The effect on lower limbs of wearing ankle weights in people under/over 70 years old: single comparison after intervention

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Research Article

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Abstract

Background

Since the emergence of Coronavirus disease 2019 (COVID-19), safety management in gymnastics classrooms has been difficult. As a result, healthy older adults are more likely to voluntarily refrain from attending because of fear of contracting COVID-19, and thus engage in less exercise. In this context, it is important to develop methods for self-prevention of frailty that can be conducted safely and easily at home. We examined the effectiveness of providing ankle weights to older adults as a frailty prevention device.

Methods

All participants were 50–90 years old and were screened for falls using the Motor Fitness Scale (MFS). Participants were divided into two groups (≤ 70 and ≥ 71 years old) and analyzed. We rented ankle weights for 3 months to older adults in the community and evaluated changes in physical and motor function before and after wearing them.
A total of 75 people who responded to the call for participants used ankle weights for 3 months, and underwent various measures of physical condition, cognitive condition, and performance (body composition, grip strength, standing on one leg with eyes open, 30-second chair stand test [CS-30], timed up-and-go test [TUG], walking speed, body sway measurement, and the Japanese version of Montreal Cognitive Assessment [MOCA-J]) before and 3 months after wearing ankle weights.

Results

CS-30 performance improved in both younger and older participants.

Conclusions

CS-30 reflects lower limb/trunk muscle strength and can be used as an index of fall risk. Our results suggest that wearing ankle weights can be recommended as a fall-prevention measure.

Trial registration:

University hospital Medical Information Network ID 000038073) and registration date at April 14th 2020

Background

Prevention of fractures and falls among older adults is an urgent priority, and can help avoid the need for long-term care, extend healthy life expectancy, and further reduce medical and nursing care costs.

While various exercise interventions are commonly practiced among older adults living in the community, it has been reported that improving physical balance is most important for fall prevention.[1] Falls among older adults can be reduced by exercise interventions, particularly balance improvement exercises and various types of combination exercises.[2] It has been reported that instructor-led gymnastics classrooms are safer and more effective than self-directed efforts and self-judgment, and are more suitable for improving physical function than exercising at home.[3] However, widespread distribution of such classrooms as part of health safeguarding cannot be expected in the near future because of shortfalls in systems, facilities, staffing, and cost, including the cost performance index. Furthermore, in the global context of the Coronavirus disease 2019 (COVID-19) pandemic, it is extremely difficult to conduct gymnastics classes that require physical gatherings of individuals. Older adults need to stay at home to avoid the risk of infection, which can increase the risk of falls and lead to increased frailty.

From this perspective, as a familiar and easy resistance exercise, we focused on home exercises using weights attached to the ankles to improve lower limb muscle strength and maintain balance.

Wearing ankle weights (AWs) on the ankles while walking is reported as a method for increasing physical activity intensity that has been used [1]. This equipment is widely available in sports stores as consumer products, and is commonly used for lower limb training by younger adults. A previous study evaluated oxygen uptake as a systemic physiological index while applying different levels of load by wearing AWs of different weights [2].

However, the effects of resistance exercises on lower limbs and preventing physical function decline have not yet been elucidated. The aim of this prospective study was to assess whether AWs can improve body composition or performance, and to examine the feasibility of AWs for further investigations.

Methods

Study design, sites, and participants

We conducted a prospective paired study (with/without feedback) at three sites in Japan: The Community Health Education and Research Center (CHC) of Nagoya City University, Asuke Hospital, and Gamagori Municipal Hospital in Aichi. Figure S1 shows the flowchart of participants at the briefing.

Participants were healthy volunteers who lived in the towns surrounding the study sites.
We recruited subjects using posters and brochures for CHC’s health measurement program. All participants were 50–90 years old, scored ≥ 11 points (men) or ≥ 9 points (women) on the Motor Fitness Scale (MFS),[5] were able to accurately respond to questions asked in a consultation with a physician, and agreed to participate in the present study. The number of applicants who gathered at the time of the

initial meeting and carried on to registration after the final interview and screening tests is presented as supplementary data (Fig. S1).

The study was approved by the Institutional Review Board of Nagoya City University (46-18-0006) and registered University hospital Medical Information Network (UMIN, ID 000038073) April 14th 2020. Each participant provided written informed consent.
The investigators kept the datasets in password-protected systems and maintained the anonymity of study participants in all presentations of the data.

Schedule and recording daily activity

Two cohorts were randomly assigned to two groups using an envelope method in each area; one group underwent individual interviews (group I) for observing behavioral changes, and the other group did not undergo individual interviews (group II). In the current study, we analyzed group I and II separately, and both groups together, and compared changes between before and after.

Figure 1 shows the flowchart of the study after obtaining consent and registration.

After obtaining consent, conducting the Motor Fitness Scale (MFS), and collecting participants' clinical history, the first measurements were performed.
After observation for 4 weeks, further measurements were performed (2nd), followed by the intervention for 12 weeks. The final measurement was performed after the intervention (3rd). In the current study, we analyzed the data before (2nd) and after (3rd) the intervention.

