Impact of Underwater Treadmill Training on Glycemic Control, Blood Lipids, and Health-Related Fitness in Adults With Type 2 Diabetes

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IN BRIEF A large number of adults with type 2 diabetes experience comorbidities that discourage physical activity and hinder regular participation in land-based exercise programs. An aquatic exercise program is an innovative exercise modality that incorporates combined aerobic and resistance exercise. The purpose of this study was to determine if an underwater treadmill walking program featuring gradual and progressive increases in walking speed and duration has a positive effect on glycemic control, metabolic health, cardiovascular function, body composition, and leg strength in middle-aged adults with type 2 diabetes.

The use of exercise as a therapeutic modality for type 2 diabetes has been shown to enhance insulin sensitivity and improve glycemic control (1). Current physical activity recommendations (2) for adults with type 2 diabetes include aerobic and resistance exercise, with the combination of both exercise modalities leading to better glycemic control compared to performing each activity mode separately (3–5). However, many adults with type 2 diabetes are overweight or obese and may experience reduced mobility because of osteoarthritis or other joint problems that limit physical activity and hinder participation in land-based endurance and resistance training (6).

An emerging therapy that may assist individuals with type 2 diabetes in overcoming barriers to active living is underwater treadmill training (UTT). A unique exercise mode that incorporates concurrent aerobic and strength training, walking on a treadmill placed in water improves cardiovascular health and provides resistance to strengthen the legs, while lowering vertical ground reaction forces (7). Compared to walking in a therapy or recreational pool, exercising on a treadmill immersed in a self-contained water tank enables walking speed to be controlled in a gradual and systematic manner, and caloric expenditure is similar to that measured during dry-land walking (8). The use of water as an unloading medium also reduces core weight and the weight of the legs, thus decreasing the strength needed to walk and support the body. From a health standpoint, the ability to increase energy expenditure is an important component in treating type 2 diabetes (9), since increased caloric output can lessen macrovascular and obesity-related complications and is linked to better glycemic control (9).

With an estimated prevalence of nearly 26 million adults with diabetes in the United States (10) and continued escalation of obesity rates and sedentary behavior in adults, it is important to explore the potential of innovative and user-friendly, activity-based interventions to improve the health and mobility of people with metabolic disease. Against this backdrop, the purpose of our study was to document the impact of UTT on

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glycemic control, blood lipids, and health-related fitness in adults with type 2 diabetes. Specifically, when compared to control measures, we hypothesized that, in this clinical population, a 12-week program of underwater treadmill walking would lead to *1*) decreased levels of A1C, LDLs, total cholesterol, and triglycerides (TGs); *2*) an increase in HDL concentration; and *3*) improved cardiovascular function, body composition, and leg strength.

Research Design and Methods

Participants

Twenty-six adults with physician-diagnosed type 2 diabetes volunteered to participate in this study. The sample size for this study was determined based on an a priori sample size assessment with a medium power effect size of 0.70. Inclusion criteria were a diagnosis of type 2 diabetes for a minimum of 2 years, medical clearance to participate in an exercise program, and a sedentary lifestyle, defined as not performing regular aerobic activity (exercising less than two times a week for at least 20 minutes) or any type of resistance exercise in the 6-month period preceding the study (5). Exclusion criteria included having a myocardial infarction within 6 months before the start of the investigation, presence of unstable chronic medical conditions (e.g., respiratory disease, heart failure, renal disease, or hepatic disease), changes in oral hypoglycemic medication use 6 months before the beginning of the study, and diabetic-related myopathies or neuropathies that would prevent full completion of the aquatic walking program (5,11). This study was approved by the university institutional review board, and participants provided written informed consent. During the investigation, participants were asked to maintain their current medication use and refrain from engagement in structured exercise programming.

We used a single-center, 26-week, randomized treatment-control research design. After obtaining baseline measurements, participants were allocated randomly to either the treatment (UTT) group or the control group and stratified by sex. The treatment group performed UTT, during which participants were asked to maintain their current dietary patterns and avoid participation in a formal exercise training program, both of which were verified through email and phone calls. Participants in the control group were also instructed to maintain their current dietary and physical activity habits, and weekly emails and phone calls were made to confirm adherence to these requests.

