

A randomized controlled trial of the effect of supervised progressive crosscontinuum strength training in older medical patients: the STAND-Cph trial

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Abstract

Background: During hospitalization, older adults (+65) are inactive, which puts them at risk of functional decline and loss of independence. Systematic strength training can prevent loss of functional performance. However, we lack knowledge about the effect of strength training commenced during hospitalization and continued after discharge in older medical patients. This assessor-blinded, randomized study investigated the effect of a simple, supervised strength training program for the lower extremities, combined with post-training protein supplementation during hospitalization and 4 weeks at home after discharge on change in mobility in older medical patients.

Methods: Older medical patients (≥ 65 yrs) admitted acutely from their home to the Emergency Department were randomized to either standard care or supervised progressive strength training and an oral protein supplement during hospitalization and at home 3 days/week for 4 weeks after discharge. The primary outcome was between-group difference in change in mobility from baseline to 4 weeks after discharge assessed by the De Morton Mobility Index. Secondary outcomes were 24-hour mobility, lower extremity strength, gait speed, grip strength and Activities of Daily Living.

Results: Eighty-five patients were randomized to the intervention (N=43) or control group (N=42). In the intervention group, 43% were highly compliant with the intervention. Our intention to treat analysis revealed no between-group difference in mobility (difference baseline to 4 weeks: -4.17 (IQR -11.09;2.74; $p=0.24$) nor in any of the secondary outcomes. The per protocol analysis showed that the intervention group increased significantly more in the daily number of steps taken compared to the control group (difference in change from baseline to 4 weeks: 1024.7 steps (IQR 0.7;2048.6); $p<0.05$; adjusted for mobility at baseline).

Conclusions: Simple supervised strength training for the lower extremities, combined with protein supplementation initiated during hospitalization and continued at home for 4 weeks after discharge was not superior to usual care on change in mobility at 4 weeks in older medical patients. For the secondary outcome, daily number of steps, high compliance with the intervention resulted in a higher daily number of steps. Less than half of the patients were compliant with the intervention indicating that a simpler intervention might be needed.

Trial registration: NCT01964482, <https://clinicaltrials.gov/ct2/show/NCT01964482>, registration date: October 14, 2013, trial protocol: PubMed ID (PMID): 27039381.

Background

For many older adults, the ability to live independently is ranked a very important health outcome [1], and independence is considered a prerequisite for control and freedom of choice in daily life [2]. Therefore, it is unfortunate that for many older adults (+65) hospitalization is linked with an increased risk of functional decline and loss of independence [3, 4] partly due to preventable events like excessive bed rest or low levels of mobility [5–9]. There is extensive knowledge about the risk of adverse events as a

consequences of in-hospital inactivity: loss of muscle mass and -strength [10–15] especially in the lower extremities [11, 14, 16, 17]; loss of independence in everyday activities [18]; institutionalization and death [7]. Nevertheless, older adults spend the majority of their in-hospital time in bed [7, 19–23].

It has been reported that functional status at discharge and one month after discharge are associated with long term outcomes [24, 25]. Thus, it seems imperative to reduce physical inactivity during hospitalization and to focus on regaining functional performance within the first month after discharge. Preferably by initiating an exercise program in the hospital and continuing this program in the home setting after discharge [26–28].

Systematic strength training has shown promising results in preventing loss of strength and functional performance [29–33]. Also, weight-bearing exercises seem preferable to non-weight-bearing exercises [34] and higher intensities superior to lower intensities [35–38]. However, there's a lack of knowledge regarding the optimal dose and intensity of strength training and the optimal exercises in different settings for older adults [29, 35, 39], and challenges with compliance have been reported [27, 40, 41].

Therefore, in this randomized controlled trial in older medical patients, we determine the effect on mobility of a simple, low technology, supervised, high intensity strength training program for the lower extremities, combined with post-training protein supplementation initiated during hospitalization and continued in the home setting for 4 weeks after discharge. We hypothesized that the intervention was superior to usual care.

Methods

Study design and participants

This is the primary trial report of a randomized controlled trial conducted from September 2013 to September 2016 at Copenhagen University Hospital Hvidovre in Denmark and in the participants' own homes (ClinicalTrials.gov-identifier: NCT01964482). Patients from three municipalities (Copenhagen, Hvidovre and Broendby) were recruited on weekdays except during holiday periods. During this period, recruitment was paused for 7 months in the municipality of Copenhagen (January to July 2014) and for 1 month in the municipality of Hvidovre (June 2015) due to lack of staff. A full trial protocol has previously been published [42]. Briefly, on weekdays the primary investigator or one of three assistant investigators identified eligible newly admitted patients. Older medical patients (≥ 65 yrs) acutely admitted from their own home to the Emergency Department of the hospital were included based on random sampling. Patients were excluded for the following criteria: terminal illness, in treatment for diagnosed cancer, diagnosis of Chronic Obstructive Pulmonary Disease (COPD) and participation in a

COPD rehabilitation program, living outside the three included municipalities, inability to speak or understand Danish, inability to cooperate in tests/exercises, transferal to the intensive care unit, isolation-room stay, an expected hospitalization <24 hours, or inability to stand. The reporting of this study follows the CONSORT (Consolidated Standards of Reporting Trials) Statement, using the extension for non-pharmacological trials [43].

Procedures

Assessments and randomization

After inclusion, baseline assessments were performed by one of four outcome assessors at the Acute Medical Admissions Ward or at an internal medicine ward at the hospital. Hereafter, the included patients were randomized to either the intervention group or the control group according to a computer-generated block randomization list developed by the study coordinator [42]. The patients were re-assessed in their own homes within the first week following discharge, four to five weeks after discharge (primary end-point and end of intervention) and 6 months after discharge. The primary investigator or one of the three assistant investigators, who are all trained physiotherapists, were outcome assessors and performed all baseline and follow-up assessments. All assessments of a patient were performed by the same investigator whenever logistically possible.

Blinding

We ensured that the outcome assessors were blinded to group assignment [42] and the randomization list was unavailable to the outcome assessors at all times. The research assistant was in charge of all communication with physiotherapists in charge of supervising the strength training sessions and all logistics in connection with home assessments. Also, all patients were asked not to reveal to the investigators to which group they belonged.

Study groups

Control group

Patients assigned to the control group received standard care during hospitalization and following discharge (for further details, please see Pedersen et al. 2016 [42]).

Intervention group

Patients assigned to the intervention group received progressive strength training supervised by a skilled physiotherapist on weekdays during hospitalization and 3 days per week for 4 weeks in their own home after discharge. A total of 12 training sessions (over a maximum of 5 weeks) were provided after discharge. Every training session consisted of a warm up program for the lower extremities followed by two progressive strength training exercises, a sit-to-stand exercise (STAND) (Figure 1) followed by a heel raise exercise (Heel-raise) (Figure 2) as outlined in Pedersen et al 2016 [42]. Both exercises followed predefined models of progression allowing for performance of the exercise from a seated position to performing the exercise unilaterally with extra load (level 1 to level 7/level 8). The STAND progression model was found feasible in a previous study [44]. Both exercises were performed for 3 sets of 8-12 repetitions maximum (RM) in each set [45]. The progression models shown in Figures 1 and 2 were applied to every single set of both exercises by the supervising physiotherapist. Each training session lasted approximately 20 minutes including warm up. Immediately after each training session the patients were asked to consume an oral protein supplement (Nutridrink Compact Protein from Nutricia A/S) containing 18 g milk-based protein and 300 kcal.