The weight of an AW is based on 2% of body weight.

Because ready-made commercially produced AWs (0.5 kg: KW-505,0.8, 1 kg: KW-506, 1.5 kg: KW-507, IRONMAN CLUB, Taiwan) weigh 0.5, 0.8, 1.0, and 1.5 kg per lateral ankle only, it is impossible to set the exact weight according to body weight.
The actual weight was decided upon by each individual after pre-wearing the AW for 5–10 minutes.

As an intervention rule, we set a lower limit of one 20-minute session of outdoor walking per day while wearing AWs, at least twice a week, for 12 weeks.

Participants were free to wear the AWs at other times without any upper limit.
It was also possible for participants to change the weight if it did not adequately match their body weight.

During the intervention period, we asked participants to record daily activity of AW use.

At this time, we conducted individual interviews with members of group I concerning AW-wearing status, physical problems, and advice of various types (thin arrow in Fig. 1).

The first physical and fitness measurements were performed immediately after enrollment (dark arrow in Fig. 1), followed by a 4-week pre-observation period (data not reported).

The second measurement period was then performed while participants wore AWs for 12 weeks.
The third measurements were conducted after 12 weeks. Thereafter, the post-observation period is scheduled to continue until the final measurement, planned for 1 year after the initial measurement. In the current study, we analyzed the results of the second and third (pre- and post-intervention) measurements performed thus far.

Questionnaire survey on lifestyle

Data on participants' demographic and clinical characteristics, including age, sex, profession, living situation, underlying diseases, medications, smoking and alcohol intake, and sleep quality, were collected during clinical consultations with physicians using an original questionnaire designed by the study investigators.

Furthermore, as daily activities, participation in gymnastics classes, yoga, walking, dancing, swimming, and the presence or absence of sports activities such as tennis, baseball, and golf were also collected.

Muscle measurements

Multiple measures of executive function were assessed. Body composition parameters, including lower leg circumference and skeletal muscle mass, were assessed using multi-frequency bioelectrical impedance with an In Body device (In Body Japan, Tokyo, Japan).[6] Although there were differences in the generation of the model at each facility (as shown in supplementary data), there were no differences in data acquisition and analysis.

The skeletal muscle mass index (SMI) was derived as the sum of the muscle mass of the four limbs (right arm, left arm, right leg, and left leg muscles) divided by the square of height (kg/m^2).[7] Grip strength was reported as a representative indicator [3], measured with a conventional grip dynamometer (YO2, Tsutsumi Seisakusho Co., Ltd, Chiba, Japan) to assess muscular strength. We hypothesized that muscles related to respiration and swallowing would be strengthened by lower leg muscle building. Respiratory function was measured via physiological examinations in each hospital and tongue pressure measurement was performed using an Orarize device (JMS, Hiroshima, Japan).

Balance and mobility tests

Three measures of balance and mobility (the one-leg standing test [OLST],[8] timed up-and-go test [TUG],[9] and 30-second chair stand test [CS-30][10]) were assessed.

The OLST is a balance assessment method used for older adults.[8] In the current study, the rater instructed participants to stand on one leg with their upper limbs hanging downward and their eyes open, without specifying any conditions for lifting the other leg. The measurement, with 120 seconds as the longest measurement time, was conducted twice for each lower limb (affected and unaffected sides), and the highest value was recorded.

The 3.0-meter TUG measures coordination, agility, balance, and speed.[9] Participants begin from a fully seated position with their feet flat on the ground. At the start of the test, participants are instructed to stand up and walk as quickly as possible, without running, around a cone placed 3.0 meters in front of a chair and then to return to their initial seated position in the chair. In our study, the shorter time of two trials was used for the analysis. The TUG was also performed at normal walking speed. A stopwatch was used to assess the time of each trial.

The CS-30 measures lower extremity strength [4]. A chair with a seat height of 40-cm was used for the assessment [4].

The starting position of participants was standardized with regard to buttock placement, back support, use of hands, and foot placement.
The participants were instructed to cross their arms at the wrists and hold them against their chest.
Participants were asked to sit and stand as many times as possible in 30 seconds.
The total number of completed chair stands within 30 seconds was then counted and recorded.

Furthermore, balance function was analyzed using the Gravicorder sway meter for the center of gravity (Anima, Tokyo, Japan). Although there is a difference in the generation of the model at each facility, the acquisition and analysis of the sway of the center of gravity were unified using the Gravicorder device.