Primary Health Outcomes

Glycemic Control and Blood Lipid Profile

Glycemic control was evaluated by measuring plasma levels of A1C, which reflect average blood glucose concentration over a 1- to 3-month period (12). Serum cholesterol and TG values were selected as primary blood lipid markers. A 10-mL venous blood sample was drawn from a forearm vein, and A1C was determined using immunoturbidimetry (Roche COBAS Integra 800, Indianapolis, Ind.; 1.5–3.0% coefficient of variation [CV]). HDL (2.8–3.9% CV), LDL (calculated), and TG levels (1.3–2.1% CV) were analyzed using spectrophotometry (Beckman Coulter AU5400, Brea, Calif.).

Cardiovascular Function

Measures of resting heart rate (RHR) and blood pressure were used as indicators of general cardiovascular health (13). After 10 minutes of seated rest in a dark quiet room (14), RHR was obtained by doubling the number of beats recorded from palpation of the radial pulse for 30 seconds and counting the first beat as zero (14). Two measures of RHR obtained over a 5-minute period were averaged to obtain mean RHR. Using the same adult sphygmomanometer and stethoscope, resting systolic blood pressure (RSBP) and resting diastolic blood pressure (RDBP) were recorded by the primary investigator at the brachial artery (13).

The 6-minute walk for distance (6MWFD) test, chosen as a measure of endurance performance, has been shown to reflect the ability of a person to perform a variety of daily life activities (15). This assessment was selected based on its reliability and safety when used by people with disease (15). Participants walked for 6 minutes around an oval course on an indoor collegiate track, were instructed to cover as much distance as possible within the prescribed time limit, and were given standardized encouragement during the test at equally spaced intervals. Total walking distance was recorded to the nearest foot using a calibrated measuring wheel and converted to meters.

Body Composition

Duplicate measures of body mass to the nearest 0.1 kg (without shoes) were obtained using a flat digital scale (SECA 869) and averaged to determine mean body mass. Standard procedures (16) were followed to measure skinfold thicknesses at seven body sites (abdomen, pectoral, suprailiac, mid-axillary, subscapular, quadriceps, and triceps) on the right side of the body. Using population- and sex-specific equations (14), body fat percentage was calculated from measures of average skinfold thickness at each body site. Duplicate measures of waist circumference, taken as the narrowest point between the iliac crest and the xiphoid process (17), were obtained using a Gulick tape measure and averaged to derive mean waist circumference (in centimeters).

Leg Strength

Concentric peak torque of the dominant leg quadriceps and hamstrings at 30° $\cdot$ second^{-1} and 60° $\cdot$ second^{-1} was assessed using a Biodex System III dynamometer. Contraction velocities were chosen to encompass the range of walking speeds used by adults (18). Participants were seated in an upright position and adjustable straps were placed around the upper body and

TABLE 1. Walking Duration and Intensity During the UTT Program

	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12
Intensity (% HRR)	40–50	40–50	40–50	50–60	50–60	50–60	50–60	50–60	50–60	50–70	50–70	50–70
Duration (min)	10	10	12	12	14	14	16	16	18	18	20	20
Total time (min)	30	30	36	36	42	42	48	48	54	54	60	60

Each session included three walking sessions. W, week; % HRR, percentage of heart rate reserve.

dominant thigh to isolate the quadriceps and hamstring muscles and limit the amount of muscle activation in muscle groups that were not evaluated. Following three accommodation trials, three maximum voluntary sessions were completed in a randomized order at both contraction velocities, with a total of 30 seconds of rest interspersed between trials. The highest peak torque measure across testing sessions for each muscle group and individual velocity was recorded. Leg strength values were expressed in peak torque (ft-lbs), which is considered a representative indicator of strength for both knee flexion and knee extension (19).

Treadmill Accommodation and UTT

Before starting UTT, participants performed a walking accommodation session on a treadmill submerged in a water tank (Ferno, Wilmington, OH). In addition to a treadmill, the tank contained a control panel from which the treadmill was operated, a water reservoir with a water filtration system, a variable-speed motor, and two large Plexiglas windows that enabled participants to be monitored visually. The height of the water, which was set at 10 cm below the xiphoid process, was maintained for the duration of the training period (7). The walking accommodation session consisted of 5 minutes of walking at a speed eliciting 20% of heart rate reserve (HRR = [(220 – participant's age – RHR) × % intensity desired] + RHR).

