Effects of Aquatic Physical Exercise on Motor Risk Factors for Falls in Older People During the COVID-19 Pandemic: A Randomized Controlled Trial

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Abstract

Objective: The aim of this study was to assess the effects of aquatic training on motor risk factors for falls in older people during the COVID-19 pandemic.

Methods: A randomized controlled trial was carried out with older people, divided into an aquatic training group (ATG) (n = 24) and a control group (CG) (n = 25). Muscle strength was assessed by the 5-Times Sit-to-Stand Test, mobility by the simple and dual-task Timed Up and Go Test, and postural stability through stabilometric data (force platform). The CG received monthly calls to monitor general health. The ATG carried out training lasting 16 weeks, with two 1-hour sessions per week.

Results: Both groups improved muscular strength and cognitive-motor tasks, and they performed a dual task with fewer errors in the secondary task after 16 weeks regardless of the pandemic and COVID-19 diagnosis. There was a significant decrease in the area of center of pressure displacement in the tandem posture with eyes closed in the CG. When analyzing participants who adhered at least 50% to the intervention, the ATG significantly reduced the number of steps on the Timed Up and Go Test performance. Both groups improved muscular strength and cognitive-motor tasks and increased the cognitive task cost. In the CG, there was a significant decrease in the mean amplitude of the anteroposterior center of pressure displacement in the feet together with eyes open.

Conclusion: We found that aquatic physical exercise presented positive effects on some potentially modifiable motor risk factors for falls (mobility and muscle strength) regardless of the COVID-19 pandemic and COVID-19 diagnosis, especially among people who adhered to the intervention. (J Manipulative Physiol Ther 2022;45;378-388)

Key Indexing Terms: *Aged; Exercise; Accidental Falls; Hydrotherapy*

Introduction

Falls are a public health problem with a high social impact, and their prevention is crucial for older adults' health.[1] According to a systematic review, muscle weakness, postural stability deficit, and gait deficit were the most important individual risk factors for falls.[2] In addition, reductions of muscle strength, flexibility, postural stability, and reaction time are potentially modifiable risk factors for falls, providing logic to create interventions that improve these risk factors aiming to reduce falls in older people.[3]

The American College of Sports Medicine[4] recommends that practicing physical exercise should be regular and include multicomponent training associated with cognitive tasks (dual tasks) among community-dwelling older people. Aquatic intervention is an option for preventing falls in older people based on the positive effects on risk factors for falls, the safe and low-impact environment, and the interest and adherence of this population.[3,5]

There are many components of physical fitness that can be trained in an aquatic environment and reduce fall risk, such as agility, postural stability, coordination, strength, flexibility, and speed. The aquatic environment is beneficial to promoting muscle hypertrophy and functional capacity, especially protocols that emphasize lower limbs, respecting the principle of training specificity.[3]

Although there is evidence on the benefits of physical exercise to prevent and reduce fall risk in community-

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dwelling older people, there is limited literature regarding randomized clinical trials involving aquatic physical exercise and motor risk factors of falls in older people. There is a lack of information about training in a clear and replicable way.[3,5] It is still unknown how the COVID-19 pandemic[6] influences the findings of clinical trials considering social distancing and physical and social restrictions of older people, as they are considered a risk group for COVID-19 complications. Also, it is important to understand how COVID-19 can influence the benefits of an aquatic exercise protocol.

The purpose of this study was to assess the effects of an aquatic physical exercise protocol on potentially modifiable motor risk factors for falls (muscle strength, postural stability, and mobility) in community-dwelling older people, taking into account the influence of being or not in the study during the COVID-19 pandemic and restriction in Brazil, and COVID-19 diagnosis or not as confounding variables.

Methods

Study Design

A single-center, randomized, single-blind, parallel-group controlled trial was conducted. The CONSORT (Consolidated Standards of Reporting Trials) statement was used as a guideline to report the present study.[7]

Ethics

The study was approved by the Federal University of Mato Grosso do Sul Ethics Committee (3.177.309/2019) and registered in the Brazilian Registry of Clinical Trials (RBR-48z4vp). The study was conducted at Federal University of Mato Grosso do Sul and at volunteers' houses from September 2019 to February 2021. All participants signed the informed consent form.

All participants performed the initial assessment before the COVID-19 pandemic in Brazil. In March 2020, assessments and interventions were suspended due to the pandemic, and, in October 2020, they were returned according to biosecurity measures. However, due to the increased cases in November 2020, interventions were suspended again, and assessments were performed at the volunteers' homes until February 2021. To schedule the second assessment, the 16 weeks were counted from baseline until March 2020 and from October 2020 to February 2021.

