Combating sarcopenia in geriatric rehabilitation patients: study protocol of the EMPOWER-GR observational cohort, sarcopenia awareness survey and randomised controlled feasibility trial

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ABSTRACT

Introduction  Sarcopenia is highly prevalent in geriatric rehabilitation patients. Resistance exercise training (RET) combined with protein supplementation is recommended to increase muscle mass and strength in older adults. However, sarcopenia awareness, feasibility to diagnose and treat sarcopenia, and efficacy of treatment in geriatric rehabilitation patients remain to be established.

Methods and analysis  Enhancing Muscle POWER in Geriatric Rehabilitation (EMPOWER-GR) encompasses four pillars: (1) an observational cohort study of 200 geriatric rehabilitation inpatients determining sarcopenia prevalence, functional and nutritional status at admission; (2) a survey among these 200 patients and 500 healthcare professionals and semistructured interviews in 30 patients and 15 carers determining sarcopenia awareness and barriers/enablers regarding diagnostics and treatment; (3) a feasibility, single-centre, randomised, controlled, open-label, two parallel-group trial in 80 geriatric rehabilitation patients with sarcopenia. The active group (n=40) receives three RET sessions per week and a leucine and vitamin D-enriched whey protein-based oral nutritional supplement two times per day in combination with usual care for 13 weeks. The control group (n=40) receives usual care. Primary outcomes are feasibility (adherence to the intervention, dropout rate, overall feasibility) and change from baseline in absolute muscle mass at discharge and week 13. Secondary outcomes are feasibility (participation rate) and change from baseline at discharge and week 13 in relative muscle mass, muscle strength, physical and functional performance, mobility, nutritional status, dietary intake, quality of life and length of stay; institutionalisation and hospitalisation at 6 months and mortality at 6 months and 2 years; (4) knowledge sharing on sarcopenia diagnosis and treatment.

Ethics and dissemination  Ethical exemption was received for the observational cohort study, ethics approval was received for the randomised controlled trial. Results will be disseminated through publications in scientific peer-reviewed journals, conferences and social media.

Strengths and limitations of this study

► This is the first study assessing feasibility and efficacy of a combined resistance exercise training (RET) and protein supplementation intervention to combat sarcopenia in geriatric rehabilitation inpatients.
► The study provides comprehensive insights from patients, carers and healthcare professionals.
► RET and protein supplementation will not be studied separately, making it impossible to indicate whether effects of the intervention are additional of one or the other.
► Due to the nature of the intervention, neither the study team nor the patient will be blinded in the feasibility randomised controlled trial.

INTRODUCTION

Geriatric rehabilitation after acute hospitalisation is a crucial step in an older patient’s functional recovery.1 It is estimated that over 50% of geriatric rehabilitation patients suffer from sarcopenia,2 low muscle mass and strength at older age.3 Malnutrition is an important modifiable risk factor of sarcopenia4; both conditions frequently coexist5 6 and are associated with worse functional recovery,7–10 readmission and mortality in geriatric rehabilitation patients.11–14 Diagnosis and treatment of sarcopenia is therefore essential.

Characterisation of muscle, functional and nutritional status in geriatric rehabilitation remains limited.15–17 Moreover, lack of knowledge and equipment impedes the integration of sarcopenia diagnosis and treatment in acute hospital, long-term, home and primary care.18–23 This remains unstudied in geriatric rehabilitation while gaining knowledge is crucial to raise
awareness and change clinical, evidence-based practice. To combat sarcopenia, resistance exercise training (RET), protein supplementation and its combination have been shown to improve muscle mass and/or muscle strength in older adults. While RET and protein supplementation are suggested to positively affect functional recovery in geriatric rehabilitation patients, feasibility and efficacy of their combination remain to be established.

Enhancing Muscle POWER in Geriatric Rehabilitation (EMPOWER-GR) aims to assess: (1) sarcopenia prevalence, functional and nutritional status of geriatric rehabilitation inpatients; (2) sarcopenia awareness and barriers/enablers of patients, carers and healthcare professionals regarding diagnostics and treatment of sarcopenia in geriatric rehabilitation; (3) feasibility and effect of a 13-week combined RET and protein supplementation intervention compared with usual care in geriatric rehabilitation patients with sarcopenia; (4) share knowledge on sarcopenia diagnosis and treatment.

METHODS AND ANALYSIS

Study design and setting
EMPOWER-GR is a consortium of university (VU, Vrije Universiteit Amsterdam), academic hospital (Amsterdam UMC), geriatric rehabilitation care provider (Cordaan) and industry (Danone Nutricia Research) partners in the Netherlands. The research project includes four pillars: (1) an observational cohort study; (2) a sarcopenia awareness survey and semistructured interviews; (3) a feasibility randomised controlled trial (RCT); (4) sharing knowledge (figure 1). The study is being conducted at all three geriatric rehabilitation locations (120 beds) of Cordaan, a large community care provider in the Amsterdam area, the Netherlands.