Statistical analysis

A similar number of participants were under and over 70 years old, which was close to the mean age of participants.
Participants were divided into two groups (≤ 70 and ≥ 71 years old).
Data were expressed as median and interquartile range (25th to 75th percentile) or as mean and standard deviation (SD) for continuous variables, and proportions were used for categorical variables.
Participants were divided into two groups, aged ≤ 70 (younger group) or ≥ 71 years (older group).
In addition, participants were divided into two groups on the basis of the SMI criteria defined by the Asian Working Group for Sarcopenia (AWGS)[7]: normal SMI: ≥7.0 kg/m^2 (men), ≥ 5.7 kg/m^2 (women); low SMI: <7.0 kg/m^2 (men), < 5.7 kg/m^2 (women). The AWGS proposes measurement of SMI in older adults (aged ≥ 65 years) with low grip strength (men < 26 kg, women < 18 kg) or slow walking speed (≤ 0.8 m/s), and a diagnosis of sarcopenia is made if low SMI (as defined above) is detected.[7] Comparisons were made between these two groups using the χ^2 test or Fisher's exact test for categorical variables, and the Mann–Whitney *U* test or Student's *t*-test for continuous variables. We examined the correlations between age, physical measurement, muscular strength, and balance and mobility tests using Pearson's correlation coefficients. Possible factors influencing SMI were determined using logistic regression analysis with independent variables of age, sex, body mass index, chest circumference, hand grip strength, OLST, 3.0-m walk test, TUG (normal), TUG (fast), and CS-30 performance. A stepwise selection method was used to select variables.

Data were analyzed using IBM SPSS, Version 25.0 (IBM, Armonk, NY, USA). For all analyses, significance levels were two-tailed, and $P < 0.05$ was considered statistically significant.

Results

Background overview and harmful events during the intervention

Ninety-nine people participated in the information session, and consent was obtained from 74 individuals.
In the MFS questionnaire, all participants achieved a passing score in the initial measurement.
However, one participant withdrew, and 73 participants began the study.
There were no dropouts during the examination period, but one incident occurred, in which a participant lost balance after taking off the AW and sustained a bruised face.
After consulting a general physician, no problems were identified, and the participant was able to continue with the trial.

Participants' general background information is shown in Table 1.

Overall, 73 people aged 66–76 years (median 71 years) participated, 25% of whom were male and most of whom were homemakers or retirees.
Few participants had ever smoked, and more than half reported having some sleep difficulties.
Of the more than 40% of people who had been hospitalized, more than half received medication for an underlying disease (Table 1).

Table 1
General characteristics of participants

	N = 73
General conditions	
Age, years, median (IQR)	71 (66–76)
age ≥ 71, n (%)	37 (50.7)
Gender-male, n (%)	18 (24.7)
Living conditions	
Living with family, n (%)	58 (79.5)
Profession	
Employee	3 (4.1)
Self-employed person	2 (2.7)
Homemaker	27 (37.0)
Retiree	25 (34.2)
Part time job	11 (15.1)
Others	4 (5.5)
Habitation	
Smoking history, n (%)	6 (8.2)
Drinking alcohol, n (%)	27 (37.0)
Having problems with Sleep, n (%)	35 (47.9)
Clinical conditions	
1 ≥ of underlying disease, n (%) (n = 71)	46 (63.0)
Experience of hospitalization, n (%)	31 (42.5)
Taking prescription medication, n (%) (n = 72)	48 (65.8)

The factors of age, physical measurement, muscular strength, and balance and mobility tests exhibited no correlations using Pearson's coefficients. In addition, although the data were not reported in this study, there were individual differences in the presence or absence of sports activities.

Changes in body composition before and after intervention

Changes in body composition during the intervention are shown in Table 2, with measurements by In Body. There were minor changes in physical composition. SMI was calculated in 44 cases automatically in the CHC, and significantly decreased after intervention in both the younger and older groups.

Table 2
Body composition among participants before and after intervention

	Age, ≤ 70			**Age, ≥ 71**		
	n = 36			**n = 37**		
Parameters-mean(SD)	Before	After	*P* value	Before	After	*P* value
BMI	23.0 (3.4)	23.0 (3.3)	0.908	22.1 (2.3)	22.2 (2.3)	0.318
Body fat %	29.3 (8.3)	28.9 (8.1)	0.220	28.2 (7.0)	28.1 (7.2)	0.941
Muscle mass	38.8 (7.4)	39.1 (7.8)	0.176	36.0 (7.5)	36.1 (7.2)	0.698
Skeletal muscle mass	22.2 (4.6)	22.4 (4.9)	0.104	20.4 (4.6)	20.5 (4.5)	0.490
Right arm muscle mass	2.0 (0.6)	2.0 (0.5)	0.722	1.8 (0.6)	1.8 (0.6)	0.075
Left arm muscle mass	2.0 (0.6)	2.0 (0.5)	0.865	1.8 (0.5)	1.8 (0.5)	0.097
Trunk muscle mass	18.0 (3.6)	18.0 (3.3)	0.985	16.6 (3.4)	16.7 (3.4)	0.065
Right leg muscle mass	6.4 (1.5)	6.6 (1.7)	0.287	5.8 (1.5)	5.8 (1.5)	0.738
Left leg muscle mass	6.4 (1.5)	6.5 (1.7)	0.310	5.8 (1.5)	5.8 (1.4)	0.596
SMI (n = 22)	6.5 (0.9)	6.4 (0.9)	*0.045	6.3 (1.0)	6.2 (0.9)	*0.024

BMI, body mass index; SMI, skeletal muscle mass index. * $p < 0.05$

Anthropometry

General anthropometry results are presented in the top third of Table 3. The lower limb circumference in older subjects significantly increased. There was no change in blood pressure or heart rate.