Study participants completed three UTT sessions per week on alternate days for a total of 12 weeks. Each training session consisted of three walking sessions separated by at least 5 minutes of rest on a flotation device. Water temperature was kept in a neutral range (29–31°C) (20). During UTT, a gradual progression of exercise intensity and duration was implemented, based on water-based exercise training programs (6,21) and exercise guidelines published by the American College of Sports Medicine (17). Table 1 depicts the progression of walking intensity and duration used during UTT. Exercise heart rate was monitored continuously in each exercise session with a Polar heart rate monitor (Polar, Finland). Once a week, participants were verbally asked about physician visits, acute illnesses, and hypoglycemic events that occurred while engaged in UTT so that they could be documented (11).

Statistical Analyses

Descriptive statistics are presented as means ± SDs (Table 2). For each primary health outcome, the effectiveness of the UTT intervention was measured by quantifying the amount of change from baseline to post-training in the treatment group compared to change over the same time period in the control group. The 95% CIs for the amount of change were constructed to determine if a significant change occurred in each participant group, and one-way ANOVA was used to evaluate whether the amount of change for each primary health outcome differed between treatment and control groups. Partial eta squared values (η_p^2) were calculated as shown in Eq. 1 and used to quantify effect size. Significance level was set at an α level of 0.05 for all statistical analyses.

$$\frac{{}^{SS}Effect}{{}^{SS}Effect + {}^{SS}Error}$$

EQ. 1

Results

Adherence to the UTT program was 100%, with the participants completing all 36 UTT sessions (12 weeks × 3 sessions per week). No UTT-related injuries were reported during the study, and no symptoms of hypoglycemia were reported during the walking sessions. Descriptive statistics and 95% CIs for change scores are reported in Table 3.

Glycemic Control and Blood Lipid Profile

ΔA1C was different for UTT and control groups [F (1, 24) = 37.18, P <0.001, η_p^2 = 0.61], such that A1C

TABLE 2. Participant Baseline Characteristics

	n	Mean ± SD
Age (years)		58.0 ± 5.0
Sex (F/M)	16/10	
Height (m)		1.8 ± 0.2
Body mass (kg)		91.2 ± 9.6
Time since diabetes diagnosis (years)		7.1 ± 4.6
Number of current smokers	3	
Percent taking diabetes medication		70.4 ± 4.0
Metformin users	15	
Metformin dosage (mg/day)		1127 ± 280
Sitagliptin users	3	
Sitagliptin dosage (mg/day)		92 ± 14
Participants who reduced medication use during the study	2	

values decreased for the UTT group (M = –0.67) but not for the control group (M = 0.02). Likewise, ΔHDL varied for UTT and control groups [F (1, 24) = 10.13, P = 0.004, η_p^2 = 0.30], with an improvement in HDL detected for the UTT group (M = 6.15) but not the control group (M = –1.46). While no group difference was observed in ΔLDL and ΔTG [F (1, 24) = 0.68, P = 0.419, η_p^2 = 0.03, and F (1, 24) = 2.25, P = 0.147, η_p^2 = 0.09, respectively], the TG/HDL ratio was lower for the UTT group (M = –1.06) compared to the control group (M = 0.06) [F (1, 24) = 4.37, P = 0.047, η_p^2 =0.15].

Cardiovascular Function

Differences in ΔRHR, ΔRSBP, and ΔRDBP varied between UTT and control groups [F (1, 24) = 9.00, P = 0.005, η_p^2 = 0.28; F (1, 24) = 9.58, P = 0.005, η_p^2 = 0.29; and F (1, 24) = 9.32, P = 0.005, η_p^2 = 0.28, respectively]. Follow-up analyses revealed decreases in RHR (M = –8.00), RSDP (M = –7.69), and RDBP (M = –6.00) for the UTT group, whereas no reductions were noted for the control group (RHR M = 3.31, RSBP M = 0.15, RDBP M = –0.46). Δ6MWFD also differed

