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A multidimensional program including standing exercises, health education, and telephone support to reduce sedentary behavior in frail older adults: Randomized clinical trial

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ABSTRACT

Objectives: The primary aim of this study was to evaluate the effect of a multidimensional program including home-based standing exercises, health education, and telephone support for the reduction of sedentary behavior in community-dwelling frail older adults. The secondary aim of this study was to evaluate the safety and adherence of the program.
Study design: A single-blind, randomized controlled trial.
Methods: A total of 43 frail older adults were randomly assigned to the intervention and control groups. The intervention consisted of combined strategies including home-based standing exercises, health education, and telephone support for 16 weeks for frail older adults. The control group received orientation regarding the harmful effects of a sedentary lifestyle. Sedentary behavior was evaluated by total sedentary time, accumulated sedentary time in bouts of at least 10 min, and by the break in sedentary time, measured by an accelerometer used for at least 600 min/day for 4 days. Safety was assessed by self-reporting of possible adverse events. Adherence was assessed based on the number of days in which standing exercises were performed by the participants. Repeated measures ANOVA and Tukeys post hoc test were used to analyze the collected data.
Results: The intervention group reduced the sedentary time by 30 min/day (p= 0.048), but without significant maintenance after 30 days of the program. Of the total number of participants, 82% (n = 14) of the intervention group participants showed more than 70% adherence to the program. The main adverse effects faced by the intervention group participants were tiredness (53%; n = 9) and lower limb pain (47%; n = 8).
Conclusions: The multidimensional program reduced sedentary behavior, was safe, and showed satisfactory adherence in frail older adults.

1. Introduction

Populational aging contributes to a higher prevalence of frailty, yielding a pooled mean of 12% of older adults around the world (O'Caoimh et al., 2021). Frailty is a potentially disabling condition, characterized by dysfunction in several physiological systems and culminating in greater vulnerability after mild stress (Fried et al., 2001). Physical frailty consists of lower weight, energy, strength, and resistance, which leads to adverse health outcomes such as hospitalization, falls, disability, and death (Morley et al., 2013). It is associated with advanced age, female sex, worse socioeconomic conditions, and physical inactivity (Hoogendijk et al., 2019).

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In addition to low levels of physical activity, frail older adults spend most of their waking time in the sitting position, with a mean of 9.6 h daily (Blodgett et al., 2015). Physical activity and sedentary behavior, although closely related, are independent and should be approached differently (Cunningham et al., 2020). The literature is vast in pointing out that a higher level of physical activity has the potential to prevent or reverse frailty (Travers et al., 2019; Dent et al., 2019). However, less attention has been paid to the negative effects of sedentary behavior that stands out as an independent risk factor for several negative outcomes, such as cardiometabolic diseases, physical disability, dependence, frailty, and mortality (Mañas et al., 2017).

Sedentary behavior is mainly identified by sitting posture, with low levels of energy expenditure and strongly influenced by environmental, social attributes, motivations, and individual preferences (Owen et al., 2011). Although there is no cut-off point to guide the reduction of sedentary time (Manini et al., 2015), a longer standing time was related to a lower risk of mortality (Katzmarzyk, 2014), and 30 min of light physical activity, replacing a sedentary behavior, was pointed out as a promise to minimize adverse health outcomes in this population (Martin et al., 2015; Mañas et al., 2017; Nagai et al., 2018).

Two systematic reviews on specific interventions to reduce sedentary behavior, involving robust older adults, corroborate that multidimensional strategies, which associate changes in habits, education, and mild activity, tend to produce more favorable results, compared to the exclusive increase in the level of physical activity to achieve moderate to vigorous intensities (Copeland et al., 2017; Chase et al., 2020). The interventions applied in these studies involved behavioral theories and remote monitoring, characterized by telephone support (Rosenberg et al., 2015; Barone Gibbs et al., 2017; Lewis et al., 2016) and electronic devices, which provided real-time feedback on sedentary time (Barone Gibbs et al., 2017; Fitzsimons et al., 2013; Harvey et al., 2018). In addition, education, and goal setting, including expert and individual counseling, have had significant effects on sedentary behavior (Chase et al., 2020).

However, several barriers can prevent the older adult from moving more, such as lack of motivation, pain, tiredness, or fear of falling (Moraes et al., 2020). A multidimensional program can assist in understanding strategies for behavioral change through psychological approaches associated with physical exercise (Borbon Castro et al., 2020). The present study fills a gap in the literature when investigating the effects of a multidimensional program on the reduction of sedentary behavior objectively measured in older adults with physical frailty, identified by validated criteria (Dent et al., 2019). The primary aim of this study was to evaluate the effect of a multidimensional program including home-based standing exercises, health education, and telephone support for the reduction of sedentary behavior in frail older adults. Secondary aims were to evaluate the safety and adherence of the trial. We hypothesize that this program would decrease sedentary behavior in frail older adults.

2. Methods

2.1. Research design

This study included a single-center, single-blind randomized controlled clinical trial involving two groups: the intervention group subjected to combined strategies including home-based standing exercises, health education, and telephone support, and a control group, which received usual care from a multidisciplinary team and orientation regarding the harmful effects of a sedentary lifestyle. The study was developed following the Consolidated Standards of Reporting Trials (CONSORT) statement and was registered in the Registry of Clinical Trials as RBR-8w35rx. Written informed consent was obtained from all the participants. The study was approved by the Commission for Research Ethics and the local ethics committee under the number 65494617.8.0000.0068, according to the Declaration of Helsinki.