Observational cohort study
The observational cohort study will include 200 patients admitted to geriatric rehabilitation. Sarcopenia prevalence, functional and nutritional status will be assessed by use of a comprehensive geriatric assessment within 4 days of admission by physicians, nurses, physiotherapists, occupational therapists and a researcher. Length of stay and discharge destination will be recorded at discharge, and mortality data will be collected 6 months and 4 years after admission to geriatric rehabilitation.

Sarcopenia awareness
Within the observational cohort, a survey will be completed to assess sarcopenia awareness, perception of the importance of muscles for health and independence and barriers/enablers of treatment such as RET and protein supplementation. Semistructured interviews will be conducted in a random subset of 30 patients with sarcopenia and 15 carers, in chronological order of patient inclusion, to further explore the topics introduced in the survey. Additionally, knowledge about sarcopenia, diagnostic and treatment practices and barriers/enablers to the diagnosis and treatment of sarcopenia will be inquired among 500 geriatric rehabilitation healthcare professionals with an online survey. The survey will be distributed through Cordaan, various healthcare professional associations in the Netherlands as well as social medial (LinkedIn).

Feasibility RCT
The feasibility, single-centre, randomised, controlled, open-label, parallel-group intervention study aims to include 80 patients with sarcopenia admitted to geriatric rehabilitation. Figure 2 provides a schematic diagram. The screening assessment (visit 0 (V0)) will be performed within 4 days after admission to geriatric rehabilitation. Eligible participants will be randomly allocated (parallel group 1:1; block-randomised) to the intervention or to the control group by a researcher, stratified by sex and location. The random allocation sequence and randomisation will be generated by an independent statistician and sealed in envelopes. The intervention group will receive a combined RET and protein supplementation intervention in combination with usual care. The control group will receive usual care. Neither the study team nor the patients will be blinded given the nature of the intervention. Muscle strength and physical performance outcomes will be assessed by an independent assessor. Study assessments will be performed at baseline (V1), discharge (V2) and week 13 (V3). After completion of V1, the intervention will start during the geriatric rehabilitation admission and continue after discharge for a total of 13 weeks. In case of hospitalisation during the study period for 48 hours to 1 week, an additional assessment of primary/secondary outcomes will be performed within 48 hours after hospital discharge. No additional assessment will be performed for hospitalisation <48 hours and admission for >1 week will result in dropout.

Figure 1 EMPOWER-GR (Enhancing Muscle POWER in Geriatric Rehabilitation) study overview. RET, resistance exercise training.

*Patients from the observational cohort study that are able to answer the survey questions in opinion of the researcher and/or physician.
Usual care

Usual care for geriatric rehabilitation patients consists of four to five physiotherapy sessions depending on the needs of the patient, including functional (walking, transfer from bed/chair, stair climbing), balance, endurance and resistance training, and two occupational therapy sessions per week. Rehabilitation targets are formulated based on the International Classification of Function, Disability and Health. Progress is regularly assessed to evaluate the possibility of discharge. Most patients receive ambulatory treatment after discharge, including a total of two to three physiotherapy sessions. Patients using oral nutritional supplements (ONS) during hospitalisation and/or with inadequate nutrition during geriatric rehabilitation are referred to a dietitian by the physician and can be prescribed ONS. This will be closely monitored during the study.

Intervention

Patients in the intervention group will complete three progressive RET sessions of 30–45 min/week, which will replace three of the five regular physiotherapy sessions. The two other weekly sessions will be dedicated to functional, balance and endurance training as part of usual care. The RET sessions will be conducted by physiotherapists according to a predefined protocol at a relative intensity of the patient’s own maximal effort. The patient’s 1-RM (one repetition maximum) will be measured for each exercise during the first session. After familiarisation, exercises will be performed at 60% of 1-RM (week 1–2), aiming to progress to 70% (week 3–4) and finally 80% (week 5–13). The sessions will include a selection of seven upper body (chest press, lat pull down, vertical row, biceps curl) and lower body exercises (leg press, hamstrings curl, quadriceps extension), two to three sets and 8 to 15 repetitions per exercise. The exercises will be performed with a leg press, pulley or free weights.

Patients will consume two servings of a ready to drink leucine and vitamin D-enriched whey protein-based ONS (Fortimel Advanced, Nutricia N.V., Zoetermeer, the Netherlands) per day (200 mL per serving) provided at breakfast and lunch. On RET days, one serving of the supplement will be consumed after the RET session. The ONS is designed for patients with disease-related malnutrition and muscle loss and contains, per serving, 302 kcal, 21 g protein, 3 g leucine, 30 g carbohydrate, 10 g fat, 10 µg vitamin D and a mixture of other vitamins, minerals and fibres (online supplemental table 1). The combination of whey protein, leucine and vitamin D in the study product has been shown to stimulate muscle protein synthesis and increase muscle mass, as well as lower extremity function in sarcopenic older adults.