Participants

The eligibility criteria were people aged above or equal to 65 years old, residents in Campo Grande (Mato Grosso Do Sul, Brazil), noninstitutionalized, and having the possibility of contact by telephone. Inclusion criteria were the ability to walk alone with or without a walking device, availability to attend the training site twice a week, availability to participate in a randomized survey, and not having performed supervised and regular physical exercise for 150 minutes or more per week.[4]

The exclusion criteria were any cardiovascular or infectious disease present in the list of absolute contraindications described in the Physical Activity Readiness Medical Examination[8]; a Mini-Mental State Examination score below the cut-off point according to years of education minus 1 standard deviation[9]; having motor sequelae of cerebral vascular accident and other neurological diseases that interfere with cognition or mobility; severe and uncorrected audiovisual disorder that hinders communication during assessment; urinary incontinence; open wounds; and sensitivity to chemical products used in pools. In addition, participants presented a medical certificate for practicing aquatic physical exercise.

The sample size was calculated using the G*Power 3.1 software (Kiel University). Assuming the type of study design considering the primary outcomes (2-way analysis of covariance [ANCOVA] test), error type I at 5%, statistical power of 80%, an effect size from moderate to large magnitude (0.2),[10] and a possible sample loss of 15% according to previous studies of the research group, a minimum of 48 people should constitute the total sample. The volunteers were divided into 2 groups (aquatic training group [ATG] and control group [CG]). A randomization sequence was created with Random Allocation software (M. Saghaei), with a 1:1 allocation ratio using random block sizes by an independent researcher. Each volunteer corresponded to an opaque and sealed envelope, numbered in order, containing a card indicating in which group the individual would be inserted. The envelopes were opened after the first assessment by another independent researcher who was responsible for advising participants of their allocation by telephone.

Assessment

After pilot tests, assessments were performed at baseline and after 16 weeks in a closed environment with minimal visual and auditory stimuli, preferably at the same time of day. The assessor (trained physical therapist) was blinded to group allocation. Because of the type of intervention, participants and therapists were not blinded. Clinical and sociodemographic data were collected at baseline.[11]

Regarding motor measures, muscle strength was assessed by the 5-Times Sit-to-Stand Test. The time taken to perform the test was recorded.[12] Mobility was assessed by the Timed Up and Go (TUG) Test, and TUG was associated with a cognitive-motor task (TUG-DT). Initially, the isolated cognitive-motor task was performed. In a seated position in front of the table, the participant was instructed to pick up the telephone, dial the numbers, and place the phone on the table. After the isolated cognitive-motor task, the TUG Test was performed.[13] After TUG, the TUG-DT