2.2. Participants

The participants of this study were community-dwelling older adults registered and followed in the geriatric outpatient facility specializing in the care of the frail older adults, located in a tertiary hospital of the medical school, University of São Paulo, Brazil, where they received health care from a multidisciplinary team. These older adults were presumed to be frail or prefrail because they were treated at a specific outpatient clinic for physical frailty. First, a screening was performed by telephone to identify frail older adults who reported spending more than 8 h/day in a sitting position. Potential participants were invited for a face-to-face evaluation to determine their eligibility for the study. Inclusion criteria were as follows: older adults, aged 60 years or more, presence of three of the five frailty phenotype criteria (Fried et al., 2001), self-reported sitting time > 8 h/day, and use of the accelerometer at least 4 days, 600 min/day. Exclusion criteria were as follows: an inability to remain standing even with support due to any disease or clinical condition (pain, orthopedic, mental, or neurological diseases), and absence of a caregiver to supervise the exercise in the case of older adults at high risk for falling, screened by the Timed Up and Go Test up to 20 s (Podsiadlo et al., 1991).

Randomization was carried out by a researcher who was not involved in the evaluation of participants, and it was performed electronically (www.randomization.com) with varying block sizes and concealed opaque envelopes.

2.3. Sample size calculation

The sample size calculation was performed using the G*Power program, based on the repeated measures ANOVA for the comparison of two groups and three evaluations, adopting an effect size of 0.25, alpha of 5%, and a beta of 80%. The total sample size was 28 participants. Considering a potential loss (attrition) of 30%, 36 participants were considered to be classified into two groups ($n = 18$ in each group).

2.4. Intervention group

Standing exercises: The intervention group participants performed five exercises at home, five times a week for 16 weeks: (1) standing, feet parallel, standing still; (2) standing, feet parallel, transferring medial-lateral weight; (3) standing, feet parallel, carrying out anteroposterior weight transfer; (4) standing, feet in a semi-tandem position, with associating anteroposterior weight shift, and (5) similar to step (4), inverting the lower limb placed in front. The duration of the exercises was determined based on the total time that each participant was able to remain standing in the initial assessment. The total time tolerated in the standing position (maximum of 30 min) was divided among the five exercises mentioned above, resulting in the personalized duration of each exercise (with a maximum time of 6 min each). Between exercises, the participants sat and rested for 1 min. Caregivers or relatives of the participants who were vulnerable to a higher risk of falling were instructed to remain at home with the participant throughout the exercise duration to offer greater support and safety. All the participants received an information pamphlet including guidance on each exercise and a calendar to fill in the days and time of practice, difficulties, and possible adverse effects.

Health education: The frail older adults participated in three face-to-face and individual meetings, which occurred in the pre-, intermediate- (8 weeks), and post-intervention (16 weeks) phases, to receive personalized guidance for self-management regarding sitting time. Subsequently, they were encouraged to identify opportunities to be more active in their daily routine (e.g., distribute tasks throughout the day, visit the environments of the house, explore external areas such as the backyard, garage, or garden and stand up during each advertising interval of television programs). The meetings lasted an average of 20 min and were overseen by a physiotherapist. All participants also received a general health care orientation provided by a multidisciplinary team composed of physicians and physiotherapists, and this orientation consisted of consultations and verbal guidance on the harmful effects of sedentary behavior.

Telephone support: A weekly telephone contact was made by a physiotherapist to encourage and provide guidance to the participant, and to discuss the participant's exercise implementation with the caregiver and the progression of their execution time (approximately 20% per week) according to the feeling of tiredness or discomfort. In these interactions, the participants' self-management of the exercises was encouraged, and the participants were given tips for practicing the exercises in different contexts of daily life (e.g., while watching television, sunbathing in the window or gate, helping someone to cook).

2.5. Control group

In the pre-, intermediate- (8 weeks), and post-intervention (16 weeks) phases, the participants of the control group received only usual health care consisting of three face-to-face consultations (pre-, intermediate-, and post-intervention) regarding the harmful effects of sedentary behavior.

2.6. Procedures

The data were collected by trained researchers, blinded to the allocation groups. Frailty was evaluated by the phenotype criteria (Fried et al., 2001). Unintentional weight loss, 5% of body weight or more in the last year; weakness measured with a handgrip dynamometer, using the best of three measures from the dominant hand, with cutoff point adjusted for gender and body mass index (BMI - weight/height^2) (men: BMI $\leq$ 23, cutoff point (CP) $\leq$ 27.00 kgf; 23 $<$ BMI $<$ 28, CP $\leq$ 28.67 kgf, 28 $\leq$ BMI $<$ 30, CP $\leq$ 29.50; BMI $\geq$ 30, PC $\leq$ 28.67; women: BMI $\leq$ 23, PC $\leq$ 16.33; 23 $<$ BMI $<$ 28, PC $\leq$ 16.67; 28 $\leq$ BMI $<$ 30, PC $\leq$ 17.33; BMI $\geq$ 30, PC $\leq$ 16.67) (Costa et al., 2011); Slowness measured by the time taken to walk 4.6 m, with cut-off point (PC) adjusted by sex and height (men: height $\leq$ 168, PC $\leq$5.49 s; height $>$ 168, PC $\leq$ 5.54 s; women: height $\leq$ 155, PC $\leq$ 6.61 s; height $>$ 155, PC $\leq$ 5.92 s) (Costa et al., 2011); Exhaustion defined by answering “a moderate amount of the time” or “most of the time” during the last week for the two questions “I felt that everything I did was an effort” and “I could not get going” (Batistoni, Neri, Cupertino, 2007); Physical inactivity measured by the International Physical Activity Questionnaire, short version, defined as no vigorous, moderate, or walking activity in the last 7 days (Craig et al., 2003). Secondary outcomes were collected in the intermediate- (8 weeks), and post-intervention (16 weeks). Sociodemographic and clinical data were collected at the baseline of the study.