TABLE 3. Descriptive Statistics for Primary Health Outcomes

	UTT Group (*n* = 13)				Control Group (*n* = 13)			
	Baseline Mean	Change Mean	95% CI for Change Mean		Baseline Mean	Change Mean	95% CI for Change Mean	
Glycemic control (A1C, %)	7.25	**–0.67**	–0.91	–0.43	7.90	0.02	–0.03	0.07
Blood lipid profile								
HDL (mg/dL)	57.23	**6.15**	1.20	11.11	43.38	–1.46	–3.07	0.15
LDL (mg/dL)	101.77	–1.15	–10.21	7.90	133.15	2.77	–2.32	7.86
TG (mg/dL)	163.69	–11.62	–28.67	5.44	215.15	0.69	–4.69	6.08
TG/HDL	4.02	–1.06	–2.18	0.05	5.69	0.06	–0.31	0.43
Cardiovascular function								
RHR (bpm)	74.00	**–8.00**	–13.00	–3.00	82.00	3.00	–3.00	9.00
RDBP (mmHg)	82.00	**–6.00**	–8.70	–3.30	81.08	–0.46	–3.35	2.42
RSBP (mmHg)	128.62	**–7.69**	–12.29	–3.09	129.08	0.15	–2.91	3.21
6MWFD (m)	476.46	**95.08**	64.18	125.98	508.92	0.77	–6.60	8.14
Body composition								
Body mass (kg)	94.96	**–2.99**	–3.50	–2.48	102.70	**0.73**	0.01	1.44
Body fat (%)	31.24	**–2.48**	–2.94	–2.02	29.64	0.38	–0.14	0.90
Waist circumference (cm)	104.89	**–4.15**	–5.10	–3.21	115.54	0.80	–0.04	1.64
Leg strength (ft-lbs)								
Hamstring peak torque @ 30° · second^{-1}	73.80	**6.62**	2.46	10.77	87.37	–0.51	–2.91	1.89
Hamstring peak torque @ 60° · second^{-1}	52.87	**7.99**	1.75	14.22	64.38	0.50	–0.69	1.68
Quadriceps peak torque @ 30° · second^{-1}	70.00	3.51	–0.06	7.08	85.40	0.07	–1.41	1.55
Quadriceps peak torque @ 60° · second^{-1}	50.70	**7.83**	3.07	12.59	60.51	**1.00**	0.03	1.97

Boldface indicates changes having a 95% CI that excludes 0.

between UTT and control groups [F (1, 24) = 41.84, P <0.001, η_p^2 = 0.64], such that the UTT group displayed an improvement in 6MWFD (M = 95.08), but no change was observed in the control group (M = 0.77).

Body Composition

Measures of Δbody mass, Δbody fat percentage, and Δwaist circumference differed between UTT and control groups [F (1, 24) = 85.59, P <0.001, η_p^2 = 0.78; F (1, 23) = 80.31, P <0.001, η_p^2 = 0.78; and F (1, 24) = 72.74, P <0.001, η_p^2 = 0.75, respectively]. Examination of body composition data indicated that body mass (M = –2.99), body fat percentage (M = –2.48), and waist circumference (M = –4.15) values were lower after UTT, while no change in body fat percentage (M = 0.38) or waist circumference (M = 0.80) was detected for participants in the control group. Additionally, body mass increased in the control group (M = 0.73).

Leg Strength

Differences in Δhamstring peak torque at 30° · second^{-1} and 60° · second^{-1} were noted for participants in the UTT and control groups [F (1, 24) = 10.45, P = 0.004, η_p^2 = 0.30, and F (1, 24) = 6.61, P = 0.017, η_p^2 =0.22, respectively]. Strength values for the hamstring muscles at 30° · second^{-1} (M = 6.62) and at 60° · second^{-1} (M = 7.99) were higher for the UTT group, but no changes occurred in the control group (30° · second^{-1}, M = –0.51; 60° · second^{-1} M = 0.50). ΔQuadriceps peak torque at 60° · second^{-1} was higher for the UTT group (M = 7.83) than the control group (M = 1.00) [F (1, 24) = 9.37, P = 0.005, η_p^2 = 0.28]; however, both groups displayed a significant change in this variable. The Δquadriceps peak torque at 30° · second^{-1} was similar for UTT (M = 3.51) and control (M = 0.07) groups [F (1, 24) = 3.77, P = 0.064, η_p^2 = 0.14].

Discussion

In support of our study hypotheses, UTT resulted in better glycemic control, a healthier blood lipid profile, and improved cardiovascular function, body composition, and leg strength in a group of obese, middle-aged adults with type 2 diabetes. Secondary analyses also revealed that total caloric intake and relative macronutrient intake remained stable between control and treatment conditions (P <0.05), thus emphasizing the singular impact of UTT on key health variables in men and women with type 2 diabetes.