Table 3
Changes in results of performance tests and standing position balance before versus after intervention

	Age, ≤ 70			**Age, ≥ 71**		
	n = 36			**n = 37**		
Parameters-mean(SD)	Before	After	*P* value	Before	After	*P* value
Anthropometry						
Calf circumference						
Right	39.2 (8.2)	40.1 (7.9)	0.551	33.5 (3.0)	33.8 (2.9)	*0.023
Left	35.1 (2.6)	35.0 (3.1)	0.494	33.6 (3.0)	33.9 (3.1)	*0.031
Blood pressure (mmHg/mean of right and left arm)						
Systoric	133.3 (23.3)	133.2 (23.0)	0.986	130.1 (18.5)	131.8 (13.0)	0.626
Digastric	78.4 (16.9)	76.8 (16.3)	0.309	69.6 (10.8)	70.1 (10.4)	0.474
Hear rate(beat/minutes)						
Right	82.0 (13.5)	81.0 (10.8)	0.524	76.8 (9.6)	76.1 (9.0)	0.635
Performance assessment						
Tongue pressure	39.2 (8.2)	40.1 (7.9)	0.199	35.6 (8.9)	37.3 (1.4)	0.106
Grip strength (mean of right and left arms)						
Right arm (kg)	30.0 (8.1)	30.2 (7.3)	0.818	25.4 (6.7)	25.4 (6.9)	0.928
Left arm(kg)	27.2 (6.8)	27.5 (6.6)	0.637	25.4 (6.9)	23.3 (6.0)	0.099
OLST total 120, n (%)	21 (58.3)	20 (55.6)	1.000	11 (29.7)	13 (35.1)	0.804
3.0-m walking (second)	1.7 (0.2)	1.6 (0.2)	*0.012	1.7 (0.3)	1.7 (0.3)	0.225

OLST, One-leg standing test with eye open; VC, vital capacity; FVC, forced vital capacity; $FEV_{1.0}$, forced expiratory volume in 1 second; 3.0-m TUG, timed 2.4 meter up-and-go test; CS-30, 30-second chair stand test. * $p < 0.05$

	Age, ≤ 70 n = 36			Age, ≥ 71 n = 37		
TUG (usually) (second)	7.5 (1.2)	7.4 (1.2)	0.707	7.5 (1.2)	7.8 (1.3)	(0.022)
TUG (fast) (second)	5.7 (0.9)	5.7 (0.6)	0.453	6.3 (0.8)	6.1 (0.9)	0.355
CS-30 (times)	23.4 (5.6)	24.7 (5.9)	0.042	21.0 (5.9)	22.4 (7.3)	*0.020
MOCA-J (points)	28.0 (2.1)	28.1 (1.9)	0.782	26.0 (3.0)	26.1 (3.1)	0.772
≤ 26[illegible], n (%)	32 (88.9)	32 (88.9)	1.000	24 (64.9)	25 (67.6)	1.000
Standing position balance						
Opened eyes						
Area (cm^2)	4.48 (1.94)	4.88 (2.67)	0.502	4.29 (2.69)	4.03 (2.16)	0.451
Speed (cm/second)	1.76 (0.47)	1.80 (0.47)	0.655	1.73 (0.48)	1.82 (0.68)	0.186
Congestion (1/cm)	27.14 (11.02)	27.76 (13.42)	0.820	29.0 (11.37)	30.26 (9.85)	0.401
Center left and right (cm)	0.05 (0.52)	-0.10 (0.66)	0.177	-0.13 (0.90)	− 0.04 (0.63)	0.639
Center front and rear (cm)	-0.56 (1.69)	-0.13 (0.90)	*0.012	-0.13 (0.63)	-0.23 (1.20)	0.706
Area Long Berg rate	1.33 (0.49)	1.27 (0.49)	0.762	1.33 (0.80)	1.35 (0.49)	0.889
Short area (cm^2)	10.53 (4.58)	11.79 (6.06)	0.351	10.49 (7.27)	9.03 (5.72)	0.086
Rms value area (cm^2)	2.39 (1.58)	2.35 (1.36)	0.923	2.00 (5.73)	1.84 (1.08)	0.482
Total track length (cm)	100.29 (36.83)	108.03 (29.24)	0.168	103.56 (28.57)	108.93 (40.63)	0.195
Closed eyes						