Recruitment and sample size

Eligible patients will be approached by a healthcare professional from Cordaan. Patients that show interest to participate will receive verbal and written information about the study by a researcher. After written informed consent is obtained, and inclusion and exclusion criteria (table 1) will be reviewed in consultation with a physician from Cordaan. For the observational cohort study, the sample size was set at 200 patients based on previous studies assessing sarcopenia prevalence and expected number of covariates to be analysed (approximately 20). For the feasibility RCT, in the absence of preliminary data to estimate the expected treatment difference, the sample size was set at 60 patients to be able to detect a large effect size (0.8) that is significant with 95% confidence and with a power of 90%. Expecting a dropout rate of 25%, also considering the prolongation of the intervention after discharge of geriatric rehabilitation, we aim to randomise 80 patients. Enrolment for the observational cohort study started in November 2020 and is expected to be completed by October 2021. For the feasibility RCT, enrolment started in May 2021 and is expected to be completed within 2 years.

Primary and secondary outcomes

Observational cohort study

The primary outcome is sarcopenia prevalence, and the secondary outcomes are functional and nutritional status at admission to geriatric rehabilitation.

Sarcopenia awareness

The primary outcome is sarcopenia awareness, that is, knowledge of the concept of sarcopenia, among geriatric rehabilitation inpatients, carers and healthcare professionals. Secondary outcomes include perception of the
importance of muscles for health and independence and barriers/enablers for sarcopenia diagnosis and treatment.

Feasibility RCT
The primary outcomes are feasibility, measured as adherence to the RET and ONS intervention, dropout rate and overall feasibility, and change from baseline in absolute skeletal muscle mass (SMM) at discharge and week 13. Secondary outcomes are feasibility measured as participation rate and change from baseline in the following parameters at discharge and week 13:

1. Relative muscle mass: fat-free mass percentage, relative SMM.
2. Muscle strength: handgrip strength, leg press 1-RM.
3. Physical performance: total Short Physical Performance Battery (SPPB) score, individual chair stand and gait speed tests.
4. Functional performance: Katz index for Activities of Daily Living (ADL), Lawton and Brody scale for Instrumental Activities of Daily Living (IADL).
5. Mobility: Functional Ambulation Classification (FAC).
6. Malnutrition: Global Leadership Initiative on Malnutrition (GLIM) criteria.
7. Dietary intake: 3-day dietary record.
8. Quality of life: 5-level EuroQol-5D version (EQ-5D-5L).
9. Length of stay in geriatric rehabilitation, 6-month institutionalisation and hospitalisation, 6-month and 2-year mortality.

Assessments
A schedule of assessments is provided in table 2.

Patient characteristics
Age, sex, primary reason for admission, medication and supplements use will be retrieved from patient files. Marital status, living situation, ethnicity, education, smoking behaviour, alcohol consumption and diet will be collected with a patient survey. Disease burden will be documented by a physician using the 56-point Cumulative Illness Rating Scale (CIRS) and 37-point Charlson Comorbidity Index (CCI), in which higher points

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Table 1 Inclusion and exclusion criteria of the observational cohort study and feasibility randomised controlled trial

| Inclusion criteria | Exclusion criteria |
|--------------------|-------------------|
| Aged 65 years or older | Unable to provide informed consent |
| Admitted to geriatric rehabilitation | Patients in isolation/quarantine |
| Written informed consent | Any condition that prevents completion of the study |
| Palliative care | Not possible to communicate in Dutch |

Feasibility randomised controlled trial

| Inclusion criteria | Exclusion criteria |
|--------------------|-------------------|
| Aged 65 years or older | Unable to provide informed consent and no proxy to consent |
| Admitted to geriatric rehabilitation | Rehabilitation after stroke or cancer |
| Diagnosed with sarcopenia (EWGSOP2 definition) | Patients in isolation/quarantine |
| Written informed consent | Palliative care or other adverse prognosis precluding post-intervention follow-up |
| Ongoing cancer treatment or radiotherapy/chemotherapy in the last 6 months | |
| Any GI disease that interferes with bowel function and nutritional intake | |
| Other relevant medical history or medication that could prevent participation in the intervention or affect the study outcome | |
| Patients with tube feeding at admission to geriatric rehabilitation. | |
| Renal impairment (estimated glomerular filtration rate <30 mL/min/1.73 m²) | |
| Body mass index >40 kg/m² | |
| Known soy allergy, known cow's milk protein allergy or galactosaemia, known severe Lactose intolerance; patients requiring a fibre-free diet | |
| Current alcohol or drug abuse in opinion of the investigator | |
| Not possible to communicate in Dutch | |

*Our aim is to assess muscle mass in minimum 60 participants. Therefore, a maximum of 20 patients with an electronic implant/pacemaker will be included in the study.

