA displayed considerably lower gait speeds than normative data (1.07–1.16 vs. 1.29 $m \cdot s^{-1}$) (6). After the aquatic treadmill training, participants' gait speed was nearly identical to normative values for people without OA (1.28 $m \cdot s^{-1}$), suggesting that mobility was positively affected in patients with OA.

The mechanisms for decreased pain and improved balance and function in this study are probably multifaceted (3) but most certainly related to muscle strength gains as evidenced in the reduced contact times for the FLT and the rising index in the STS. In support of this contention, Messier et al. (29) observed that greater lower extremity muscle strength of adults with chronic knee pain was associated with improved balance. Fransen et al. (15) observed that greater lower extremity strength was also associated with greater gait speed. Aquatic treadmill exercise may be an effective training mode to improve lower extremity strength in patients with OA, given that joint loads are reduced (1) and exercise intensities can be doubled for a given walking speed using changes in water jet intensities (8).

Ideally, this current study would have included a separate control group that performed a matched dose HIT program on a land treadmill. However, it was evident from pilot testing that participants with OA symptoms, such as those displayed by participants in the current study, would not have been able to reach the high exercise intensities of the training program on a land treadmill because of load-elicited pain. Although not specific to walking or balance training, control participants might have been able to perform stationary cycling at high exercise intensities because it is a partial weight bearing mode of exercise (27).

Another option for a control group would be to have participants complete a traditional aquatic exercise training program that includes shallow water walking, calisthenics, and other resistive exercises. However, as Bartels et al. (2) point out, these modes of aquatic exercise lack control over exercise intensity and prevent valid comparisons between treatment interventions. It should be noted that the magnitude of improvements in pain, balance, function, and mobility observed in the present study were generally greater than what has been observed after traditional land and aquatic exercise interventions (2), suggesting that the results of this research may be considered relevant and worthy of future investigations.

Practical Applications

This study provides the practitioner an evidence-based protocol that seems to be effective at managing symptoms of OA and perhaps the comorbidities. For instance, participants displayed exceptional adherence to the exercise protocol reported in Figure 1 and none reported adverse effects of the exercise progression reported in Table 2, other than mild to moderate muscle fatigue and soreness in the lower extremity. These observations are quite remarkable considering the high exercise intensities used. No other land-based training, that the authors are aware of, has successfully implemented aerobic HIT in patients with OA. It may be that HIT on an aquatic treadmill was possible because the environment allowed for a reduced fear of falling, lower joint loads, and 3-dimensional support from hydrostatic pressure to maintain balance. Many of the participants provided unsolicited comments that supported these contentions. Finally, because HIT requires less exercise time to achieve the same health benefits as traditional training, HIT on an aquatic treadmill may be a time-efficient exercise strategy to manage symptoms of OA during the early phases of exercise therapy. It would be expected that patients would eventually progress to a land-based exercise program; however, the time to transition is not well understood (2) and likely depends on the individual and their tolerance for greater joint loads. Other research using HIT on land treadmills in heart failure patients (40) also reported good exercise adherence and improved cardiovascular health after training interventions lasting 12 weeks. This observation, along with results of the current study, suggests that people with OA may use HIT on an aquatic treadmill for intervention periods lasting longer than the 6 weeks used in the current study with no adverse effects. Indeed, future research will need to test this contention.

In conclusion, this study observed that patients with OA display reduced joint pain and improved balance, function, and mobility after participating in a 6-week aquatic treadmill exercise program that incorporated a balance and HIT training component. The same benefits were not observed after a non-exercise control period. Adherence to the exercise was exceptional and no participants reported adverse effects, suggesting that aquatic treadmill exercise that incorporates high-intensity intervals is well tolerated by patients with OA and seems to be effective at managing symptoms of OA.

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