OLST, One-leg standing test with eye open; VC, vital capacity; FVC, forced vital capacity; $FEV_{1.0}$, forced expiratory volume in 1 second; 3.0-m TUG, timed 2.4 meter up-and-go test; CS-30, 30-second chair stand test. * $p < 0.05$

	Age, ≤ 70 n = 36			Age, ≥ 71 n = 37		
Area (cm^2)	5.81(2.87)	5.28 (2.20)	0.177	5.23 (3.43)	5.34 (3.38)	0.823
Speed (cm/second)	2.52 (0.95)	2.30 (0.73)	0.148	2.50 (1.25)	2.52 (1.18)	0.778
Congestion (1/cm)	30.48 (12.93)	29.68 (12.48)	0.652	32.55 (11.59)	32.23 (11.65)	0.870
Center left and right (cm)	0.09 (0.65)	-0.16 (1.78)	*0.039	-0.12 (0.67)	-0.10 (0.77)	0.935
Center front and rear (cm)	-0.08 (1.78)	-0.82 (1.00)	*0.021	0.24 (1.61)	0.11 (1.26)	0.650
Area Long Berg rate	14.58 (7.59)	13.05 (5.09)	0.298	12.97 (8.91)	11.76 (6.78)	0.264
Short area (cm^2)	2.45 (1.17)	2.25 (0.96)	0.118	2.20 (1.40)	2.20 (1.26)	0.950
Rms value area (cm^2)	151.23 (56.81)	138.17 (43.83)	0.151	149.71 (75.30)	151.51 (70.53)	0.773

OLST, One-leg standing test with eye open; VC, vital capacity; FVC, forced vital capacity; $FEV_{1.0}$, forced expiratory volume in 1 second; 3.0-m TUG, timed 2.4 meter up-and-go test; CS-30, 30-second chair stand test. * $p < 0.05$

Performance

Performance measurement data are shown in the middle third of Table 3. In general, the results tended to show slight worsening in younger participants and improvement in older participants. Although the difference was not significant, tongue pressure tended to increase.

Grip strength slightly increased in the younger group, but the difference was not significant.

Figure 2 shows the graphs of individual changes in normal walking (a, b) and rapid walking (c, d) in TUG and CS-30 performance (e, f) before and after intervention are shown for participants younger and older than 70 years. There was substantial variation in all datasets, with some participants exhibiting improved performance and others exhibiting decreased performance.

The usual speed in each trial of the TUG of participants aged ≥ 71 years was slower than younger. Examining individual changes (Fig.

2) in TUG performance, for both walking at normal speed and while walking fast, revealed that the time taken by younger participants was shorter in many cases.

There was a marked improvement in CS-30 performance, particularly among participants aged ≥ 71 years, performing a significantly greater number of chair stands following the intervention.

Examining individual data revealed that, regardless of the number of chair stands before the intervention, each participant completed more chair stands in 30 seconds after the intervention (Fig. 2).

Regarding cognition, no significant changes resulted from the intervention; 10% of participants exhibited mild cognitive impairment, with a MOCA-J test score of 26 points or less.[12]

Standing position balance

The data acquisition and analysis of sway of the center of gravity using the Gravicorder are shown in the lower third of Table 3. The center-of-gravity sway meter showed no general tendency toward change. Changes in the front-rear and left-right center of gravity with eyes closed in the younger group were aggravated after the intervention. Examining individuals' data (not shown) revealed substantial variability among individuals, with some individuals exhibiting improvement after the intervention, and others showing no improvement. This variation was more prominent in older participants.

Discussion

To prevent the onset and progression of frailty syndrome, multi-factorial exercise programs can be effective, including resistance exercise, balance training, and functional training health in older adults who live in the community. In addition, fall-rate reduction has been reported through a combination of balance exercise, functional exercise, and resistance exercise [5] [6]. In addition to multi-factorial exercise, intensified training with trainers [7] or multi-professional teams [8] could lead to optimal effects.

Although AWs are used in gymnastics classes for older adults in some areas of Japan, there are various risks involved, and no guidelines currently exist for safe personal use by older individuals.
AWs have been found to have a beneficial effect on gait factors when properly used by healthy adults[9]. However, the effects of simple programs, including resistance training to prevent falls, dance and walking, are unknown [10].

Because we targeted older people living in the community, there was a relatively low change of falling, and our outcomes were focused on frailty prevention, particularly muscle strengthening effects.

The effectiveness of measures to improve locomotor function among older people has been reported using elastic bands [11], iron arrays [12], and machine-based muscle strengthening exercises [13].

In an intervention using AWs in healthy older women, performing muscle strengthening of the lower limbs using an elastic band and AWs three times a week for 12 weeks, including an instruction session once a week, resulted in a significant improvement in isometric knee extension muscle strength, isometric elbow flexion muscle strength, grip force, and weight ratio leg extension power, but no improvement in movement ability, such as standing up and stepping up/down [14].

The recent prevalence of the COVID-19 pandemic has led to a decrease in exercise classes with instructors.