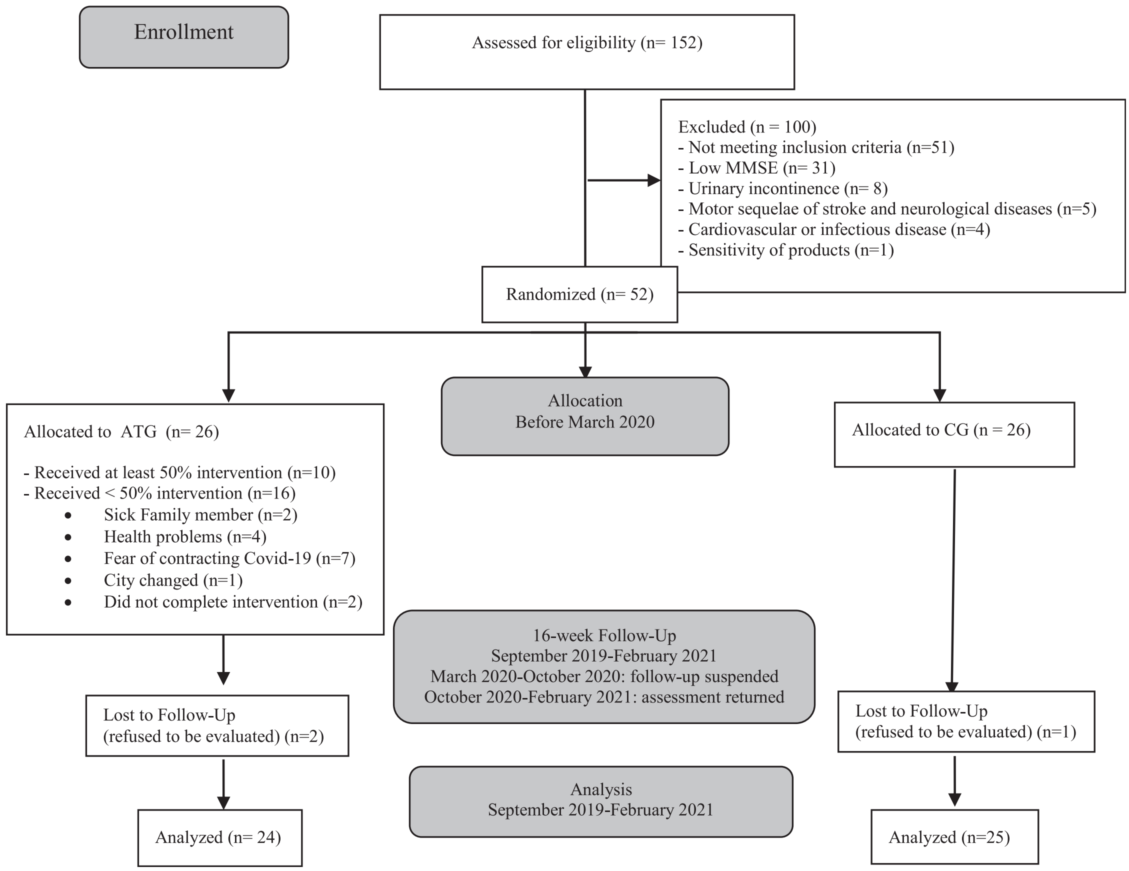

Fig 1. *Flowchart of participant recruitment. ATG, aquatic training group; CG, control group; MMSE, Mini-Mental State Examination.*

was performed. With a newly drawn card containing 8 numbers and fixed on the phone, the participant was instructed to get up, walk to the table placed 50 cm away from the chair, pick up the phone, walk while dialing the numbers, return the phone to the table, and sit down.[13,14]

Postural stability was assessed by stabilometry method using a Force Platform (EMG System of Brazil, SP, Ltda) composed of a 500-mm^2 board, 4 load cells, and a 100-Hz calibration system.[15] The following 4 conditions were studied: (1) standing posture looking at a target 51 cm away,[16] arms along the body, feet together, open eyes; (2) same posture, feet together, closed eyes (FT-CE); (3) same posture, tandem position, open eyes (TANDEM-OE); and (4) same posture, tandem position, closed eyes (TANDEM-CE). There was one 60-second trial in each condition, with a 1-minute interval between them.[15,16] After confirming the data processing, data were processed in the MATLAB program (The MathWorks, Inc, Natick, Massachusetts), using a sampling of 100 Hz and a second order Butterworth low-pass filter at 35 Hz. Negative values in the anteroposterior and mediolateral planes represent displacement of the body backward and to the left, respectively.[16]

Intervention

The CG received monthly calls to monitor general health (including falls, change of medication, diagnosis of new disease, diagnosis of COVID-19, hospitalization, and other social or health change) to check any change of routine and to provide general guidance on health, pandemic, and related care following World Health Organization recommendations, which advocates health promotion actions to maintain quality of life in older people.[1,6] Besides monthly calls, the ATG performed a multicomponent aquatic training lasting 16 weeks, with 2 1-hour sessions per week on nonconsecutive days. All interventions were performed by a physical therapist researcher who was independent of assessment and randomization.

A week of familiarization was performed for better adaptation to training and aquatic environment (pool with a depth of 1.40 m and temperature around 80.6°F-89.6°F). The training involved 5 minutes of warm-up, 20 minutes of resistance and muscle activation exercises focusing on the main muscle groups of trunk and lower limbs interspersed with cognitive tasks, 15 minutes of balance exercises with motor and cognitive tasks, 10 minutes of aerobic exercises, and 5 minutes of cool-down.[3,4,17] The intensity was

Table 1. *Clinical and Sociodemographic Characteristics of the Total Sample (N = 49)*

Characteristic	Aquatic Training Group (n = 24)	Control Group (n = 25)	*P* Value
Age (y)	70.15 ± 4.24	71.40 ± 4.57	.318
Female, n (%)	22 (91.7)	18 (72.0)	.076
Marital status (married), n (%)	12 (50.0)	15 (60.0)	.765
Comorbidities (total number), mean ± SD	2.21 ± 1.35	1.76 ± 1.23	.231
Diabetes, n (%)	8 (33.3)	6 (24.0)	.470
SAH, n (%)	18 (75.0)	13 (52.0)	.095
Bifocal or multifocal glasses, n (%)	20 (83.3)	22 (88.0)	.641
Walking device, n (%)	1 (4.2)	0 (0)	.302
BMI (kg/m^2), mean ± SD	30.54 ± 5.80	28.05 ± 3.91	.084
Years of education, mean ± SD	7.17 ± 5.19	5.80 ± 4.42	.326
Medications (total number), mean ± SD	4.67 ± 2.46	4.04 ± 2.79	.409
MBQE, mean ± SD	5.80 ± 3.38	4.93 ± 4.63	.456
Fallers, n (%)	2 (8.3)	4 (16.0)	.413

BMI, body mass index; *MBQE*, Modified Baecke Questionnaire for the Elderly; *SAH*, systemic arterial hypertension; *SD*, standard deviation.

checked every week and progressed according to the Modified Borg Effort Perception Scale (BORG-CR10), with a desirable score between 5 and 7 points.[18] Ferreira et al detailed the protocol used.[19]

Data Analysis

A significance level of 5% was adopted, and the SPSS software (version 20.0; IBM Corp, Armonk, NY) was used for statistical analysis by intention to treat. The Shapiro-Wilk normality test and visual method (histogram) were applied to all continuous variables to verify the distribution of data from the total sample (N = 49). The descriptive statistics used were mean ± standard deviation for continuous numeric variables and ratios (%) for categorical variables. The χ^2 test and the independent *t* test were used to compare groups regarding clinical and sociodemographic characteristics.