Standardization of assessments and intervention

To ensure standardization of the intervention, the primary investigator performed pre-intervention meetings with all involved outcome assessors and physiotherapists. At meetings for outcome assessors only, the assessors were introduced to and trained in the assessments to ensure standardization. In addition, before conducting an assessment the outcome assessors observed 1 or 2 sessions conducted by the primary investigator. Further, the primary investigator supervised each assessor for an assessment at the hospital and an assessment in a home setting. At meetings physiotherapists only, the physiotherapists were trained in both the warm up program and the strength training protocol. Should questions arise during the study, the outcome assessors could contact the primary investigator regarding the assessments and the physiotherapists could contact a senior physiotherapist regarding the exercise intervention. Also, a geriatrician could be contacted in case of medical concerns.

Outcomes

The outcome assessments were performed: on admission (baseline), within the first week after discharge, four to five weeks after discharge (primary endpoint) and 6 months after discharge.

Primary Outcome Measure

The primary outcome was change in the De Morton Mobility Index (DEMMI) score from baseline to 4 weeks after discharge. The DEMMI is a valid and reliable measure of mobility in older adults [46–49]. The

DEMMI is scored from 0 to 100 where 100 represents the highest level of mobility [46, 47], and a score below 62 is considered to reflect limited mobility in community-dwelling older adults [50]. In acute older medical patients, the minimal clinically important difference on the DEMMI score is 10 points [46, 49].

Secondary Outcome Measures

The secondary outcomes have been described in detail in Pedersen et al. 2016 [42]). Briefly, the secondary outcomes were:

- 24-hour mobility measured by an *activPAL3*TM activity monitor (PAL Technologies Ltd, Glasgow, UK). The patient wore the *activPAL3*TM during hospitalization, the first week after discharge, the first week after the 4-week assessment and the first week after the 6-month assessment. The *activPAL3*TM monitors continuously for 7 days assessed time spent sitting/lying, standing and walking, and the number of steps taken. The monitor was replaced after 7 days in case of hospitalizations extending beyond 7 days. In agreement with an observational study preceding this randomized controlled study [19], and to maximize the number of full days with 24 hours of measurements, we considered a day to be from 12 am until 12 am to avoid half-day measurements as the accelerometers were normally attached in the morning. Because very few patients are hospitalized for more than 6 days, we only included the first 6 days of hospitalization in the analysis. To avoid skewed days in the analysis only patient-days with more than 20 hours of measuring were included when studying the distributions of sitting/lying, standing and walking. The *ActivPal3*TM has been shown valid and reliable in measuring posture and transitions in mobility limited older adults [51, 52] and in measuring walking at speeds between 0.67 m/s and 1.56 m/s [53–55]. The *ActivPal3*TM data will be dichotomized into sedentary (sitting/lying) and upright time (walking/standing) according to our protocol [42] if 15% walk at speeds below 0.67 m/s, since the percentage error in measuring steps is higher for slow walkers than fast walkers [52–56].
- Isometric knee extension strength (IKE; Nm/kg) in the dominant leg measured by a handheld dynamometer (Power Track II Commander; JTech Medical, Utah) with the patient seated in a standard chair (height 45 cm), arms crossed over the chest and 90 degrees knee flexion [57, 58]. The patient was asked to perform three maximal knee extensions (5 second duration, 1 minute apart). The highest value obtained was used as the outcome.
- The 30-sec sit-to-stand test (STS; number in 30 secs) using a standard arm chair (seat height 45 cm) [59]. The patient was asked to stand up and sit down as many times as possible in 30 seconds. We used a modified 30-sec sit-to-stand test allowing arm rest support for patients who were unable to rise once from the chair with the arms crossed over the chest.
- Habitual gait speed (HG; m/s) measured on a 4-meter course [60, 61] from a standing start position (walking aids were allowed). The faster of two walks was used as the outcome. A gait speed below

0.8 m/s is considered to reflect poor mobility [62].

- Hand-grip strength (HGS; kg) in the dominant hand measured with a handheld dynamometer (Digi-II; Saehan) with the patient seated in a standard armchair (seat height 45 cm) with the lower dominant arm placed on the armrest, 90 degrees elbow flexion and neutral wrist position. The highest value of three maximal squeezes of the handle (5 second duration, 1 minute apart) was used as the outcome.
- The Barthel Index 20 (BI) was used as a measure of Activities of Daily Living (ADL) [63]. The BI is scored between 0 and 20 with higher scores indicating less disability in ADL's.

Additional variables

We collected descriptive variables and possible confounders and modifiers: age, sex, education, living status, history of smoking, use of ambulatory devices, use of municipal help, history of falls during the last year, mobility by the New Mobility Score [64, 65], ambulatory capacity by the Cumulated Ambulation Score [66], cognition by the Short Orientation-Memory-Concentration test (OMC) [67] and the Mini Mental State Examination [68], depression by the Geriatric Depression Scale (GDS) [69], health status by the EuroQol instrument [70], nutritional state by the Mini Nutritional Assessment [71], self-reported physical activity [72, 73], pain before and after training by the Verbal Ranking Scale (VRS) [74, 75], medications, history of training before admission and history of municipal training after discharge. In addition to the protocol [42], from January 2015 patients in the intervention group were asked about their satisfaction with the strength training intervention in 5 questions with corresponding 3-4 level rating scales: 1. How satisfied are you with the training intervention? (Very satisfied; Satisfied; Dissatisfied; Very dissatisfied; Don't know); 2. I have benefitted from the strength training sessions (Strongly agree; Agree; Disagree; Strongly disagree; Don't know); 3. The amount of training was (Appropriate; Too little; Too much; Don't know); 4. I will (Continue training on my own; Continue training with others; Stop training; I don't know); 5. Are you satisfied with the results of the training? (Very satisfied; Satisfied; Dissatisfied; Very dissatisfied; I don't know). A research assistant called the participant after completion of the intervention to ask the 5 questions. Also, from the National Patient Registry we obtained data on comorbidities and readmissions. The Charlson Comorbidity Index [76] was calculated based on the International Classification of Diseases, 10th Edition (ICD-10) [77], and we used registry data on hospital admissions and outpatient visits during the 10 years preceding the admission causing inclusion into this study.

Exercise diary

During each training session the supervising physiotherapist recorded the exercise level, number of repetitions completed, and the extra load added (kg). Pain before and after each training session was recorded using the Verbal Ranking Scale [74]. The amount of protein consumed and reasons for non-participation were also recorded. High compliance with the intervention was defined as completion of 80 % of all training sessions with a minimum of two sets performed per session and moderate compliance

was defined as completion of 67% of all training sessions (8 out of 12 sessions) performed with a minimum of two sets per session.

Data management

Trial data management complied with the rules of the Danish Data Protection Agency and was performed blinded to group allocation. All data were double entered in Epidata Entry 3.1 (Epidata Associations, Odense, Denmark). Ranges were checked for data values and checked against the case report forms. Data from the *activPAL3*TM monitors were downloaded using the *activPAL*TM Professional software version 7.2.32. All data were exported to SAS Enterprise Guide 7.1 (SAS Institute Inc., Gary, NC, USA).