In future, the utilization of internet technology including video, remote instruction and virtual reality may be important as effective substitutes for face-to-face classes with a trainer [7] or multi-professional team [8]. Thus, it is important to investigate safe and sustainable exercise environments at home. The current study produced primary data verifying the effect of AWs as a wearable muscle load device. We sought to contribute to the development of environments in which exercise can be safely continued at home with AWs. However, depending on the method employed, this approach could cause health problems, and some products warn against use by older adults alone. There is currently no specified safe environment for older adults to voluntarily incorporate AWs as a frailty prevention measure.

In the current study, we implemented a 3-month intervention with minimum requirements of use during the intervention period.

Data regarding usage frequency and pre-falling incidents, obtained from sensors attached to AWs or self-recording, were not connected to individual anthropometry and performance data.
Thus, the current study is considered an interim report in a larger project. There were no serious accidents or incidents during the study period, and the AW intervention induced significant increases in lower limb circumference and CS-30 performance in older subjects, verifying the beneficial effects of the AW intervention on strengthening lower limb muscle.

Compared with other intervention studies [14] [15], the focus of the current study was not strict, and the sample size was not sufficient.

Nevertheless, the lower leg circumference of older participants and CS-30 performance in both groups exhibited a significant improvement.

A previous study reported that the CS-30 is a highly reproducible test that is significantly correlated with leg extension muscle strength, and can be used to evaluate lower extremity muscle strength among people aged 60 years and over living in the community [4]. Figure 2 shows that, although there was no overall improvement, there was an average trend toward improvement, and it is possible that differences in individual effort are reflected in the measured values after the intervention. No improvement was observed in other performance items. In TUG, some studies have reported positive effects [16] while other studies have reported negative effects [17]. In future studies, it would be useful to collate each individual's sensor data and activity diary with these measurement data.

Although no significant differences were observed in bilateral lower limbs, trunk muscle mass (Table 2), or tongue pressure (Table 3), future studies should conduct trials with a longer intervention period and more participants. The sway of the center of gravity also integrates complex functions, such as deep sensation and the extrapyramidal tract, and improvement is not only exhibited by improvement of lower limb strength. Previous studies have reported that gravity changes are not directly affected by muscle strength [18] [19] [17] [20].

Considering the attachment site of AWs, the load would be expected to particularly affect the swing motion of the lower limbs and the flexion motion of the hip joint during walking motion. These movements tend to be weakened with aging, and if additional stress can be selectively applied to these movements, it could not only serve as an exercise load but also suppress the deterioration of walking function among older people. It is also possible that this method could be applied as a high-quality exercise therapy.

Because the study regime was not strict, various factors may have affected individual effort.

Furthermore, it was difficult to control for confounding factors, such as the effects of participating in regular individual exercise classes and sports activity, such as yoga and personal gym use.

Currently, while staying at home to contain the COVID-19 pandemic, inactivity among older people has become a serious problem. Frailty prevention approaches are moving toward self-restraint and outdoor activities that avoid close contact. Outdoor activities such as walking while avoiding contact with others are preferred options for strengthening physical fitness. Walking has been widely adopted for physical strengthening. However, although walking may have an effect on improving cardiopulmonary function, it has been reported to have little effect on muscle strengthening and fall prevention [21]. However, incorporation of walking combined with wearing AWs has the potential to be effective for lower limb muscle strengthening. In the case of older adults, however, because there is a large difference in individual abilities, it is necessary to propose measures that are suitable for each individual's physical characteristics, muscle mass, muscle strength, and exercise abilities. To provide feedback, a system for formulating a menu that suits each individual according to guidelines for proper use would be useful.

Finally, one participant remarked that taking part in the study motivated them to exercise, and to walk. This comment suggests the importance of fostering and maintaining motivation in healthy older adults.

The present study involved several limitations. First, it is difficult to conduct ideal exercise intervention research in older adults' daily lives. Therefore, various data regarding daily activity and AW-wearing records that we intended to collect were not possible to measure in this study. It would be valuable for future studies to develop a research system that collects and collates these data sources automatically.

We asked participants to select the wearing conditions of AWs according to the appropriate situation for each individual and advised a minimum use requirement of 20 minutes at least once to twice per week. However, it was difficult for some participants to understand the self-administration conditions.

Conclusion

The present study revealed significant increases in lower limb circumference and CS-30 performance in older subjects, indicating improved lower limb/trunk muscle strength. These results suggest that wearing AWs can be recommended as an easy method for strengthening lower limbs. In addition, our findings suggest that investigating a research system to collect and collate these data automatically may be a valuable next step.