The 2-way ANCOVA test was used to verify the interaction between groups and assessments (independent factor: group [treatment vs CG]; repeated factor: time [pre- vs posttreatment]), having as confounding variables whether or not they were in the study during the COVID-19 pandemic and the restriction in Brazil and diagnosis of COVID-19 or not. Effect size analysis was performed by partial squared eta (ηp^2) ([ηp^2 = .0099, small effect size), (ηp^2 = .0588, medium effect size), (ηp^2 = .1379, large effect size)]. The Bonferroni post hoc test was used to identify significant differences between times and groups if the group*time interaction was significant. As adherence to training was low due to the pandemic, an additional analysis was carried out to verify interaction between groups (CG and participants who adhered at least 50% to ATG) and assessments by the 2-way ANCOVA test, with the same confounding variables.

Results

After 16 weeks, 11 participants were reassessed before suspension due to the pandemic in March 2020. In October 2020, 2 women were reassessed at the institution. After a new interruption, 36 people were reassessed at home from December 2020 to February 2021. Only 3 volunteers were not reassessed due to moving to another city and refused to participate. Thus, the final sample consisted of 24 participants of the ATG and 25 participants of the CG (Fig 1). No significant differences were found between groups regarding clinical and sociodemographic characteristics (Table 1).

Adherence to Training and Adverse Effects

In the ATG, 41.6% adhered to at least 50% of the intervention. Regarding adverse effects, the main complaint was cramping, especially in lower limbs, which occurred in

Table 2. *Muscle Strength and Mobility Outcomes in the Final Sample*

Motor Measures, Mean ± SD	Aquatic Training Group (n = 24)		Control Group (n = 25)		Time* Group Partial η^2; *P* Value	Group Partial η^2; *P* Value	Time Partial η^2; *P* Value
	Baseline	16 wk	Baseline	16 wk			
5-Times Sit-to-Stand Test (s)	16.33 ± 3.42	14.76 ± 3.24	16.37 ± 4.23	15.12 ± 5.33	0.000; .966	0.001; .856	0.166; .004
TUG							
Time (s)	12.51 ± 2.72	11.51 ± 3.21	12.04 ± 2.35	11.51 ± 2.42	0.017; .380	0.004; .614	0.003; .738
Number of steps	16.04 ± 2.21	14.46 ± 3.10	15.16 ± 2.65	14.40 ± 2.50	0.057; .107	0.013; .447	0.057; .106
Cognitive-motor task							
Time (s)	16.99 ± 4.50	14.78 ± 4.80	16.86 ± 4.05	14.06 ± 3.58	0.020; .344	0.001; .853	0.407; .000
Errors	0.37 ± 1.24	0.29 ± 0.69	0.20 ± 0.50	0.16 ± 0.47	0.000; .961	0.018; .372	0.013; .439
TUG-DT							
Time (s)	23.23 ± 4.84	22.25 ± 6.18	23.13 ± 3.71	22.51 ± 4.56	0.003; .715	0.000; .929	0.010; .501
Number of steps	21.63 ± 3.53	19.75 ± 3.37	21.16 ± 2.73	20.80 ± 3.59	0.073; .066	0.004; .686	0.032; .231
Stops	2.13 ± 0.68	2.25 ± 0.94	2.20 ± 0.57	2.24 ± 0.77	0.005; .624	0.002; .769	0.059; .101
Errors	0.08 ± 0.28	0.08 ± 0.28	0.20 ± 0.70	0.04 ± 0.20	0.027; .269	0.011; .484	0.097; .033
Cognitive task cost	14.82 ± 57.77	29.85 ± 19.67	25.70 ± 18.33	34.26 ± 14.26	0.003; .697	0.024; .296	0.042; .169
Motor task cost	0.89 ± 0.39	0.99 ± 0.61	0.95 ± 0.43	0.96 ± 0.50	0.021; .325	0.002; .773	0.018; .365

Confounding variables were COVID-19 diagnosis and participating in the research during the COVID-19 pandemic.
SD, standard deviation; *TUG*, Timed Up and Go Test; *TUG-DT*, TUG associated with cognitive-motor task.