Similar to results from an earlier investigation (22) documenting the safety and efficacy of UTT in this clinical population, no exercise-related injuries of adverse clinical events were recorded during the course of our study, and the adherence rate to the training protocol was 100%. The absence of injury and diabetes complications in the current study differs markedly from published findings indicating the presence of 5–10 hypoglycemic events and adverse rate events varying from 2% to 38% in studies of adults with type 2 diabetes who participated in traditional treadmill- and resistance-based exercise programs (5,11,23). Although speculative, the absence of hypoglycemic symptoms with UTT may be related to a shorter overall exercise duration while performing concurrent aerobic and resistance training in the water compared to the time spent participating in separate land-based endurance and strength exercise programs (4,5,24). A high rate of adherence to UTT in adults with type 2 diabetes may also be linked to fewer diabetes complications and a decrease in ground reaction forces acting on the lower extremities (25,26).

Glycemic Control

A1C level was reduced by 0.67% to a mean sample value below 7.0% after 12 weeks of UTT. Compared to land-based investigations, the degree to which glycemic control was improved after UTT is superior to the 0.57% reduction in A1C observed after 16 weeks of combined aerobic and resistance training performed on land (4,27) and within the range of values reported in meta-analyses showing an average decrease in A1C of 0.50–0.80% among individuals with type 2 diabetes who completed a minimum of 12 weeks of land-based aerobic training or combined resistance and aerobic exercise (1,22,28). In view of evidence showing that a decrease in A1C of 0.70% represents a potential reduction of up to 76% in long-term complications from diabetes (29), the degree to which glycemic control was improved in our study is clinically significant. Moreover, the 0.67% reduction in A1C noted in the present study is similar to the improvement in glycemic control (0.60–0.80%) typically observed after dietary intervention and long-term drug or insulin therapy (4). Potential mechanisms associated with reductions in A1C after UTT include upregulation of mitochondrial proteins (30), heightened glycogen synthase activity (31), increased glucose-4 transporter protein content and contractile protein content (31), a higher basal metabolic rate and elevation in absolute glucose uptake (32), and diminished regional visceral and intermuscular fat stores, which can directly influence insulin sensitivity (33).

Blood Lipid Profile

In our study, a 3-month period of UTT was linked to an increase in HDL (+6.15 mg/dL) and a reduction in the TG/HDL ratio (–1.12). The increase in HDL level contrasts with data revealing no change in HDL cholesterol in middle-aged and older adults with type 2 diabetes who participated in an aquatic-based exercise programs (30,34). This discrepancy may be related to the longer training period and larger decrease in body mass (4.11 kg) reported in our investigation compared to other water-based studies (26,35). Increases in HDL concentration after endurance training have been attributed to an increase in the production and action of several enzymes that stimulate the reverse cholesterol transport system (36,37).

While mean reductions in LDL and TG levels were observed, there was no significant change in either variable. These findings are comparable to those of Cuff et al. (3), who reported nonsignificant changes in LDL and TG levels after combined aerobic and resistance training in middle-aged postmenopausal women. The lack of significant reductions in LDL and TG in our study may have been due to the absence of a dietary intervention to supplement UTT. Despite the lack of change in TG and HDL concentrations, the TG/HDL ratio was lower after UTT. Reductions in the TG/HDL ratio have also been documented in other aquatic-based intervention studies featuring 8 weeks (26) or 12 weeks of supervised moderate-intensity exercise and are comparable to changes detected after extended periods of land-based aerobic or resistance training programs or combined aerobic and resistance training in adults with type 2 diabetes (28,34,35,38–41). From a clinical perspective, a decrease in the TG/HDL ratio is consistent with a lower risk of cardiovascular disease and metabolic abnormalities (30), as well as improved insulin action and sensitivity (42).

Cardiovascular Function

In the present investigation, measures of RHR, RSBP, RDBP, and 6MWFD were used as descriptors of cardiovascular fitness and performance (6,43). RHR fell by 10% after UTT, which is in agreement with the findings of Bocalini et al. (20), who recorded a 10% decrease in resting measures of heart rate in healthy, sedentary older women after 12 weeks of water-based exercise. In our study, RSBP and RDBP also decreased by an average of 8 and 6 mmHg, respectively, which is nearly identical to the 5- to 7-mmHg reduction in resting blood pressure seen in hypertensive adults after endurance training (44). Because hypertension is present in >60% of people with type 2 diabetes (45), and the risk of vascular complications is 66–100% higher in people with hypertension and type 2 diabetes compared to people with only one of these health conditions (37), the decrease in RSBP and RDBP that occurred after participation in UTT may be of clinical benefit to this population.