2.7. Primary outcome

The primary outcome was the sedentary behavior assessed by an accelerometer (Actigraph GT3X), placed in the lateral region of the hip using an elastic band, used for seven consecutive days, 24 h, removing it only for bathing. Sleep time was excluded from the analysis and the sedentary behavior pattern was described as follows: (1) Total sedentary time (ST); (2) a 10 min bout of sedentary time (ST-10) and (3) break in sedentary time (BST). Episodes of sedentary bouts of $\geq$10 min were associated with frailty in the older adults (Del Pozo Cruz et al., 2017). The analyses considered the period between 7 a.m. and 10 p.m. The data were recorded so that the ST was equal to each min where the accelerometer computed less than 100 counts; ST-10 as the minimum of 10 consecutive min with less than 100 cpm, recorded in min/day; BST minimum of 1 min with more than 100 counts, in events/day and min/day (Del Pozo Cruz et al., 2017). Data referring to the minimum of four days of use with at least 10 h daily were considered valid (Blodgett et al., 2015). Continuous sequences of 90 min or more with zero count were excluded, considered as the time of not using the device (Choi et al., 2012). All variables were analyzed every 60 min (e.g., between 7:00 a.m. and 8:00 a.m.) (Gardiner et al., 2011). To account for the variation in the use of the accelerometer by the participants, the results were obtained by the daily average of the time of use of the device on valid days (that is, the values added throughout the time of use, divided by the number of days successfully monitored for each participant).

All variables were recorded in min/day and represented by the daily average. The data were processed using the Actilife software, provided by the manufacturer (Actigraph, Pensacola, FL).

2.8. Secondary outcomes

Safety: The possible adverse effects of the multidimensional program evaluated through self-report in the intervention group, recorded in the information pamphlet and communicated during weekly telephone contacts are as follows: pain, dizziness, shortness of breath, fall, chest pain, or any other adverse effect related to the intervention.

Adherence: The intervention group was evaluated through self-report on the number of days the program was carried out. The goal of the program was to practice the exercises five times per week for 16 weeks, equivalent to 80 days in total. Adherence to the program was considered satisfactory when the sum of the days in which the standing exercises were performed was equal to or greater than 70% of the goal.

2.9. Statistical analysis

The clinical and sociodemographic variables were compared at the pre-intervention time by using the Shapiro-Wilk test. To characterize the sample, the t-independent test, chi-square test, and the Mann-Whitney *U* test were applied depending on the data distribution. The effects of time, group, and interaction between the two groups on primary outcomes were analyzed by using repeated measure analysis of variance (RM-ANOVA) and Tukey's post hoc test. The time of use of the accelerometer at each evaluation moment was adjusted, included as a covariable in the analyses. Safety was analyzed through self-recorded adverse events in the information pamphlet and expressed as numbers and percentages. Adherence to the program was assessed based on the number of days in which the standing exercises were performed and expressed as mean and standard deviation. The missing data (no more than 30% of the sample) were treated using simple imputation for the intention-to-treat analysis. The level of significance adopted was 5%. Statistical analyses were performed by using JASP program (version 0.13).

3. Results

A total of 71 patients were recruited from July 2017 to December 2019, of which 43 patients were randomized and included in the intention-to-treat analysis. The enrollment, randomization, and treatment of the samples are shown in the CONSORT flow diagram (Fig. 1).

Clinical and sociodemographic baseline characteristics were compared, with no significant differences were observed between the two groups (Table 1). The study population was primarily female (86%) with a mean age of 85 $\pm$ 6.2 and 82.9 $\pm$ 6.7 in the control and intervention groups, respectively.

3.1. Primary outcomes

Table 2 summarizes the mean values and standard deviations between the evaluation periods and the mean differences between the groups with a 95% confidence interval, where the accelerometer wear time was included as a covariable in the analyses.

Total sedentary time (*ST*): RM-ANOVA did not show an effect of time ($F = 0.39$; $p = 0.67$) or group ($F = 1.61$; $p = 0.21$) but showed an effect of interaction between time and group ($F = 3.61$; $p = 0.032$). Tukey's post-hoc test showed that the intervention group presented a reduction of 30 $\pm$ 10 min/day in total sedentary time ($p = 0.048$) (Fig. 2).