Table 3. *Postural Stability Outcomes in the Final Sample*

Motor Measures, Mean ± SD	Aquatic Training Group (n = 6)		Control Group (n = 5)		Time*Group Partial η^2; *P* Value	Group Partial η^2; *P* Value	Time Partial η^2; *P* Value
	Baseline	16 wk	Baseline	16 wk			
FT-OE							
Area-COP (cm^2)	4.67 ± 1.50	3.49 ± 1.44	6.68 ± 2.52	6.09 ± 3.33	0.131; .275	0.283; .092	0.326; .067
Amplitude-AP (cm)	−3.21 ± 3.47	−3.71 ± 1.56	−2.66 ± 1.79	−3.22 ± 1.90	0.000; .969	0.021; .672	0.047; .523
Amplitude-ML (cm)	−0.14 ± 0.69	0.18 ± 1.07	−0.51 ± 0.89	−0.29 ± 0.64	0.004; .859	0.097; .350	0.094; .359
Velocity-AP (cm/s)	1.15 ± 0.23	1.17 ± 0.26	1.44 ± 0.28	1.34 ± 0.24	0.103; .337	0.224; .142	0.057; .479
Velocity-ML (cm/s)	1.30 ± 0.25	1.28 ± 0.32	0.95 ± 1.47	1.49 ± 0.24	0.069; .434	0.006; .817	0.058; .474
FT-CE							
Area-COP (cm^2)	10.23 ± 6.53	10.30 ± 6.33	10.68 ± 2.35	13.77 ± 5.21	0.127; .282	0.044; .538	0.138; .261
Amplitude-AP (cm)	−2.56 ± 2.84	−2.63 ± 1.64	−3.98 ± 1.80	−2.41 ± 1.28	0.295; .084	0.029; .615	0.260; .109
Amplitude-ML (cm)	−0.52 ± 1.24	−0.06 ± 1.34	−0.41 ± 0.69	−0.97 ± 1.31	0.276; .097	0.053; .496	0.000; .966
Velocity-AP (cm/s)	1.67 ± 0.58	1.60 ± 0.50	2.04 ± 0.28	2.03 ± 0.29	0.018; .695	0.206; .161	0.027; .626
Velocity-ML (cm/s)	1.93 ± 0.50	1.86 ± 0.75	2.50 ± 0.44	2.27 ± 0.55	0.058; .475	0.192; .177	0.172; .204
TANDEM-OE							
Area-COP (cm^2)	7.76 ± 3.27	6.74 ± 2.24	19.74 ± 17.90	11.93 ± 7.50	0.176; .200	0.237; .128	0.265; .105
Amplitude-AP (cm)	−5.55 ± 2.85	−4.89 ± 1.45	−4.90 ± 3.45	−2.09 ± 4.43	0.148; .243	0.094; .359	0.350; .055
Amplitude-ML (cm)	−0.80 ± 0.80	−0.30 ± 1.55	−0.95 ± 0.51	−1.05 ± 1.65	0.029; .619	0.089; .372	0.013; .735
Velocity-AP (cm/s)	1.82 ± 0.62	1.72 ± 0.51	3.27 ± 1.83	2.47 ± 0.73	0.192; .178	0.289; .088	0.277; .096
Velocity-ML (cm/s)	2.58 ± 0.76	2.36 ± 0.55	3.61 ± 0.81	3.15 ± 0.24	0.039; .558	0.448; .024	0.259; .110
TANDEM-CE							
Area-COP (cm^2)	33.25 ± 31.20	36.70 ± 19.37	83.80 ± 58.51	34.95 ± 13.05	0.370; .047	0.180; .193[a]	0.308; .076[b]
Amplitude-AP (cm)	−5.28 ± 3.55	−3.46 ± 5.45	−3.99 ± 2.49	−2.80 ± 2.48	0.010; .772	0.024; .647	0.189; .182
Amplitude-ML (cm)	−0.40 ± 0.81	−0.72 ± 1.09	−0.83 ± 0.79	−1.35 ± 1.76	0.007; .802	0.081; .397	0.114; .310

(*continued*)

Table 3. (*Continued*)

Motor Measures, Mean ± SD	Aquatic Training Group (n = 6)		Control Group (n = 5)		Time*Group Partial η^2; *P* Value	Group Partial η^2; *P* Value	Time Partial η^2; *P* Value
Velocity-AP (cm/s)	3.72 ± 1.34	4.29 ± 2.25	6.52 ± 2.55	5.82 ± 1.98	0.098; .347	0.313; .074	0.001; .924
Velocity-ML (cm/s)	4.66 ± 1.43	4.90 ± 1.74	5.66 ± 0.73	5.52 ± 1.49	0.036; .576	0.101; .341	0.003; .882

Confounding variables were COVID-19 diagnosis and participating in the research during the COVID-19 pandemic. Negative values in the anteroposterior and mediolateral planes represent displacement backward and to the left, respectively.

Amplitude-AP, average amplitude of anteroposterior COP displacement; *Amplitude-ML*, average amplitude of mediolateral COP displacement; *Area-COP*, area of center of pressure displacement; *FT-CE*, same posture, feet together, closed eyes; *FT-OE*, standing posture, arms along the body, feet together, open eyes; *SD*, standard deviation; *TANDEM-CE*, same posture, tandem position, closed eyes; *Velocity-AP*, average velocity of COP displacement in anteroposterior plane; *Velocity-ML*, average velocity of COP displacement in mediolateral plane; *TANDEM-OE*, same posture, tandem position, open eyes.

[a] Baseline: *P* = .099; 16 weeks: *P* = .875.