List Of Abbreviations

Coronavirus disease 2019 (COVID-19)

Motor Fitness Scale (MFS)

30-second chair stand test (CS-30)

Timed up-and-go test (TUG)

Japanese version of Montreal Cognitive Assessment (MOCA-J)

Ankle weights (AWs)

The Community Health Education and Research Center (CHC)

University hospital Medical Information Network (UMIN)

Skeletal muscle mass index (SMI)

One-leg standing test (OLST)

Dual Energy X-ray Absorptiometry (DEXA)

Magnetic resonance imaging (MRI)

Standard deviation (SD)

Asian Working Group for Sarcopenia (AWGS)

Japan Agency for Medical Research and Development (AMED)

Declarations

Ethics approval and consent to participate

This study was carried out according to the Helsinki Declaration and **all methods were carried out in accordance with relevant guidelines and regulations**. And the study **w**as approved by the Ethics Committee of Nagoya City University (approval number 46-19-0010; August 13th, 2019). Informed consent from participants was obtained just before the pre-observation period after an information session and MFS Survey.

Consent for publication

Not applicable.

Availability of data and materials

All relevant data are included in the paper and its Supporting Information file.

Competing interests

The authors declare no conflict of interest without research funding from AMED.

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Authors’ contributions

H.A.: Total planning and management

T. M.: Data analysis

Y. K., Y. M., S. H., T. J., and S. K.: Recruitment of participants and holding of measurement sessions.

T. H., H.O.: Assisting management and supervision.

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Figures

Fig. 1

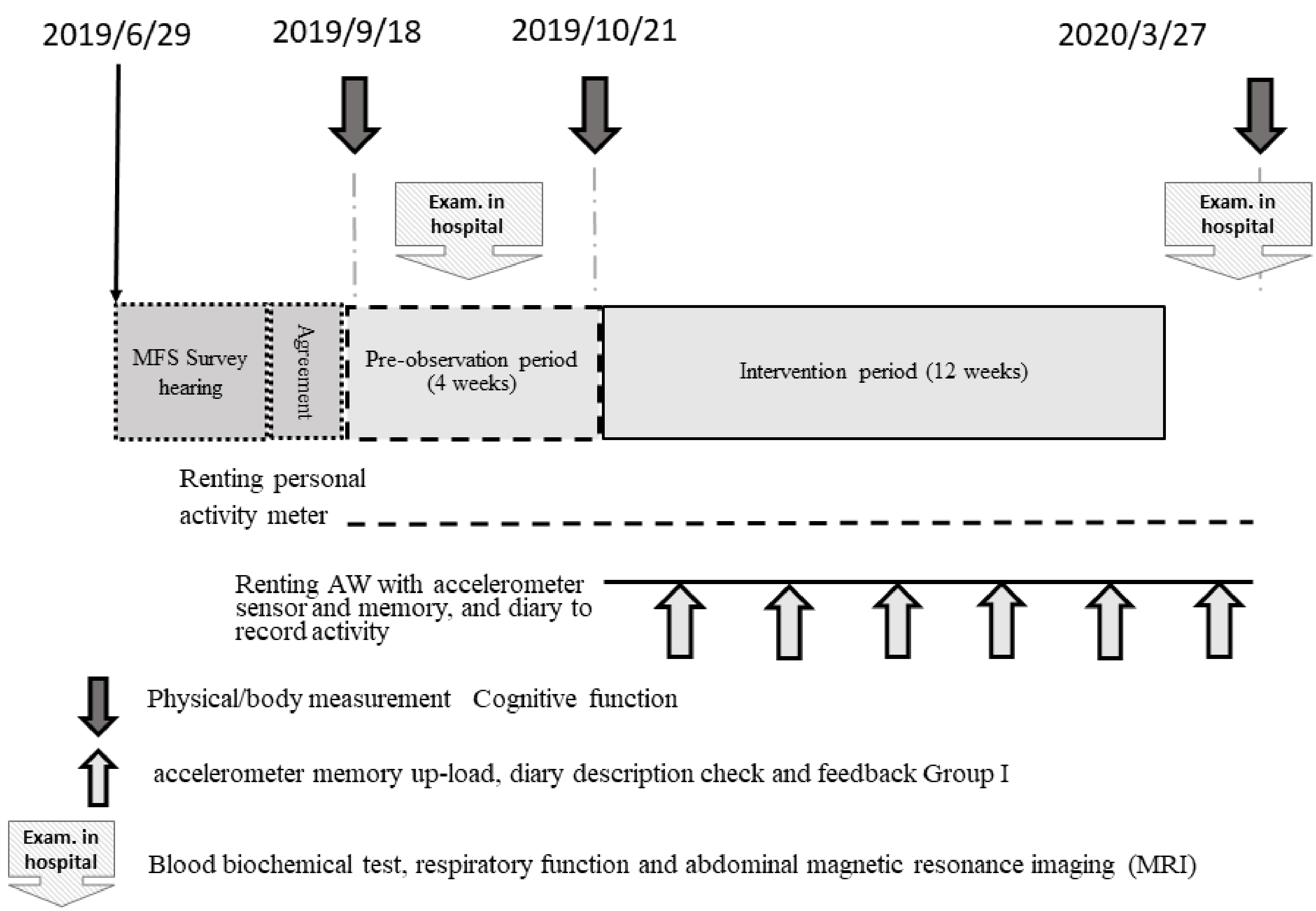

Figure 1

Flowchart of prospective intervention test. After obtaining consent, conducting the Motor Fitness Scale (MFS), and collecting participants' clinical history, the first measurements were performed. After observation for 4 weeks, further measurements were performed (2nd), followed by the intervention for 12 weeks. The final measurement was performed after the intervention (3rd). In the current study, we analyzed the data before (2nd) and after (3rd) the intervention. MFS, Motor Fitness Scale.