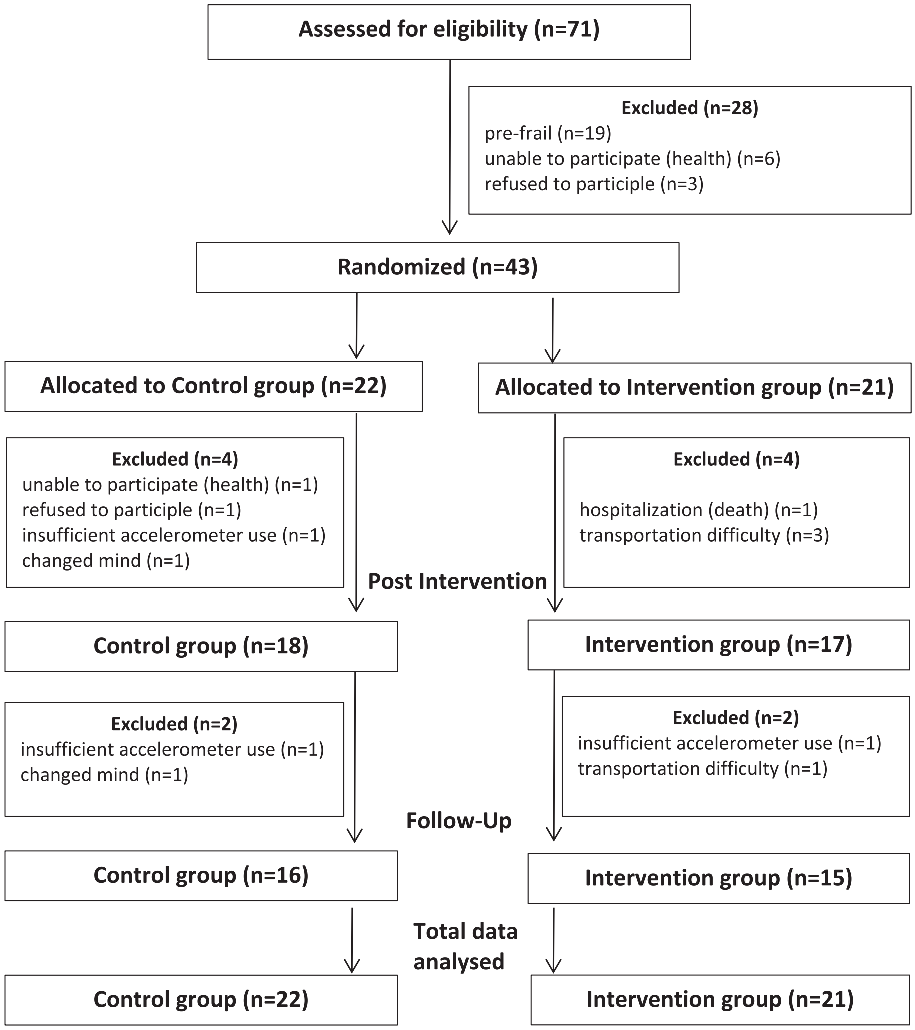

Fig. 1. Consort flowchart of enrollment, randomization, and treatment of the participants.

There was an interaction of the total sedentary time with the time of use of the accelerometer after intervention (F = 4.89; p = 0.010) e no follow up (F = 4.21; p = 0.018).

Bout sedentary time for 10 consecutive min (*ST-10*): RM-ANOVA did not show an effect of time (F = 1.27; p = 0.29), group (F = 1.83; p = 0.18), or interaction between time and group (F = 5.71; p = 0.005). There was a reduction in bouts of sedentary time of 44.8 ± 15.6 min/day, but no significant effect (Tukey's post hoc test, p = 0.058) (Fig. 2).

Break in sedentary time (*number/day and min/day*): There was no effect of time, group, or interaction between time and group in break in sedentary time in either group.

Participants in the control group showed no statistically significant differences in any of the evaluation times.

3.2. Secondary outcomes

Safety: The most common self-reported symptoms resulting from the standing exercises were tiredness and lower limb pain, reported by 53% (n = 9) and 47% (n = 8) of the participants, respectively. Most of the participants (64.7%; n = 11) presented a high risk of falls and were instructed to perform standing exercises under the supervision of their caregivers. No falls were reported by the participants.

Adherence: Of the 21 participants in the intervention group, 17 participants completed the program. Of these, 82% (n = 14) showed more than 70% adherence to the program (median days = 64.5). The causes of low adherence were unwillingness to perform the exercises (5.9%; n = 1) and fatigue and health problems (11.8%; n = 2).

4. Discussion

The primary aim of this study was to evaluate the effect of a multidimensional program including home-based standing exercises, health education, and telephone support on sedentary behavior in community-dwelling frail older adults. The secondary objective of this study was to evaluate the safety and adherence of this program.

The results of this study showed that the multidimensional program reduced 30 min/day in the total sedentary time of frail older adults. Previous pilot studies and non-controlled feasibility studies showed a decrease of 24 to 78 min/day in the sedentary time of older adults, measured by an accelerometer (Rosenberg et al., 2015; Lewis et al., 2016; Fitzsimons et al., 2013; Gardiner et al., 2011; Koltyn et al., 2019; Thralls and Levy, 2020). However, none of them included frail older adults, identified by specific and validated instruments (Dent et al., 2019). In addition, our study was a randomized clinical trial that elucidated the effects of a multidimensional intervention on sedentary behavior, specifically in frail older adults.

Although there is no ideal cut-off for reducing sedentary time (Manini et al., 2015), a decrease of 30 min/day seems to decrease the risk of frailty and all-cause mortality (Mañas et al., 2017; Nagai et al., 2018). However, previous studies on this subject were conducted based on an isotemporal analytical model, which estimates the effect of replacing sedentary time with mild physical activity; consequently, the

Table 1
Baseline characteristics of participants in the control and intervention groups.