The improvement in 6MWFD after UTT was more than double the average gain in walking distance (46 m) achieved after combined aerobic and eccentric resistance training in middle-aged adults with type 2 diabetes (4). The lower baseline walking performance (*M* = 476.5 m) of our participants, compared to that reported in the investigation by Marcus et al. (4) (*M* = 554.5 m), may have been partially responsible for the larger magnitude of improvement seen after UTT. From a practical standpoint, the gain in walking distance after participating in water-based treadmill training would enable adults with type 2 diabetes to walk for longer periods of time without undue fatigue (38,46).

Body Composition

After engaging in UTT, body mass was reduced by an average of 2.99 kg, which is consistent with the recommended weekly weight loss standard for adults endorsed by the American College of Sports Medicine (17). This decrease in body mass is essentially identical to the average reduction of 3.00 kg measured by Cugusi et al. (35) in middle-aged men with type 2 diabetes who completed a 12-week supervised aerobic- and resistance-based aquatic exercise program and slightly lower than the 3.31-kg decrease in body mass recorded by Ho et al. (47) after 12 weeks of combined land-based aerobic and resistance exercise. One potential explanation for a lower body mass after UTT is the use of a lower water height compared to other studies, which would result in a higher exercise intensity because of reduced water buoyancy.

The magnitude of reduction in body fat percentage after UTT (2.5%) falls within the range of the 1.0–3.0% loss in body fat reported in studies incorporating land-based aerobic or resistance exercise in adults with type 2 diabetes (3–5,11,24) and is similar to reductions in relative fat after 16 weeks of shallow-water circuit training in overweight, postmenopausal women (48) and 8 months of shallow-water aquatic aerobic exercise performed by middle-aged, obese women (49). Likewise, the decrease in waist circumference after UTT is consistent with data obtained after 12 weeks of deep-water circuit training in older, overweight women (5 cm) (6) and 12 weeks of aquatic-based exercise in middle-aged men (6 cm) (35). From a health perspective, an improved body fat profile and a smaller waist circumference are correlated with reduced all-cause and cardiovascular mortality (50), less central adiposity, and greater insulin sensitivity (4).

Leg Strength

Significant gains in peak torque of 16% in the quadriceps at 60° · second^{-1}, 9% in the hamstrings at 30° · second^{-1}, and 15% in the hamstrings at 60° · second^{-1} occurred after UTT. These findings align with recent data showing improved leg strength in middle-aged adults who performed 8 weeks of UTT (22) and are comparable to increases of 8% and 13% in knee extension flexion, respectively, observed in older and overweight women who participated in aquatic exercise interventions (6,38). During UTT, the constant movement of the lower limbs against water resistance provides a unique stimulus to improve muscle strength, a variable shown to be related to an enhanced glucose metabolic rate (51).

In conclusion, results from our study have demonstrated that UTT is a safe and effective multimodal training approach that can improve glycemic control, blood lipid profile, cardiovascular function, body composition, and leg strength in middle-aged adults with type 2 diabetes. The use of UTT may be a particularly appropriate treatment modality for adults with type 2 diabetes who have comorbidities or other medical issues that limit their ability to perform traditional land-based exercise protocols. In considering future research directions, additional work is needed to compare the efficacy of UTT to traditional land- and water-based exercise programs in older and younger adults with type 2 diabetes and prediabetes and document the potential association between improved glycemic control and reduction in inflammatory responses after UTT. From a practical standpoint, the use of smaller, commercially available treadmills that can be placed into existing pools located in clinical facilities and community fitness centers should also be explored as a cost-effective method of using UTT to treat larger groups of adults and children with type 2 diabetes, as well as individuals with arthritis, joint pain, and obesity who have difficulty performing land-based exercise programs.

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Duality of Interest

No potential conflicts of interest relevant to this article were reported.

Author Contributions

R.T.C. designed the study; acquired, analyzed, and interpreted the data; and wrote the manuscript. J.L.C. designed the study, interpreted the data, wrote the manuscript, and reviewed the study. J.M.C. designed and reviewed the study. D.K.F. designed the study, analyzed the data, interpreted the data, and reviewed the manuscript. D.W.M. designed the study, interpreted the data, wrote the manuscript, and reviewed the manuscript. R.T.C. is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Previous Publication

A portion of this study was presented as an abstract at the Southeast American College of Sports Medicine regional conference in Greenville, S.C., 16–18 February 2017, and at the American College of Sports Medicine national conference in Denver, Colo., 30 May to 3 June 2017. The remaining portion of this study was published an as abstract at the 77th ADA Scientific Sessions in San Diego, Calif., 9–13 June 2017.

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