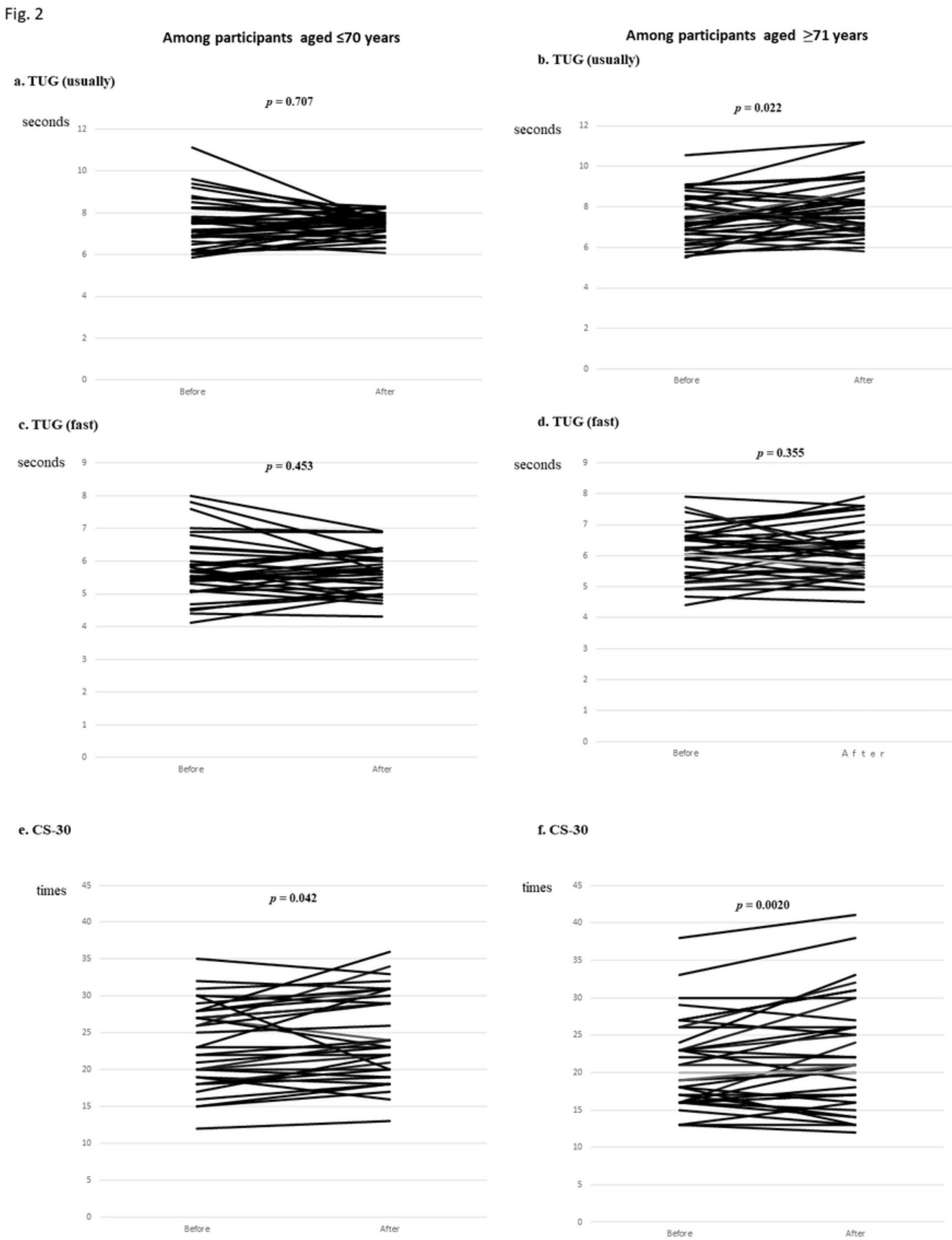

Figure 2

Graphs of individual changes in normal walking (a, b) and rapid walking (c, d) in TUG and CS-30 performance (e, f) before and after intervention are shown for participants younger and older than 70 years. There was substantial variation in all datasets, with some participants exhibiting improved performance and others exhibiting decreased performance. However, many participants showed relative improvement in CS-30 performance. TUG, timed up-and-go test; CS-30, 30-second chair stand test.

Supplementary Files

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