Variable	Control (n = 22)	Intervention (n = 21)	p-values
Age, mean (SD)	85.1 (6.2)	82.9 (6.8)	0.27[b]
Gender, n (%)			0.95[a]
Female	19 (86.3)	18 (85.7)	
Male	3 (13.6)	3 (14.3)	
Race, n (%)			
White	15 (68.2)	16 (76.2)	0.20[a]
Black	3 (13.6)	5 (23.8)	
Others	4 (18.2)	0	
Marital status, n (%)			0.15[a]
Married	2 (9.1)	7 (33.3)	
Widower	17 (77.3)	11 (52.4)	
Others	3 (13.6)	3 (14.3)	
Income, n (%)			0.60[a]
≤ 575 US$	14 (32.5)	10 (23.2)	
Between 567 and 1150 US$	7 (16.3)	10 (23.2)	
Between 1151 and 1725 US$	1 (2.3)	1 (2.3)	
Retired, n (%)	19 (86.3)	15 (71.4)	0.20[a]
Educational Status, n (%)			0.92[a]
Never attended to school	5 (22.7)	5 (23.8)	
Less than primary school	9 (40.1)	10 (47.6)	
Primary school	5 (22.5)	2 (9.5)	
High school	2 (9.1)	2 (9.5)	
University education	1 (4.5)	2 (9.5)	
Frailty criteria, n (%)			0.80[c]
3 Criteria	13 (59.1)	11 (52.4)	
4 Criteria	6 (27.3)	8 (38.1)	
5 Criteria	3 (13.6)	2 (9.5)	
Grip strength, mean (SD)	17.6 (5.9)	15.1 (6)	0.37[b]
Weight loss, n (%)	8 (36.4)	9 (42.9)	0.66[a]
Exhaustion, n (%)	14 (63.6)	9 (42.9)	0.17[a]
Walk 4,6 m (sec), mean (SD)	8.4 (2.6)	9.5 (3.8)	0.46[c]
Time Up and Go (sec), mean (SD)	20.6 (5.8)	22.1 (7.7)	0.65[c]
Falls, mean (SD)	1.1 (2.2)	0.7 (1.5)	0.72[c]
Emergency room, mean (SD)	0.2 (0.4)	0.7 (1.4)	0.20[c]
Hospitalization, mean (SD)	0.3 (0.7)	0.3 (0.6)	0.69[c]
IPAQ, n (%)			0.30[a]
Sedentary	15 (68.2)	15 (71.4)	
Irregulary active	3 (13.6)	5 (23.8)	
Active	4 (18.2)	1 (4.7)	
Seated (week), min/day	482.7 (131.5)	528.6 (184.5)	
Seated (weekend) min/day	504.5 (145.4)	525.7 (192.5)	
Chronic conditions, n (%)			0.92[a]
Between 2 and 4	16 (72.7)	15 (71.4)	
More than 5	6 (27.3)	6 (28.6)	
Accelerometer wear (min/day), mean (SD)	877.2 (32.9)	880 (28.7)	0.86[c]

IPAQ international physical activity questionnaire.
[a] Chi-square test.
[b] t-Independent test.
[c] Mann-Whitney test.

results of these studies should be considered with caution (Nagai et al., 2018).

In this study, the multidimensional program was composed of simple, functional, and easy-to-perform exercises for the home environment, providing effort with light intensity to make it easier to incorporate into the daily routine of frail older adults. These exercises increased the exposure of frail older adults to a standing position, challenging the semi-static balance, and required five sit-to-stand transfers, which contributed to increased engagement of the muscles of the lower limbs. In sedentary behavior, the absence of contractile activity of the muscles of the lower limbs is considered a stress factor in the body, leading to muscle atrophy (Charansonney et al., 2011). The simple standing position requires the isometric contraction of the large lower muscles to counter gravity (Hamilton et al., 2008). Additionally to standing exercises, we included strategies to promote health education by stimulating sedentary time self-management, in addition to providing telephone support to improve self-efficacy in performing exercises.

Interventions of this nature, which induce a standing position, light physical effort, and lifestyle changes, seem to be the most recommended to reduce sedentary behavior, compared to the proposals for moderate to vigorous exercises (Cunningham et al., 2020; Copeland et al., 2017; Manini et al., 2015). However, it is still necessary to understand whether specific interventions on sedentary behavior can also influence domains related to physical performance (Copeland et al., 2017).

Home intervention associated with telephone support was considered an effective strategy, as 82% of the participants showed more than 70% adherence to the program.

However, the lack of maintenance of the effects of the intervention in the follow-up may be related to the suspension of telephone support at this stage, suggesting that continued interventions are important for maintaining the engagement of this population in making changes in their sedentary lifestyle (Chase et al., 2020).

The weekly telephone support was also important to follow the safety of the multidimensional program, whose most common symptoms were tiredness and limb pain, which are understandable considering the increased effort demanded by the standing posture. Fatigue and pain are frequent complaints of older adults engaging in light physical activities and have been identified as barriers in reducing sedentary time (Cunningham et al., 2020; Moraes et al., 2020). The importance of the caregiver is also emphasized in this study, who were responsible for monitoring the participants with a higher risk of falling.

The negative results of the control group suggest that verbal guidance alone is insufficient to reduce the sedentary behavior in frail older adults. These results reinforce the importance of coordination among health professionals in the use of strategies that involve health education and motivation for older adults, family members, and caregivers (Copeland et al., 2017).

This study had some limitations. First, it was impossible to blind the participants to the intervention model. Second, the randomized participants were mostly female and were selected from a single geriatric care service of a tertiary hospital, which reduced the external validity of the results of this study. Third, although the device used in this study is one of the most used accelerometers to investigate sedentary behavior (Boerema et al., 2020), we recognize its limitation in differentiating between standing and sitting positions with the potential to overestimate the time spent in sedentary behavior (Aguilar-Farías, Brown, Peeters, 2014; Boerema et al., 2020).