Sample size

We estimated our sample size based on unpublished data from a cohort study performed at Hvidovre Hospital in older medical patients showing a mean change in the de Morton Mobility Index [49] score of 1.8 from admission to 4 weeks after discharge and a standard deviation of 12.8. A sample of 54 patients was required to detect a 10 point difference (minimal clinically important difference [49]) in the between-group change in the DEMMI score at the four week assessment, given a type I error rate of 5% and a power of 80% for a 2-sample t-test of a normal mean difference with a 2-sided significance level. According to our protocol, we included patients until both groups contained 25 patients assessed for the primary end-point (4 weeks).

Statistical analyses

Depending on the distribution of the variables, descriptive data are presented either as means with standard deviations, medians with inter-quartile ranges or frequencies with percentages. For determining differences between the two study groups (intervention versus control) we used the χ^2 test for categorical variables, the Student's t test for normally distributed continuous variables, and the Mann-Whitney U for non-normally distributed variables. Our primary analysis for the primary outcome was a Mixed Model analysis of the between-group difference in change in the DEMMI score from baseline to 4 weeks after discharge using the SAS procedure PROC MIXED. The analysis followed the intention-to-treat (ITT) principle for all randomized patients, using multiple imputation in case of missing data points and was unadjusted (for the number of imputations at each assessment point, please see Additional File 1). Imputation of missing data was based on age, group and all previous assessments or time points. For ActivPal data, only the first day during hospitalization was imputed to avoid imputation for days when the patients were not hospitalized and thereby to account for uneven lengths of stay. This imputation was based on age, group and baseline DEMMI score. According to Graham et al [78] we used 100

imputations to avoid a power falloff. The patient identification number and municipalities were modelled as random variables, group and time were modelled as fixed factors and the between-group difference in change in DEMMI was estimated from the interaction between the time and the group variable. We also analyzed the effect during hospitalization and the effect after ended intervention based on the primary analysis model. Similar analyses were performed for the secondary outcomes with all analyses being adjusted for baseline DEMMI. Also, to account for imbalances in in-hospital time, an analysis was performed for the effect during hospitalization and the effect from baseline to end of intervention adjusted for length of hospital stay. In addition, a per protocol (PP) analysis was performed comparing patients who had fulfilled the compliance criteria (80% of post discharge sessions completed with a minimum of 2 sets in each session) with those in the control group who had not dropped out before the 4-week assessment and, thus, would have been able to comply with the intervention if they had been assigned to the intervention group. In the PP analysis, ActivPal data from days 5 and 6 at 6 months were not included in the analysis due to too many missing data. All between-group differences are expressed as the average difference in change from baseline to relevant outcome time with corresponding 95% confidence intervals. All models were investigated for goodness-of-fit (linearity, variance homogeneity and normal distribution of residuals) by visual inspection of residual plots and remodeled if necessary. We used SAS Enterprise Guide 7.1 (SAS Institute Inc., Gary, NC, USA) for all statistical analyses and considered p values ≤ 0.05 to be statistically significant.

Results

A total of 85 patients were included and randomized to the intervention group (N=43) or the control group (N=42). Figure 3 illustrates the flow of patients throughout the study [79]. Between baseline and 4 weeks, twelve patients in the intervention group were lost to follow up (27%). Reasons for declining to participate any further were: lack of information about the extent of the study; lack of time/too many things going on; being in the middle of a divorce; exercise-induced muscle soreness; and chronic leg pain. Seventeen patients in the control group were lost to follow up (40%). Reasons for declining to participate any further were: impeding surgery; not wishing to continue; lack of time/too many things going on; lack of information; and not wanting to have anything to do with the hospital. There were no significant baseline differences in age, sex and DEMMI score between patients lost to follow up and patients remaining in the study at 4 weeks (all $p > 0.31$). In both groups, 1 patient was lost to follow up between 4 weeks and 6 months. We lacked ActivPal3™ data for 24 patients during hospitalization (8 lost to follow up, 2 monitors not attached due to miscommunication, 1 allergic reaction to adhesive padding, 7 monitors lost at the ward, 6 data for less than 20 hours), 29 patients after discharge (2 took the monitor off, 1 allergic reaction to adhesive band, 14 lost to follow up, 10 did not want to wear the monitor, 1 felt itching under the monitor, 1 lost monitor), 41 patients after the 4 week assessment (27 lost to follow up, 2 not able to cooperate, 1 allergic to adhesive band, 10 did not want to wear the monitor, 1 felt itching under the monitor) and 46 patients after the 6 months assessment (29 lost to follow up, 2 not able to cooperate, 1 allergic to adhesive band, 12 did not want to wear the monitor, 1 felt itching under the monitor, 2 lost monitors).

Baseline characteristics

At baseline, no between-group differences appeared to be clinically relevant (no hypothesis testing was undertaken as suggested by the CONSORT group, Table 1). Overall, the patients were 82.3 years of age (SD 7.4), 65.9% were female and 67.1 % were living alone. The majority was admitted to the hospital with pulmonary problems and the median length of stay was 4 days.

Table 1. Baseline characteristics

Outcomes

The between-group differences for the primary and secondary outcome measures are shown in Table 2, and the values for the primary and secondary outcomes at the four assessment points are shown in Table 3.

Table 2. Between-group differences in change scores from baseline to discharge, 4 weeks and 6 months (Δ intervention- Δ control).

Table 3. Primary and secondary outcomes at 4 assessment points (ITT) (non-imputed data).

Primary outcome

Both the ITT analysis and the PP analysis showed no significant between-group difference in change in the DEMMI for any of the three periods assessed (baseline to 4 weeks after discharge; baseline to discharge; 4 weeks to 6 months) (Table 2). In addition, no differences were found when adjusting the analyses for length of stay (LOS) (results not shown). However, a significant change in DEMMI from baseline to 4 weeks was found in both groups in both the ITT analysis (mean difference from baseline to 4 weeks, intervention: 8.3 points (95 % CI 0.6;16.0), $p=0.04$; mean difference from baseline to 4 weeks, control: 11.5 points (95% CI 3.5;19.4), $p<0.01$) and in the PP analysis (mean difference from baseline to 4 weeks, intervention: 10.6 points (95 % CI 0.6;20.6), $p=0.04$; mean difference from baseline to 4 weeks, control: 11.6 points (95% CI 2.9;20.3), $p<0.01$) (results not shown).

Secondary outcomes

During hospitalization, the participants spent an average of 21.7 hours per day being sedentary (sitting/lying), a median of 1.8 hours in upright position (standing or walking) and took a median of 702 steps per day. On admission, their knee extension strength was 0.7 Nm/kg (IQR 0.5;0.9), they performed 6 sit-to-stand transitions in 30 seconds (IQR 0;9), their habitual gait speed was 0.6 m/s (IQR 0.4;0.8), their handgrip strength was 28.9 kg for men (IQR 23.1;37.0) and 15.6 kg for women (IQR 13.0;20.2), and they had a Barthel score of 20 (IQR 18;20) (Table 1).