[b] Control group: *P* = .017; aquatic training group: *P* = .831.

a few volunteers during progression changes. Other adverse effects were not reported during training.

Motor Risk Factors for Falls Outcomes in the Final Sample

In the final sample, there was no significant interaction between groups and times and no difference between groups in muscle strength and mobility outcomes. After 16 weeks, both groups significantly improved muscle strength and cognitive-motor task (time) performances and performed TUG-DT with fewer errors in the secondary task (Table 2).

Only participants evaluated after 16 weeks but before the first restriction due to the pandemic had postural stability data (ATG: n = 6; CG: n = 5). There was significant interaction between groups and times in the area of center of pressure displacement (area-COP) of the TANDEM-CE posture, with a significant decrease in the CG after 16 weeks. There was a significant difference between groups only in the average velocity of COP displacement in mediolateral plane of the TANDEM-OE posture, with a higher value in the CG regardless of time (Table 3).

Motor Risk Factors for Fall Outcomes Among People Who Adhered to Intervention

Among people who adhered to at least 50% of the intervention, there was significant interaction between groups and times only in TUG performance (number of steps). The ATG significantly decreased the number of steps after 16 weeks. After 16 weeks, both groups significantly improved muscle strength and cognitive-motor task performances and increased cognitive task cost (greater interference of the secondary task on TUG-DT performance) (Table 4).

Regarding postural stability, there was significant interaction between groups and times only in the average amplitude of anteroposterior COP displacement of the FT-CE posture. In the CG, there was a significant decrease in anteroposterior displacement after 16 weeks. There was significant difference between groups only in the average velocity of COP displacement in mediolateral plane of the TANDEM-OE posture, with higher values in the CG regardless of time (Table 5).

Discussion

In this study, we found a significant improvement in 5-times sit-to-stand performance, time spent on the cognitive-motor task, and errors of the TUGT-DT in both groups after 16 weeks. Moreover, the CG reduced the area-COP of the TANDEM-CE posture after 16 weeks.

Our sample had a low percentage of history of falls compared to other studies that reported 30% to 40% of community-dwelling older people have at least 1 fall once a year.[20] Few previous studies found positive effects of

Table 4. *Muscle Strength and Mobility Outcomes Among Volunteers Who Adhered to at Least 50% of the Intervention*

Motor Measures, Mean ± SD	Aquatic Training Group (n = 10)		Control Group (n = 25)		Time* Group *P* Value	*P* Value Groups	*P* Value Time
	Baseline	16 wk	Baseline	16 wk			
5-Times Sit-to-Stand Test (s)	16.91 ± 1.41	14.81 ± 2.89	16.37 ± 4.23	15.12 ± 5.33	.837	.939	.006
TUG							
Time (s)	12.22 ± 2.33	10.95 ± 2.02	12.04 ± 2.35	11.51 ± 2.42	.099	.747	.949
Number of steps	15.80 ± 2.44	14.20 ± 2.61	15.16 ± 2.65	14.40 ± 2.50	.022	.455[a]	.189[b]
Cognitive-motor task							
Time (s)	17.97 ± 5.11	14.69 ± 5.51	16.86 ± 4.05	14.06 ± 3.58	.634	.966	.000
Errors	0.20 ± 0.42	0.40 ± 0.96	0.20 ± 0.50	0.16 ± 0.47	.179	.507	.249
TUG-DT							
Time (s)	23.66 ± 5.94	21.94 ± 5.19	23.13 ± 3.71	22.51 ± 4.56	.350	.992	.401
Number of steps	21.10 ± 4.01	19.40 ± 2.95	21.16 ± 2.73	20.80 ± 3.59	.074	.476	.401
Stops	2.50 ± 0.70	2.10 ± 0.73	2.20 ± 0.57	2.24 ± 0.77	.378	.826	.165
Errors	0.10 ± 0.31	0.20 ± 0.42	0.20 ± 0.70	0.04 ± 0.20	.089	.440	.052
Cognitive task cost	22.26 ± 14.93	30.64 ± 22.21	25.70 ± 18.33	34.26 ± 14.26	.516	.741	.005
Motor task cost	0.94 ± 0.38	1.04 ± 0.49	0.95 ± 0.43	0.96 ± 0.50	.179	.700	.412

Confounding variables were COVID-19 diagnosis and participating in the research during the COVID-19 pandemic.
SD, standard deviation; *TUG,* Timed Up and Go Test; *TUG-DT*, TUG associated with cognitive-motor task.
[a] Baseline: *P* = .091; 16 weeks: *P* = .832.
[b] Control group: *P* = .218; aquatic training group: *P* = .001.

aquatic intervention on motor risk factors for falls (muscle strength and mobility) in older people.[3,21,22] Improvement in motor measures leads to better functional capacity, such as dual-task and cognitive-motor task performances.[17]

When analyzing volunteers who adhered to the intervention, other studies also found that aquatic physical exercise improved mobility in older people with good adherence.[3,5] In the present study, both groups improved muscle strength and cognitive-motor task performances, especially the ATG, and increased cognitive task cost. The high cognitive task cost is common in older people, as they tend to prioritize cognitive tasks over the primary task during dual-task activities.[14] Hall and Heusel-Gillig[23] found that multicomponent protocols, including dual-task exercises, improved motor risk factors for falls and facilitated gait automaticity.