5. Conclusions

In this study, a multidimensional program including home-based standing exercises, health education, and telephone support proved to be effective in reducing sedentary time in frail older people. Additionally, the program was found to be safe and had satisfactory adherence concerning frail older adults. Given the evidence on the importance of reducing sedentary behavior, the following findings may be relevant for future interventions in frail older adults.

CRediT authorship contribution statement

Fabiana C. Tosi: conceptualization, methodology, data curation, formal analysis, writing (original draft, revision & editing). Sumika M. Lin: conceptualization, methodology, investigation, data curation, writing (revision). Gisele C. Gomes: conceptualization, methodology, investigation, data curation, writing (revision). Ivan Aprahamian: conceptualization, writing (revision & editing). Naomi K. Nakagawa, Larissa Viveiro, Jessica M. R. Bacha, Wilson Jacob-Filho: conceptualization, writing (revision). Jose Eduardo Pompeu: conceptualization, methodology, writing (revision & editing), supervision.

We affirm that all authors have approved the submitted version of this manuscript which contains original work that has not been previously published and that it is not being submitted for publication elsewhere.

Table 2
Primary outcomes according to accelerometer data, adjusted by using time.

Variable	Pre	Post	FU	Mean difference 95%CI[a]		d-Cohen[a]		Comparison between groups mean difference 95% CI[a]	
	Mean (SD)	Mean (SD)	Mean (SD)	Post x Pre	FU x Pre	Pre x Post	Pre x FU	Post	FU
ST (min/day)								54.5 (−34, 143)	35.3 (−53, 123.7)
Control	697.4 (62.6)	713.4 (81.7)	697.4 (79.7)	10.8 (−41, 19.4)	6.2 (−36.6, 23.9)	−0.1	0		
Intervention	710.7 (84.2)	675.2 (88.9)	701.9 (100.6)	−30* (1, 61)	−15.3 (−15.6, 46.3)	0.45	0.2		
ST-10 (min/day)								96.4 (−53, 245.7)	71.8 (−77.8, 221)
Control	532.5 (113.2)	568.4 (128.9)	549.3 (133.6)	32.1 (−78.2, 14.1)	22.6 (−68.8, 23.5)	- 0.3	−0.2		
Intervention	559.5 (148.1)	510.6 (150.4)	535.9 (177.1)	−44.8 (−2.5, 92)	−29.6 (−17.7, 77)	0.44	0.3		
BST (n/day)								0.5 (−3.4, 4.5)	1.1 (−2.8, 5)
Control	22.9 (3.1)	22.7 (3.9)	22.2 (3.5)	−0.1 (−1.9, 2.1)	0.2 (−2.2, 1.8)	0	0		
Intervention	21.7 (5.1)	20.9 (3.9)	21.16 (4.5)	−0.9 (−1.2, 3)	−1.1 (1, 3.2)	0.2	0.2		
BST (min/day)								−98.3 (−249, 52.2)	−85.1 (−235, 65.4)
Control	343.6 (119.8)	317.9 (139)	318.3 (146)	−34.1 (−13.6, 81.9)	−29.8 (−17.9, 77.6)	0.3	0.3		
Intervention	323 (157.6)	354.6 (169.5)	349.9 (177.4)	40.5 (−89.5, 8.5)	31.6 (−80.7, 17.4)	−0.4	−0.3		
Accelerometer Wear time								21.9 (−9.3, 53.2)	−8.5 (−39.8, 22.7)
Control	877.2 (32.9)	885.5 (27.4)	875.4 (38.1)	8.7 (−29.3, 11.8)	−1.8 (−18.8, 22.3)	−0.2	0		
Intervention	880 (28.7)	864 (46.6)	884 (24.1)	−16 (−5, 37)	4 (−25, 17)	0.3	−0.1		

ST: Sedentary time; FU: Follow-Up; CI: Confidence Interval; n/day: number per day; ST-10: bout sedentary time for 10 consecutive minutes; BST: Breaks in sedentary time.
* Tukey's post hoc test $p = 0.048$.
[a] Accelerometer wear time was included as a covariable in the analyses.

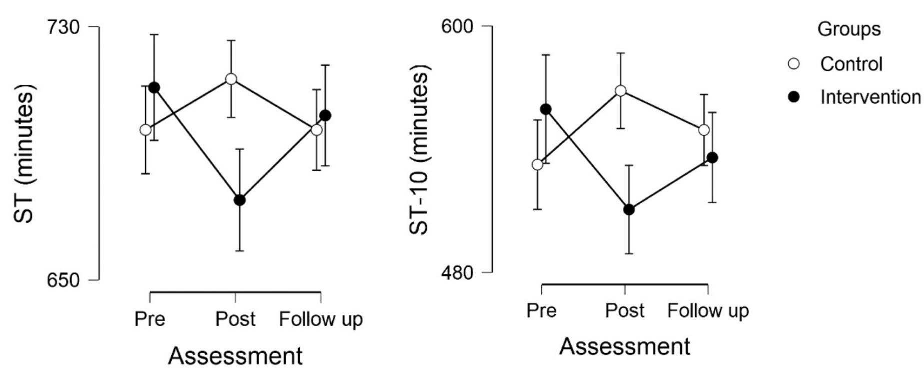

Fig. 2. Total sedentary time (ST) and bout sedentary time for 10 consecutive min (ST-10) of Control and Intervention groups. Vertical bars indicate the 95% confidence interval.