For all secondary outcomes, the ITT analyses showed no significant between group differences in change scores for any of the three periods (baseline to 4 weeks; hospitalization; post intervention) except for an increase in handgrip strength in the intervention group during hospitalization in both the unadjusted and the adjusted analyses (Table 2). The PP analyses showed that between baseline and 4 weeks post discharge, the intervention group increased significantly more in the daily number of steps taken (difference in change from baseline to 4 weeks: 1024.7 (IQR 0.7;2048.6); $p < 0.05$; adjusted for DEMMI baseline) compared to the control group and increased more in gait speed and handgrip strength during hospitalization (Table 2). Post intervention there was a significant between-group difference in knee extension strength in favor of the control group (Table 2), because knee extension strength decreased in the intervention group while this was not the case for the control group (Table 3). Overall, we found a significant increase in STS from baseline to 4 weeks (mean difference from baseline to 4 weeks, overall, ITT: 2.9 (95 % CI 1.3;4.7), $p = 0.001$; mean difference from baseline to 4 weeks, PP: 3.0 (95 % CI 0.6;5.3), $p = 0.01$). Also, a significant change was found within both groups in the ITT analysis (mean difference from baseline to 4 weeks, intervention: 3.1 (95 % CI 0.5;5.6), $p = 0.02$; mean difference from baseline to 4 weeks, control: 2.7 (95% CI 0.3;5.2), $p = 0.03$) and in the control group in the PP analysis (mean difference from baseline to 4 weeks, intervention: 3.0 (95 % CI -0.8;6.9), $p = 0.12$; mean difference from baseline to 4 weeks, control: 3.0 (95% CI 0.2;5.9), $p = 0.04$). No within group differences were found in gait speed, handgrip strength, knee extension strength and ADL (results not shown).

Compliance and satisfaction with the intervention

Overall, 43% (18/42) of the patients randomized to the intervention group were highly compliant with the intervention (80% of sessions performed with 2 sets of 8 RM). Of those who remained in the study at 4 weeks, 60% (18/30) were highly compliant and 23% (7/30) were moderately compliant with the intervention (minimum 8 out of 12 (67%) sessions performed with 2 sets of 8 RM). All patients consumed the protocolled amount of protein. Between week 1 and week 4 of the intervention, we found a general increase in the level of exercise performed in both the sit-to-stand exercise and the heel-raise exercise. Thus, in the sit-to-stand exercise 20% more patients trained at levels 6-7 in week 4 compared to week 1, and in the heel-raise exercise 24% more patients trained at levels 5-7 in week 4 compared to week 1. Also,

in both exercises those training with weighted vest (STAND level 6, heel-raise level 5) increased their load by 1.5 kg ($p < 0.01$) and 2 kg ($p < 0.01$), respectively. None of the patients reported an increase in pain during the training sessions.

Twenty-five patients from the intervention group were asked about their satisfaction with the intervention. The majority were satisfied or very satisfied (88%) with the intervention, and two thirds (68%) were satisfied or very satisfied with the results of the intervention. The majority (17/25) felt they had benefitted from the strength training sessions and that the amount of training was appropriate (20/25). Also, 16/25 said they would continue training either alone or with others.

There was no difference between the groups in the number of readmissions between discharge and 4 weeks and between discharge and 6 months. Also, there was no difference between the groups in the number of days hospitalized between discharge and 4 weeks and between discharge and 6 months (results not shown).

Discussion

This randomized controlled trial investigated the efficacy of a simple, supervised strength training program for the lower extremities, combined with post-training oral protein supplementation, initiated during hospitalization and continued in the home setting for 4 weeks after discharge in acutely admitted older medical patients. The main finding was that no effect of the intervention was seen on mobility, assessed by the DEMMI score, at any of the investigated time points. However, we did find a significant increase in the number of steps taken in the intervention group as compared to the control group in our per protocol analysis. Overall, 43% of the patients were highly compliant with the intervention and we found a general increase in the level of exercise performed in both exercises. None of the intervention group patients reported an increase in pain during the exercises and most of them expressed satisfaction with the intervention.

The intervention was not superior to usual care in improving mobility (DEMMI) from baseline to 4 weeks. However, both groups improved their mobility and the improvement reached beyond a clinically important difference [49] in the control group in the intention to treat analysis and in both groups in the per protocol analysis. Also, we found no effect on mobility during hospitalization. This is in agreement with previous studies in geriatric patients showing no effect on mobility, assessed by the DEMMI [80], nor on functional outcomes [81] of an in-hospital progressive strength training program. Several reasons for the lack of effect in our primary outcome can be suggested.

Firstly, the intervention had a relatively short duration. It is likely that longer training periods are required to benefit older adults. Studies by Hvid et al [10, 82] have shown that older adults are more susceptible to periods of inactivity and require longer time than younger adults to fully recover. Also, Jadczyk et al. recommend interventions with a duration of at least 2.5 months [83]. Accordingly, a systematic review by Valenzuela et al. [33] concludes that progressive resistance training in older nursing home residents is efficient in improving strength and functional performance despite advanced age, chronic diseases, sedentary habits, and functional disabilities. However, all interventions investigated by Valenzuela et al. had a duration of at least 2 months [33]. Equivalently, previous studies have found an effect on both strength and functional abilities of 10 weeks of supervised progressive lower extremity resistive exercises using own weight and Therabands in both frail older adults living in a care facility [84] and community dwelling older adults [85]. Equal to our study, both studies used 3 weekly training sessions, but slightly more extensive programs (4-8 exercises) [84, 85]. A systematic review by Borde et al. looking at resistance training in healthy older adults found that the training period, the intensity and the total time per repetition under tension all are parameters of significance for the effect on muscle strength with the largest effect sizes seen for the longest periods (50-53 weeks), intensities of 70-79% of 1RM, and a total time under tension per repetition of 6 seconds [86]. While the intensity and time under tension recommended by Borde et al. [86] were used in our intervention, we were far from the optimal period presented (50-53 weeks). However, it is questionable whether these recommendations can be followed in newly discharged acutely admitted older medical patients. Therefore, we chose a minimal treatment approach focusing on the initial 4 weeks after discharge. Despite a much shorter training period of only 4 weeks, we experienced a substantial drop out rate (28%) between baseline and 4 weeks and less than half of the remaining participants were highly compliant with the intervention (43%), indicating that participation would have been even lower in longer interventions.

Secondly, even though the DEMMI has been shown valid and reliable in measuring mobility in both older medical patients and in community-dwelling older adults [46, 47, 49], and has the ability to measure change in mobility after hospital discharge [49], the patients in that validation sample had much poorer mobility than our participants. Only half of the participants had a baseline DEMMI score below 62, reflecting limited mobility. The functions causing most participants difficulties were related to static and dynamic balance, i.e. tandem stand with closed eyes, walking 4 steps backwards and jumping [87]. Obtainment of a significant between group difference in favor of the intervention group would have required that the intervention group participants had learned these three functions, which is highly unlikely based on the provided intervention of sit-to-stand and heel raise exercises. Thus, for the intervention chosen, the DEMMI may not have been the best choice of primary outcome. Also, the intervention proposed may not be suitable for all patients, and it is worth considering stratifying patients to different interventions according to their mobility difficulties. Accordingly, a recent umbrella review [83] investigating the effect of exercise interventions in pre-frail community-dwelling older adults found

inconclusive results regarding the effect on mobility of both multi-component exercises and resistance exercises and suggested that only personalized exercises are effective in improving mobility.