In the present study, both groups were instructed and monitored regarding their general health. An educational program can be as effective as physical exercise interventions in improving overall health and vitality in Japanese community-dwelling older people,[24] which may justify the positive findings in the CG. Moreover, the minimal clinically important difference for the 5-Times Sit-to-Stand Test in people with chronic obstructive pulmonary disease is 1.7 seconds.[25] Volunteers who adhered to the intervention in the ATG had a mean difference between assessments of 2.1 seconds. Thus, aquatic physical exercise is a viable and effective resource for improving muscle strength and mobility in older people. There is a need for clinical trials with greater adherence and dual-task exercises associated with challenging cognitive tasks.

Regarding postural stability, a systematic review showed evidence of a possible improvement in postural stability after aquatic interventions despite the need for more randomized clinical trials to confirm the conclusion.[3] These different findings can be explained by low adherence to the intervention, a small sample with force platform data, low prevalence of fallers, and time of intervention. In addition, the tandem posture requires greater postural control due to reduced support base and increased body sway.[15] The average velocity of COP displacement in mediolateral plane during postures with open and closed eyes and the mean amplitude of the mediolateral displacement of the COP with open and closed eyes are associated with future falls.[26] Increased oscillations and average velocity of COP

Table 5. *Postural Stability Outcomes Among Volunteers Who Adhered to at Least 50% of the Intervention*

Motor Measures, Mean ± SD	Aquatic Training Group (n = 5)		Control Group (n = 5)		Time*Group *P* Value	*P* Value Groups	*P* Value Time
Power Platform	Baseline	16 wk	Baseline	16 wk			
FT-OE							
Area-COP (cm^2)	4.81 ± 1.63	3.66 ± 1.55	6.68 ± 2.52	6.09 ± 3.33	.528	.174	.076
Amplitude-AP (cm)	−2.93 ± 3.91	−3.78 ± 1.73	−2.66 ± 1.79	−3.22 ± 1.90	.868	.759	.432
Amplitude-ML (cm)	−0.20 ± 0.69	0.39 ± 1.04	−0.51 ± 0.89	−0.29 ± 0.64	.764	.203	.333
Velocity-AP (cm/s)	1.14 ± 0.25	1.17 ± 0.29	1.44 ± 0.28	1.34 ± 0.24	.336	.177	.583
Velocity-ML (cm/s)	1.30 ± 0.28	1.27 ± 0.36	0.95 ± 1.47	1.49 ± 0.24	.474	.843	.526
FT-CE							
Area-COP (cm^2)	11.15 ± 6.85	11.20 ± 6.64	10.68 ± 2.35	13.77 ± 5.21	.327	.751	.315
Amplitude-AP (cm)	−2.35 ± 3.13	−2.91 ± 1.67	−3.98 ± 1.80	−2.41 ± 1.28	.018	.668[a]	.196[b]
Amplitude-ML (cm)	−0.31 ± 1.26	0.43 ± 1.13	−0.41 ± 0.69	−0.97 ± 1.31	.086	.269	.796
Velocity-AP (cm/s)	1.74 ± 0.62	1.63 ± 0.55	2.04 ± 0.28	2.03 ± 0.29	.563	.256	.503
Velocity-ML (cm/s)	1.96 ± 0.56	1.91 ± 0.82	2.50 ± 0.44	2.27 ± 0.55	.474	.259	.278
TANDEM-OE							
Area-COP (cm^2)	8.12 ± 3.52	7.20 ± 2.16	19.74 ± 17.90	11.93 ± 7.50	.240	.187	.147
Amplitude-AP (cm)	−5.50 ± 3.19	−5.09 ± 1.53	−4.90 ± 3.45	−2.09 ± 4.43	.208	.374	.102
Amplitude-ML (cm)	−0.81 ± 0.89	0.22 ± 0.97	−0.95 ± 0.51	−1.05 ± 1.65	.339	.124	.423
Velocity-AP (cm/s)	1.86 ± 0.69	1.78 ± 0.55	3.27 ± 1.83	2.47 ± 0.73	.213	.136	.138
Velocity-ML (cm/s)	2.65 ± 0.83	2.42 ± 0.59	3.61 ± 0.81	3.15 ± 0.24	.596	.049	.149
TANDEM-CE							
Area-COP (cm^2)	35.04 ± 34.54	38.67 ± 20.97	83.80 ± 58.51	34.95 ± 13.05	.070	.272	.110
Amplitude-AP (cm)	−5.65 ± 3.84	−3.16 ± 6.04	−3.99 ± 2.49	−2.80 ± 2.48	.566	.669	.126
Amplitude-ML (cm)	−0.39 ± 0.91	−0.31 ± 0.45	−0.83 ± 0.79	−1.35 ± 1.76	.417	.251	.557
Velocity-AP (cm/s)	3.80 ± 1.49	4.32 ± 2.51	6.52 ± 2.55	5.82 ± 1.98	.412	.113	.908
Velocity-ML (cm/s)	4.75 ± 1.58	4.84 ± 1.94	5.66 ± 0.73	5.52 ± 1.49	.747	.400	.951