Declaration of competing interest

The authors declared no conflicts of interest.

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References

Aguilar-Farías, N., Brown, W.J., Peeters, G.M., 2014 May. ActiGraph GT3X cut-points for identifying sedentary behaviour in older adults in free-living environments. J. Sci. Med. Sport 17 (3), 293–299. https://doi.org/10.1016/j.jsams.2013.07.002.
Barone Gibbs, B., Brach, J.S., Byard, T., et al., 2017. Reducing sedentary behavior versus increasing moderate-to-vigorous intensity physical activity in older adults. J. Aging Health 29 (2), 247–267. https://doi.org/10.1177/0898264316635564.
Batistoni, S.S., Neri, A.L., Cupertino, A.P., 2007 Aug. Validade da escala de depressão do Center for Epidemiological Studies entre idosos brasileiros [Validity of the Center for Epidemiological Studies Depression Scale among Brazilian elderly]. Portuguese Rev. Saude Publica 41 (4), 598–605. https://doi.org/10.1590/s0034-89102007000400014. PMID: 17589758.
Blodgett, J., Theou, O., Kirkland, S., et al., 2015. The association between sedentary behaviour, moderate–vigorous physical activity and frailty in NHANES cohorts. Maturitas 80 (2), 187–191.

Boerema, S.T., van Velsen, L., Vollenbroek, M.M., Hermens, H.J., 2020 Feb 10. Pattern measures of sedentary behaviour in adults: a literature review. Digit. Health 6, 2055207620905418. https://doi.org/10.1177/2055207620905418. PMID: 32095261; PMCID: PMC7013117.
Borbón-Castro, N.A., Castro-Zamora, A.A., Cruz-Castruita, R.M., Banda-Sauceda, N.C., De La Cruz-Ortega, M.F., 2020 Jan 24. The effects of a multidimensional exercise program on health behavior and biopsychological factors in mexican older adults. Front. Psychol. 10, 2668. https://doi.org/10.3389/fpsyg.2019.02668. PMID: 32038344; PMCID: PMC6993582.
Chase, J.D., Otmanowski, J., Rowland, S., Cooper, P.S., 2020 Oct 12. A systematic review and meta-analysis of interventions to reduce sedentary behavior among older adults. Transl. Behav. Med. 10 (5), 1078–1085. https://doi.org/10.1093/tbm/ibz189. PMID: 33044538.
Choi, L., Ward, S.C., Schnelle, J.F., Buchowski, M.S., 2012. Assessment of wear/nonwear time classification algorithms for triaxial accelerometer. Med. Sci. Sports Exerc. 44 (10), 2009–2016. https://doi.org/10.1249/MSS.0b013e318258cb36.
Costa, T.B., Neri, A.L., 2011 Aug. Medidas de atividade física e fragilidade em idosos: dados do FIBRA Campinas, São Paulo, Brasil [Indicators of physical activity and frailty in the elderly: data from the FIBRA study in Campinas, São Paulo State, Brazil]. Portuguese Cad Saude Publica 27 (8), 1537–1550. https://doi.org/10.1590/s0102-311x2011000800009. PMID: 21877002.
Copeland, J.L., Ashe, M.C., Biddle, S.J., et al., 2017. Sedentary time in older adults: a critical review of measurement, associations with health, and interventions. Br. J. Sports Med. 51 (21), 1539.
Craig, C.L., Marshall, A.L., Sjöström, M., Bauman, A.E., Booth, M.L., Ainsworth, B.E., Pratt, M., Ekelund, U., Yngve, A., Sallis, J.F., Oja, P., 2003 Aug. International physical activity questionnaire: 12-country reliability and validity. Med. Sci. Sports Exerc. 35 (8), 1381–1395. https://doi.org/10.1249/01.MSS.0000078924.61453.FB. PMID: 12900694.
Charansonney, O.L., 2011 Sep. Physical activity and aging: a life-long story. Discov. Med. 12 (64), 177–185.
Cunningham, C., Sullivan, R., Caserotti, P., Tully, M.A., 2020. Consequences of physical inactivity in older adults: a systematic review of reviews and meta-analyses. Scand. J. Med. Sci. Sports 30 (5), 816–827.
Del Pozo-Cruz, B., Mañas, A., Martín-García, M., Marín-Puyalto, J., García-García, F.J., Rodriguez-Mañas, L., Guadalupe-Grau, A., Ara, I., 2017 Sep 11. Frailty is associated with objectively assessed sedentary behaviour patterns in older adults: evidence from the Toledo study for healthy aging (TSHA). PLoS One. 12 (9), e0183911 https://doi.org/10.1371/journal.pone.0183911. PMID: 28892505; PMCID: PMC5593182.
Dent, E., Morley, J.E., Cruz-Jentoft, A.J., 2019. Physical frailty: ICFSR international clinical practice guidelines for identification and management. J. Nutr. Health Aging 23 (9), 771–787. https://doi.org/10.1007/s12603-019-1273-z. PMID: 31641726; PMCID: PMC6800406.
Fitzsimons, C.F., Kirk, A., Baker, G., et al., 2013 Nov. Using an individualised consultation and activPALTM feedback to reduce sedentary time in older scottish adults: results of a feasibility and pilot study. Prev. Med. 57 (5), 718–720. https://doi.org/10.1016/j.ypmed.2013.07.017.