Overall, we found no or very few between-group differences for the secondary trial outcomes. We found a difference in hand grip strength and gait speed during hospitalization in favor of the intervention group as well as a difference in the change in daily number of steps taken between baseline and four weeks in our per protocol analysis. Previous studies have also reported improvement in functional performance measures during hospitalization [88, 89]. However, in accordance with these studies [88, 89] the patients in the present study had poor performance at discharge – their knee extension strength was at the threshold level for independent ability to perform Activities of Daily Living [90] putting them at increased risk of future mobility limitations [91]. Also, their hand grip strength and walking speed were at levels indicating mobility limitations [62]. These low levels of functional performance at discharge are worthy of concern, since functioning has been linked with future risk of falls, functional decline [92], mobility- and ADL disability [61, 93, 94], and hospital readmissions [25] as well as death [60, 92, 95]. Older adults see mobility related to everyday functioning as vital to their health and as an indicator of well-being and independence enabling them to participate in life as they know it and therefore affecting more than the physical aspects of their life [96]. This underlines the importance of trying to counteract further mobility decline in connection with a hospitalization to help older adults maintain their independence. Like our study, Tibaek et al. [81] found no effect on mobility or strength of strength training in addition to standard physiotherapy. Also, Oestergaard et al. [80] found no effect of an in-hospital chair-based exercise program on mobility and muscle strength.

During hospitalization the participants took a median of 700 steps daily. This low level of steps during hospitalization has been shown to be associated with hospital associated functional decline [97]. Acknowledging that this was a secondary finding, we observed a significant between group difference in change in the number of steps taken between baseline and 4 weeks in favor of the intervention group in our per protocol analysis. At 4 weeks the control group took a median of 2800 steps compared to 4100 in the intervention group (Table 3). This difference is promising, since Floegel et al [98] found that each 1000 additional steps in the post-discharge period in older heart failure women was associated with better physical performance. Also, Breen et al [16] found that reducing the daily number of steps in healthy older adults by 1400/day during a fortnight led to a 4% reduction in leg lean mass, modest increases in inflammation markers and altered insulin sensitivity. Although the present study did not show an effect on neither mobility nor functional performance measures, the effect on steps is promising. Merely focusing on enhancing the number of steps taken during hospitalization and post discharge could be a goal for future studies, thus lowering the requirements for the acutely ill older adults who might find themselves unable to exercise [27]. In addition, an increase in the number of steps taken during hospitalization is associated with shorter length of stay [99], while a decline is associated with

greater risk of death within 2 years after discharge [100]. Accordingly, an association has been shown between steps per day post discharge and 30-day readmission rate [101]. In addition, Brown and co-authors [102] found factors like weakness, need for assistance, lack of interest from staff, and structural barriers to be reasons for inactivity in older medical patients (≥ 75 yrs). Thus, based on the findings from the present trial, we have changed our focus from exercise to walking to increase intervention compliance. In a current study, we investigate the effect of an intervention including a physical component (i.e. promoting walking) and a component focusing on overcoming structural barriers [103].

Strengths and limitations

Study strengths included that our intervention was initiated at the hospital and continued at home a few days after discharge, as well as choosing a minimally time-consuming treatment approach taking implementation in a busy care setting into account. Acutely hospitalized older adults may prefer for exercise to be initiated in the hospital or shortly after discharge. Also, Franco and co-authors found exercise at home, an improvement in the ability to undertake daily tasks, and no need to use transportation to be the three most important attributes for engaging in physical activity among community-dwelling older adults with a history of falls or self-reported mobility disability [104]. Thus, the fact that our intervention took place in the participants own homes shortly after discharge may have enhanced compliance. However, we do not have data to support this hypothesis.

Another strength of our study is that we have tried to overcome the previously reported lack of knowledge regarding the optimal nature and dose of exercise in older adults [29, 35, 39]. According to a recent review [105] low intensities are often the first choice among physiotherapists, as this is perceived to be safer. Low intensities, though, may be inadequate to achieve optimal effects on functional performance [38], why we wanted to investigate if higher intensities could be performed by older medical patients without inducing adverse events. Since we found few studies investigating the effect of a cross-continuum program initiated during hospitalization and continued after discharge [27, 40], and due to problems with compliance in these studies, we chose a program with full supervision from trained staff. Four weeks were chosen since it has previously been reported, that recovering function within the first month after discharge is of importance for long term outcomes [24]. Also, a study in older home care clients found that structured exercise programs are not

the preferred activity of these older adults [106] why a four-week program may be more acceptable than a program of longer duration. Additionally, a previous study in older hospitalized adults showed positive effects of exercise therapy performed during the first four weeks after discharge [40], leading us to believe, that four weeks might be sufficient in inducing an effect. Protein was chosen as an integrated part of the strength training intervention. Both resistance training and amino acids can stimulate an anabolic response [107] and in combination the two have been shown to enhance the muscular response

to exercise in healthy older adults [108–110]. The provided protein supplementation was intended to boost anabolism. However, it is unclear whether it has merely reduced an existing protein deficit since less than half of our participants could be considered in normal nutritional state on admission. Nevertheless, since older adults need a greater amount of daily protein than young adults to maintain muscle mass, and older adults with acute or chronic diseases or marked malnutrition, need even more [111], our intention was to fill out a potential protein gap.

A limitation in our study was, that a substantial number of participants dropped out between baseline and 4 weeks (27%) - half of these (N=12) dropped out between the admission and the discharge assessment. However, between baseline and 4 weeks the number of drop outs was smaller in the intervention group than in the control group indicating that the intervention itself was not the reason for dropping out. This is in line with previous studies reporting equivalent drop-out rates for in-hospital [81] and post-discharge training interventions [112]. In the present study, participants in both groups choosing to refrain from further participation described they lacked time and felt that the main entrance of their house had turned into a revolving door of health professionals. Also, older medical patients that may benefit from physical rehabilitation during and after hospitalization may have barriers preventing exercise participation. In a study by Brown et al. [27] reporting difficulties recruiting acutely admitted older medical patients, those declining to participate expressed that they did not feel like exercising or did not believe they could. The reasons for non-participation in the present study were e.g. lack of time, believing oneself to be sufficiently active or disbelief in the effect of exercise. A great number of patients were excluded from our study or declined to participate, leaving us with a very selected group of older medical patients. However, similar or lower consent rates, have been reported in previous studies in older medical patients [27, 40, 113]. This underlines the difficulties recruiting patients in the acute setting and limits the generalizability of the results. In the intervention group, only 43% were highly compliant with the intervention, which may explain the lack of effect seen in this study. This level of compliance, though, is in line with a study in acutely admitted geriatric patients [80] and stresses the challenges in maintaining acutely admitted older adults in training interventions. Also, we experienced a large amount of missing data in our study, among others due to the high number of drop outs. In addition, several ActivPals were lost during the intervention period, which may have affected the results.

Conclusions

A simple, low technology, supervised strength training program for the lower extremities, combined with post-training oral protein supplementation initiated during hospitalization and continued in the home setting for 4 weeks after discharge was not superior to usual care on change in mobility 4 weeks after discharge in acutely admitted older medical patients. For the secondary outcome, daily number of steps, high compliance with the intervention resulted in a higher daily number of steps.