Confounding variables were COVID-19 diagnosis and participating in the research during the COVID-19 pandemic. Negative values in the anteroposterior and mediolateral planes represent displacement backward and to the left, respectively.

Amplitude-AP, average amplitude of anteroposterior COP displacement; *amplitude-ML*, average amplitude of mediolateral COP displacement; *area-COP*, area of center of pressure displacement; *FT-CE*, same posture, feet together, closed eyes; *FT-OE*, standing posture, arms along the body, feet together, open eyes; *SD*, standard deviation; *TANDEM-CE*, same posture, tandem position, closed eyes; *TANDEM-OE*, same posture, tandem position, open eyes; *velocity-AP*, average velocity of COP displacement in anteroposterior plane; *velocity-ML*, average velocity of COP displacement in mediolateral plane.

[a] Baseline: *P* = .342; 16 weeks: *P* = .614.

[b] Control group: *P* = .015; aquatic training group: *P* = .307.

displacement in mediolateral plane are related to worse postural stability, which corroborates the increased average velocity of COP displacement in mediolateral plane of the TANDEM-OE posture in the CG.

In relation to the reduced area-COP of the TANDEM-CE posture in the CG, decreased area-COP is related to greater postural rigidity and worse postural stability, which can lead to falls.[15] Previous studies[3] compared the effects of aquatic exercise with land-based exercises on dynamic postural stability. Although the superiority of aquatic physical exercise was not identified, aquatic interventions can be an alternative to land-based physical exercises, depending on older people's preferences and individualities.[4]

Only 41.6% of the ATG participants adhered to the intervention. Providing care to close family members with health problems is important to maintain regular physical exercise in older people. Another important factor that contributed to low adherence was the COVID-19 pandemic[6] due to social distance, physical and social restrictions, mainly in risk groups, such as older people, and fear of going out, even when activities were released in compliance with biosafety measures. On the other hand, this study showed the need to maintain emotional, social, and health support for older people during the pandemic and to adapt research within this population.[6]

This study demonstrated the safety that an aquatic environment provides to older people.[3,19,27] Our findings can be useful in clinical practice of professionals who work with the aquatic environment, as the multicomponent protocol[19,27] used is easily replicable, simple, and relatively low-cost, and it can be performed in a group. In addition, this work can serve to create and improve public aquatic intervention programs to be more accessible to older people with different profiles, taking into account their individualities and interests.

Limitations

The present work presented some limitations, including the low adherence of older people influenced mainly by the pandemic, the possible interference of pandemic and its consequences and the small sample regarding force platform data, and the effect size analysis of the results varied between small and large. We suggest future research involving an aquatic environment with a multicomponent protocol for preventing falls and reducing their risk factors in falls in community-dwelling older people, with strategies to guarantee greater adherence to intervention.

Conclusion

We found that aquatic physical exercise provided some positive effects on older people during the COVID-19 pandemic. These benefits included some potentially modifiable motor risk factors for falls (mobility and muscle strength) regardless of the COVID-19 pandemic and COVID-19 diagnosis, especially among people who adhered to the intervention.

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Contributorship Information

Concept development (provided idea for the research): D.L.F., D.M.C., G.C., A.L.J., M.J.B.L.C., J.H.A.
Design (planned the methods to generate the results): D.L.F., D.M.C., G.C., A.L.J., M.J.B.L.C., J.H.A.
Supervision (provided oversight, responsible for organization and implementation, writing of the manuscript): D.L.F., D.M.C., G.C., A.L.J., M.J.B.L.C., J.H.A.
Data collection/processing (responsible for experiments, patient management, organization, or reporting data): D.L.F., D.M.C., G.C., A.L.J., M.J.B.L.C., J.H.A.
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Writing (responsible for writing a substantive part of the manuscript): D.L.F., D.M.C., G.C., A.L.J., M.J.B.L.C., J.H.A.
Critical review (revised manuscript for intellectual content, this does not relate to spelling and grammar checking): J.H.A.

Practical Applications

- Aquatic exercise may improve risk factors for falls (muscle strength and mobility), especially in people with good adherence to training.
- This trial may help to inform clinical practice of professionals who work in aquatic environments, as the multicomponent protocol may be easily replicable, simple, and relatively low-cost, and it can be performed by a group.
- The present work may inform aquatic intervention programs for different profiles, such as faller, frail, sarcopenic, and sedentary older people.

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