Fried, L.P., Tangen, C.M., Walston, J., 2001. Frailty in older adults: evidence for a phenotype. J. Gerontol. A Biol. Sci. Med. Sci. 56, 146e156.6.
Gardiner, P.A., Eakin, E.G., Healy, G.N., Owen, N., 2011 Aug. Feasibility of reducing older adults' sedentary time. Am. J. Prev. Med. 41 (2), 174–177. https://doi.org/10.1016/j.amepre.2011.03.020.
Hamilton, M.T., Healy, G.N., Dunstan, D.W., Zderic, T.W., Owen, N., 2008 Jul. Too little exercise and too much sitting: inactivity physiology and the need for new recommendations on sedentary behavior. Curr. Cardiovasc. Risk Rep. 2 (4), 292–298. https://doi.org/10.1007/s12170-008-0054-8. PMID: 22905272; PMCID: PMC3419586.
Harvey, J.A., SFM, Chastin, Skelton, D.A., 2018 Mar 1. Breaking sedentary behaviour has the potential to increase/ maintain function in frail older adults. J. Frailty Sarcopenia Falls 3 (1), 2631. https://doi.org/10.22540/JFSF-03-026. PMID: 32300691; PMCID: PMC7155349.
Hoogendijk, E.O., Afilalo, J., Ensrud, K.E., Kowal, P., Onder, G., Fried, L.P., 2019 Oct 12. Frailty: implications for clinical practice and public health. Lancet 394 (10206), 1365–1375. https://doi.org/10.1016/S0140-6736(19)31786-6.
Katzmarzyk, P.T., 2014. Standing and mortality in a prospective cohort of Canadian adults. Med. Sci. Sports Exerc. 46 (5), 940–946. https://doi.org/10.1249/MSS.0000000000000198.
Koltyn, K.F., Crombie, K.M., Brellenthin, A.G., et al., 2019. Intervening to reduce sedentary behavior in older adults–pilot results. Health Promot. Perspect. 9 (1), 71.
Lewis, L.K., Rowlands, A.V., Gardiner, P.A., et al., 2016. Small steps: preliminary effectiveness and feasibility of an incremental goal-setting intervention to reduce sitting time in older adults. Maturitas 85, 64–70.
Mañas, A., Del Pozo-Cruz, B., García-García, F.J., et al., 2017. Role of objectively measured sedentary behaviour in physical performance, frailty and mortality among older adults: a short systematic review. Eur. J. Sport Sci. 17 (7), 940–953.
Manini, T.M., Carr, L.J., King, A.C., et al., 2015. Interventions to reduce sedentary behavior. Med. Sci. Sports Exerc. 47 (6), 1306.
Martin, A., Fitzsimons, C., Jepson, R., et al., 2015. Interventions with potential to reduce sedentary time in adults: systematic review and meta-analysis. Br. J. Sports Med. 49 (16), 1056–1063. https://doi.org/10.1136/bjsports-2014-094524.
Moraes, S.A., Furlanetto, E.C., Ricci, N.A., Perracini, M.R., 2020 Sep-Oct. Sedentary behavior: barriers and facilitators among older adults after hip fracture surgery. A qualitative study. Braz. J. Phys. Ther. 24 (5), 407–414. https://doi.org/10.1016/j.bjpt.2019.07.001. Epub 2019 Jul 10. PMID: 31345662; PMCID: PMC7563798.
Morley, J.E., Vellas, B., van Kan, G.A., et al., 2013 Jun. Frailty consensus: a call to action. J. Am. Med. Dir. Assoc. 14 (6), 392–397. https://doi.org/10.1016/j.jamda.2013.03.022. PMID: 23764209; PMCID: PMC4084863.
Nagai, K., Tamaki, K., Kusunok, H., et al., 2018. Isotemporal substitution of sedentary time with physical activity and its associations with frailty status. Clin. Interv. Aging 13, 1831.
O'Caoimh, R., Sezgin, D., O'Donovan, M.R., et al., 2021 Jan 8. Prevalence of frailty in 62 countries across the world: a systematic review and meta-analysis of population-level studies. Age Ageing 50 (1), 96–104. https://doi.org/10.1093/ageing/afaa219.
Owen, N., Sugiyama, T., Eakin, E.E., et al., 2011 Aug. Adults' sedentary behavior determinants and interventions. Am. J. Prev. Med. 41 (2), 189–196. https://doi.org/10.1016/j.amepre.2011.05.013.
Podsiadlo, D., Richardson, S., 1991 Feb. The timed "Up & Go": a test of basic functional mobility for frail elderly persons. J. Am. Geriatr. Soc. 39 (2), 142–148. https://doi.org/10.1111/j.1532-5415.1991.tb01616.x.
Rosenberg, D.E., Lee, I., Young, D.R., et al., 2015. Novel strategies for sedentary behavior research. Med. Sci. Sports Exerc. 47 (6), 1311.
Travers, J., Romero-Ortuno, R., Bailey, J., Cooney, M.T., 2019 Jan. Delaying and reversing frailty: a systematic review of primary care interventions. Br. J. Gen. Pract. 69 (678), e61-e69 https://doi.org/10.3399/bjgp18X700241. Epub 2018 Dec 3. PMID: 30510094; PMCID: PMC6301364.
Thralls Butte, K., Levy, S.S., 2020 Dec 2. Stand up now: a sedentary behavior intervention in older adults of moderate to low physical function. J. Aging Phys. Act. 1, 13. https://doi.org/10.1123/japa.2020-0047. Epub ahead of print. PMID: 33271504.