Abbreviations

ADL: Activities of Daily Living

BI: The Barthel Index 20

CI: Confidence interval

CONSORT: Consolidated Standards of Reporting Trials

COPD: Chronic Obstructive Pulmonary Disease

DEMMI: The De Morton Mobility Index

GDS: The Geriatric Depression Scale

Heel-raise: Heel raise exercise

HG: Habitual gait speed

HGS: Hand-grip strength

ICD-10: The International Classification of Diseases, 10th Edition

IQR: Interquartile Range

ITT: Intention-to-treat

OMC: The Short Orientation-Memory-Concentration test

PP: Per protocol

RM: Repetition Maximum

SD: Standard Deviation

STAND: Sit-to-stand exercise

STS: The 30-sec sit-to-stand test

VRS: The Verbal Ranking Scale

Declarations

Ethics approval and consent to participate

All participants gave written informed consent before participation and the study procedures were approved by The Ethics Committee of the Capital Region of Denmark (H-2-2012-115) and by the Danish Data Protection Agency (2007-58-0015).

Consent for publication

Not applicable

Availability of data and material

The datasets generated and/or analysed during the current study are not publicly available due to regulations set out by the Danish Data Protection Agency regarding data anonymization but are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests. The funding bodies have had no authority over study design, collection and interpretation of data or the writing of the manuscript.

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Authors' contributions

MMP, TB, JP, OA and NB designed the study in collaboration with the municipalities of Copenhagen and Broendby. MMP was the primary investigator and project leader and responsible for patient recruitment and data management. HGJL helped in training the included patients. PSJ was responsible for the randomization list. MMP and JP were responsible for analyzing data. MMP wrote the first manuscript draft. Hereafter, all authors revised the manuscript critically for important intellectual content, and all authors approved the final version to be submitted for publication.

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Tables

Table 1. Baseline characteristics

Descriptive data	N	Overall (N=85)	N	Intervention (N=42)	N	Control (N=43)
Age (yrs)	85	82.3 (7.4)	42	82.1(7.4)	43	82.5(7.5)
Sex	85		42		43	
Male	29	34.1 %	12	28.6%	17	39.5%
Female	56	65.9 %	30	71.4%	26	60.5%
BMI	85	25.3(22.3;29.3)	42	25.3(22.3;29.1)	43	24.5(22.3;30.0)
Living alone (yes;%)	57	67.1%	29	69.1%	27	65.1%
Education (%)	85		42		43	
<High school	23	25.9%	10	23.8%	10	27.9%
Skilled	47	55.3%	23	54.8%	24	55.8%
High school	3	3.5%	2	4.8%	1	2.3%
Graduate	8	9.4%	4	9.5%	4	9.3%
Post graduate	5	5.9%	3	7.1%	2	4.7%
Smoking status	85		42		43	
Smoking (yes;%)	15	17.7%	8	19.1%	7	16.3%
Previous smoker (yes;%)	69	81.2%	33	78.6%	36	83.7%
Assistive devices	85		42			
Walking stick	22	25.9%	6	14.3%	16	37.2%
Crutches	7	8.2%	4	9.5%	3	6.9%
Walker	29	34.1%	12	28.6%	17	39.5%
Wheel chair	3	3.5%	2	4.8%	1	2.3%
Furniture support	24	28.6%	12	29.3%	12	27.9%
Scooter	5	5.9%	1	2.4%	4	9.3%
Use of municipal help	85		42		43	
Assistance from community (yes;%)	53 10	62.4% 11.8%	26 8	61.9% 19.1%	27 2	62.8% 4.7%
Personal help (yes;%)	17	20.0%	7	16.7%	10	23.3%
Cleaning (yes;%)						
Fall during past year (yes;%)	85 44					
		51.8%	22	52.4%	22	51.2%
Short Falls Efficacy Scale (score)	83	8 (7;10)	42	8(7;11)	41	8(7;9)
Admission diagnosis (category)	85		42		43	
Pulmonary	37	43.5 %	19	45.2 %	18	41.9 %
Cardiovascular	22	25.9 %	9	21.4 %	13	30.2 %
Other*	26	30.6 %	14	33.3 %	12	27.9 %
Charlson Comorbidity Index (no.)	85		42		43	
0	16	18.8 %	9	21.4%	7	16.3%
1-2	45	52.9 %	20	47.6%	25	58.1%
3+	24	28.2 %	13	31.0%	11	25.6%
Length of Stay (days)	83	4 (2;7)	40	4.50(2.5;7.0)	43	4(2;6)
New Mobility Score (points)	85		42		43	
Admission		5 (2;7)		4(2;7)		5(2;9)
In retrospect		7 (5;9)		7(6;9)		6(5;9)

Variables are presented as mean(SD), median(IQR) or percentages depending on the distribution of the variable. * Endocrinological, Neurological, Hepato-nephrological, Gastrological, Dermatological.

Table 2. Between-group differences in change scores from baseline to discharge, 4 weeks and 6 months (Δ intervention- Δ control).

Primary outcome	Baseline to 4 weeks	P	Baseline to discharge	P	4 weeks to 6 months	P
EMMI, score (ITT)	-4.17 (-11.09;2.74)	0.24	-0.51 (-6.51;5.49)	0.87	2.97 (-2.81;8.76)	0.31
EMMI, score (PP)	-1.00 (-9.28;7.27)	0.81	4.70 (-3.30;12.70)	0.25	1.55 (-2.86;5.95)	0.49
Secondary outcomes						
24-hour activity measures (ActivPal)						
Upright time, hrs/day (ITT)	0.06 (-0.89;1.02)	0.90	-0.60 (-1.20;0.001)	>0.05	0.25 (-1.02;1.53)	0.70
Upright time, hrs/day (PP)	0.22 (-0.79;1.23)	0.67	-0.57 (-1.18;0.05)	0.07	-0.01 (-1.33;1.31)	0.99
Lying/sitting, hrs/day (ITT)	0.03 (-1.02;1.09)	0.95	0.46 (-0.21;1.14)	0.18	-0.001 (-1.35;1.34)	0.99
Lying/sitting, hrs/day (PP)	-0.09 (-1.08;0.90)	0.86	0.30 (-0.39;0.99)	0.40	-0.19 (-1.45;1.07)	0.77
Steps, no. (ITT)	472.48 (-536.44;1481.41)	0.36	117.76 (-465.37;700.90)	0.69	339.12 (-1152.00;1830.25)	0.65
Steps, no. (PP)	1006.83 (-14.18;2027.84)	0.053	303.02 (-272.84;878.88)	0.30	44.59 (-1658.60;1747.79)	0.96
Adjusted for DEMMI baseline	1024.69 (0.74;2048.63)	<0.05	321.94 (-255.46;899.32)	0.27	44.59 (-1658.60;1747.79)	0.96
Adjusted for DEMMI baseline and LOS	1040.93 (13.92;2067.93)	<0.05	332.41 (-246.67;911.49)	0.26	44.59 (-1658.60;1747.79)	0.96
Physical performance measures						
ES, Nm/kg (ITT)	0.11(-0.02;0.24)	0.09	0.08 (-0.05;0.20)	0.24	-0.09 (-0.20;0.02)	0.11
ES, Nm/kg (PP)	0.13 (-0.02;0.29)	0.10	0.10 (-0.07;0.27)	0.23	-0.11 (-0.23;-0.002)	<0.05
FS, no. (ITT)	0.04 (-1.88;1.96)	0.97	0.33 (-1.22;1.87)	0.68	1.28 (-0.76;3.31)	0.22
FS, no. (PP)	-0.01(-2.29;2.27)	1.00	0.21(-1.96;2.39)	0.85	1.45 (-0.94;3.84)	0.23
S, m/s (ITT)	0.02(-0.06;0.10)	0.64	0.07(-0.003;0.15)	0.06	0.02(-0.06;0.11)	0.57
S, m/s (PP)	0.04(-0.07;0.15)	0.45	0.11(0.004;0.22)	0.04	0.02(-0.08;0.11)	0.74
G, kg (ITT)	0.49(-1.40;2.39)	0.61	1.86 (0.49;3.23)	<0.01	0.17 (-1.46;1.80)	0.84
G, kg (PP)	0.75(-1.37;2.87)	0.48	2.05(0.32;3.77)	0.02	-0.28(-2.11;1.55)	0.76
Harthel, score (ITT)	-0.09 (-0.83;0.66)	0.82	-0.26 (-0.87;0.34)	0.40	0.30 (-0.11;0.70)	0.16
Harthel, score (PP)	0.44 (-0.42;1.31)	0.30	0.02 (-0.65;0.70)	0.94	0.20 (-0.20;0.61)	0.33

Unadjusted values are shown for all comparisons and adjusted values are shown where these differ from the unadjusted analyses.

All values are given as mean (95% confidence interval). ITT: Intention to treat (N=85); PP: Per protocol (N=18 in intervention group (only those compliant with the intervention); N=26 in control group); DEMMI:

DeMorton Mobility Index; LOS: Length of stay; KES: Knee extension strength; STS: 30-sec sit-to-stand; GS: Gait speed; HG: Hand grip strength; Barthel: Barthel Index. For the number of imputations imputations at different time point for the primary and secondary outcomes please see Appendix 1.

Table 3. Primary and secondary outcomes at 4 assessment points (ITT) (non-imputed data).

	Intervention (N=42)							
	N	Hospitalization	N	Discharge	N	4 weeks	N	6 months
De Morton Mobility Index (points)	42	63.5(16.4)	37	69.8(16.5)	30	71.9(15.7)	27	70.9(15.5)
24-hour mobility (hrs/day)								
Lying/sitting	36	21.8(1.2)	31	20.6(1.3)	25	19.7(1.8)	22	19.4(1.9)
Uptime	36	1.4(0.1;1.8)	31	3.2(1.8;3.7)	25	4.0(3.0;5.2)	22	4.1(2.7;5.3)
Standing	36	1.2 (0.8;1.7)	31	2.5(1.5;3.1)	25	2.8(2.4;4.5)	22	3.1(2.2;4.4)
Walking	36	0.2 (0.1;0.3)	31	0.5(0.3;0.8)	25	0.9(0.4;1.0)	22	0.9(0.4;1.1)
Steps (no./day)	36	660(264;1285)	31	1962(1114;3219)	25	4147(1471;4683)	22	3515(1751;4805)
Transitions (no. up-down/day)	36	50 (41;82)	31	57(46;78)	25	54(47;64)	22	56(43;78)
Isometric knee extension (Nm/kg)	42	0.7(0.5;0.9)	36	0.7(0.5;0.9)	29	0.8(0.6;1.0)	26	0.8(0.6;0.9)
30-sec Sit-to-Stand test (reps)	40	5.5(0;9.5)	37	8(5;11)	30	9.5(6;12)	27	10(5;12)
30-sec sit-to-stand test mod. (reps)*	11	5(2;7)	6	6.5(5;8)	5	4(4;9)	5	7(4;8)
Habitual Gait Speed (m/s)	41	0.6(0.4;0.8)	37	0.7(0.6;0.9)	30	0.7(0.6;0.9)	27	0.7(0.6;0.9)
Hand grip strength (kg)	42	19.6(13.8;26.9)	38	23.5 (9.9)	30	23.5(10.0)	27	24.0(10.2)
Barthel Index 20 (points)	42	20(19;20)	37	20(19;20)	30	20(20;20)	27	20(19;20)
	Control (N=42)							
	N	Hospitalization	N	Discharge	N	4 weeks	N	6 months
De Morton Mobility Index (points)	43	58.1(16.2)	28	64.9(14.2)	26	69.5(15.7)	25	65.1(15.8)
24-hour mobility (hrs/day)								
Lying/sitting	25	21.5(1.5)	25	18.0(2.1)	19	20.3(1.7)	17	19.9(1.9)
Uptime	25	1.8(1.1;2.8)	25	3.7(2.0;4.5)	19	3.4(2.3;4.2)	17	3.9(2.7;4.6)
Standing	25	1.7(1.0;2.1)	25	3.1(1.5;4.0)	19	2.7(1.6;3.7)	17	2.9(2.1;3.8)

Walking	25	0.2(0.1;0.6)	25	0.5(0.3;0.6)	19	0.6(0.5;0.9)	17	0.6(0.4;0.9)
Steps (no./day)	25	754(187;2352)	25	1961(1370;2791)	19	2800(1607;3509)	17	2319(1300;4092)
Transitions (no. up- down/day)	25	47(26;68)	25	46.7(38;65)	19	51(36;64)	17	57(39;69)
Isometric knee extension (Nm/kg)	40	0.6(0.5;0.8)	27	0.6(0.4;0.8)	26	0.57(0.44;0.75)	23	0.6(0.5;0.7)
30-sec Sit-to- Stand test (reps)	39	6(0;9)	28	8.5(3.5;10)	26	7.5(5;12)	24	6(3;11.5)
30-sec sit-to- stand test mod (reps)*	10	7.5(4;9)	4	5.5(3.5;7)	3	7(6;9)	4	6(4;8.5)
Habitual Gait Speed (m/s)	41	0.6(0.5;0.8)	29	0.7(0.5;0.8)	26	0.64(0.54;0.87)	25	0.6(0.5;0.8)
Hand grip strength (kg)	43	20.2(14.4;25.8)	29	21.8(8.9)	26	22.4(8.7)	25	21.8(8.4)
Barthel Index 20 (points)	43	19(18;20)	29	20(19;20)	26	20(19;20)	25	20(19;20)

Variables are presented as mean(SD) or median(IQR) depending on the distribution of the variables.

**modified version where the use of the armrests is allowed.*

Figures

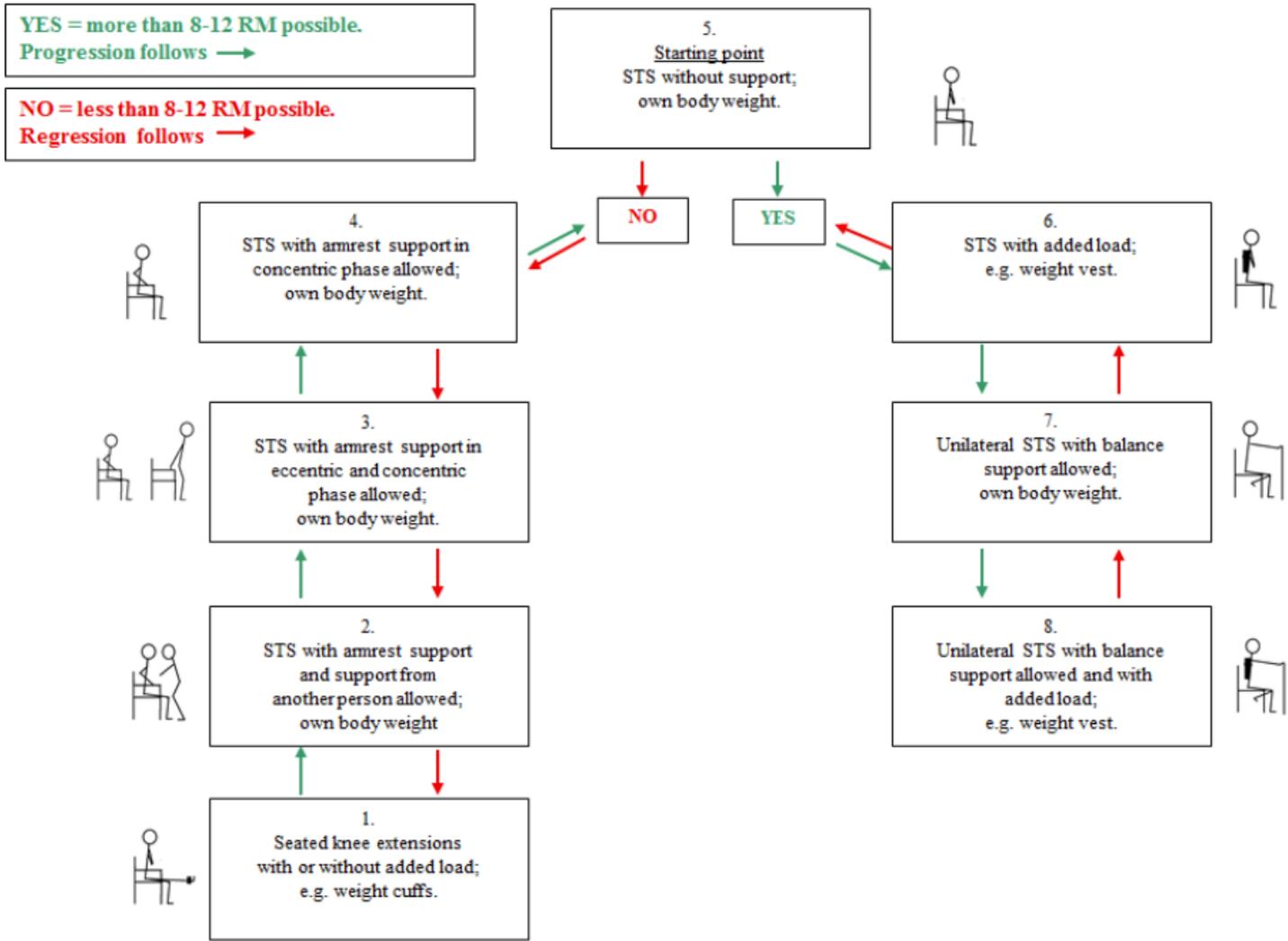


Figure 1

Progression model for loaded sit-to-stand exercise (STAND). The starting point in STAND in the first session was level 5. The patient was seated in a standard chair with armrests with the feet on the floor at shoulder-width and arms crossed at the wrist with the hands placed on the opposite shoulder. The patient was asked to rise to a fully extended position and to sit down in a constant pace and was encouraged verbally to perform as many repetitions as possible. The supervising physiotherapist ensured that each set of the exercise was performed at a level of the model ensuring 8-12 RM. If extra weight was needed, a weight vest (Titan Box, 1-30 kg) was used.

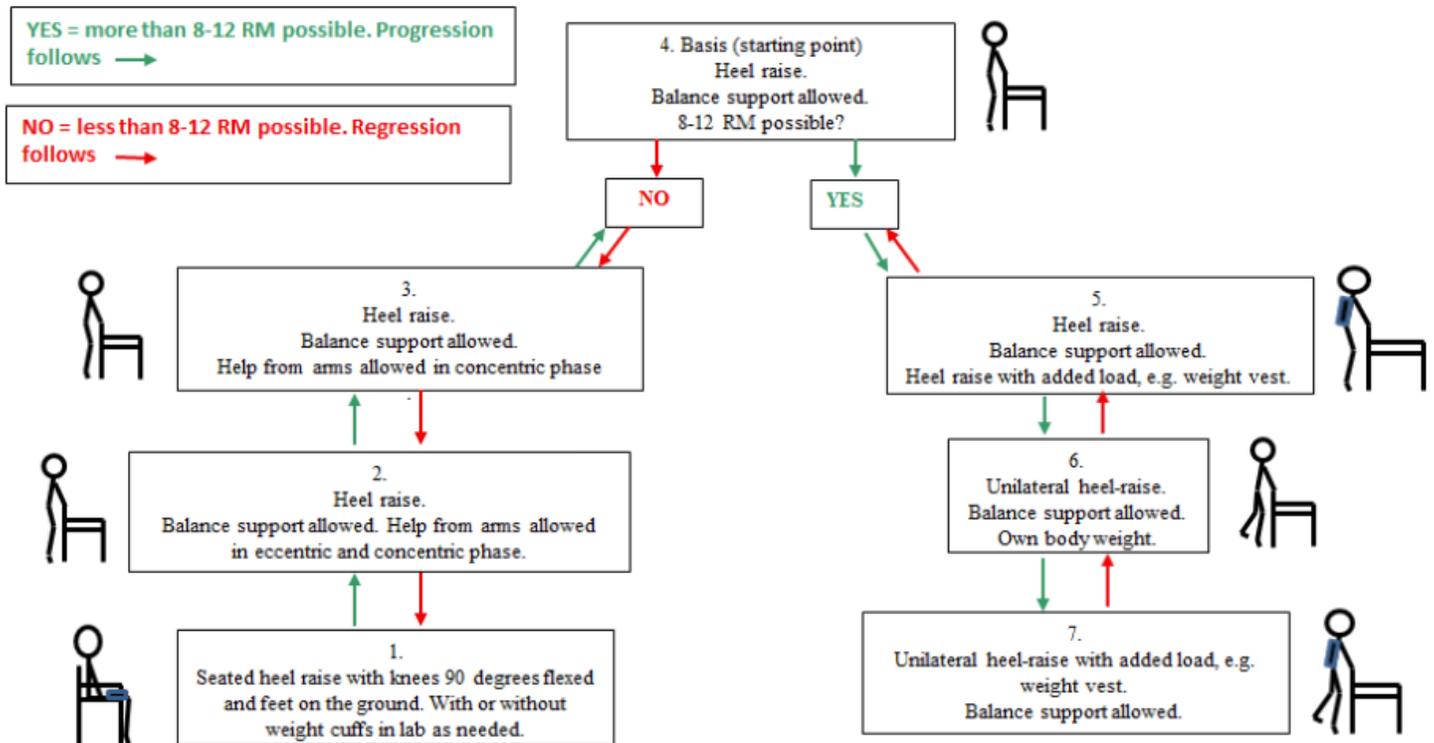


Figure 2

Progression model for loaded heel-raise (Heel-raise). The starting point in Heel-raise in the first session was level 4. The patient was standing behind a standard chair using the chair for balance support and keeping the feet on the floor at shoulder-width. The patient was asked to lift both heels to stand on the forefoot and to lower the heels to a standing position at a constant pace and was encouraged verbally to perform as many repetitions as possible. The supervising physiotherapist ensured that each set of the exercise was performed at a level of the model ensuring 8-12 RM. If extra weight was needed, a weight vest (Titan Box, 1-30 kg) was used.

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