BIA, bioelectrical impedance analysis; EWGSOP, European Working Group on Sarcopenia in Older People; GI, gastrointestinal.
Table 2  Study parameters and schedule of assessments of the observational cohort study and feasibility randomised controlled trial

| Study parameters                                      | Source or instrument                        | OCS | Feasibility RCT |
|-------------------------------------------------------|---------------------------------------------|-----|-----------------|
| **Patient characteristics**                           |                                             |     |                 |
| Age, sex, reason for admission                        | Patient file                               | x   |                 |
| Marital status, living situation, ethnicity, education, smoking, alcohol consumption, diet | Patient survey                             | x   | x               |
| Medication/supplements use                            | Patient file                               | x   | x               |
| Comorbidities                                          | CIRS, score 0–56                           | x   | x               |
| Comorbidities                                          | CCI, score 0–37                            | x   | x               |
| Cognition                                              | SMMSE, score 0–30                          | x   | x               |
| Depression                                             | GDS, score 0–15                            | x   | x               |
| Risk of sarcopenia                                     | SARC-F, score 0–10                         | x   | x               |
| Height/knee height                                     | Stadiometer/calliper, cm                    | x   |                 |
| Weight                                                 | Chair scale/passive lift, kg               | x   | x               |
| Body mass index                                        | Weight/height², kg/m²                      | x   | x               |
| Nutritional status                                     | MNA-SF, at risk yes/no                     | x   | x               |
| Length of stay in GR                                    | Patient file, days                         | x   |                 |
| Discharge destination                                  | Patient file                               | x   |                 |
| Institutionisation                                     | Telephone interview                        |     | 6 months        |
| Hospitalisation                                        | Telephone interview                        |     | 6 months        |
| Mortality                                              | Dutch population registers 6 months/4 years|     | 6 months/2 years|
| **Muscle and physical performance measures**           |                                             |     |                 |
| Skeletal muscle mass                                   | BIA, kg                                     | x   | x               |
| Fat-free mass                                          | BIA, %                                      | x   | x               |
| Relative skeletal muscle mass                          | BIA, %                                      | x   | x               |
| Handgrip strength                                      | Hand-held dynamometer, kg                  | x   | x               |
| Leg press 1-RM                                         | Leg press, kg                              | x   | x               |
| Physical performance                                   | SPPB, score 0–12                           | x   | x               |
| Gait speed, m/s                                        |                                            | x   | x               |
| **Functional performance, mobility and quality of life**|                                             |     |                 |
| Activities of Daily Living                             | Katz Index, score 0–6                      | x   | x               |
| IADL                                                   | Lawton and Brody, score 0–8                 | x   | x               |
| Mobility                                               | FAC, score 0–5                             | x   | x               |
| Quality of life                                        | EQ-5D-5L, index/VAS                        | x   | x               |
| **Nutritional status and dietary intake**              |                                             |     |                 |
| Malnutrition                                           | GLIM, n (%)                                 | x   | x               |
| Dietary intake                                         | 3-day dietary record                       |     | x               |
| **Safety**                                             |                                             |     |                 |
| Gastrointestinal tolerance                             | Questionnaire                              | x   | x               |
| (Serious) adverse events                               | (S)AEs log                                  | x   | x               |

*Status of pre-hospital admission and at admission to geriatric rehabilitation.

BIA, bioelectrical impedance analysis; CCI, Charlson Comorbidity Index; CIRS, Cumulative Illness Rating Scale; EQ-5D-5L, 5-level EuroQol-5D version; FAC, Functional Ambulation Classification; GDS, Geriatric Depression Scale; GLIM, Global Leadership Initiative on Malnutrition; IADL, Instrumental Activities of Daily Living; MNA-SF, Mini Nutritional Assessment Short Form; OCS, observational cohort study; RCT, randomised controlled trial; SARC-F, Strength, Assistance with walking, Rising from a chair, Climbing stairs, and Falls; SMMSE, Standardised Mini-Mental State Examination; SPPB, Short Physical Performance Battery; V, visit; VAS, Visual Analogue Scale.
indicate higher morbidity. Cognition will be evaluated by a physician with the Standardised Mini-Mental State Examination (SMMSE) with a higher score indicating better cognition (0–30 points). The Geriatric Depression Scale (GDS) will be filled in by the patient with a higher score expressing higher depressive complaints (0–15 score). The Strength, Assistance with walking, Rising from a chair, Climbing stairs, and Falls (SARC-F) questionnaire (0–10 score) will be completed by the patient with a score of four points or higher indicating a risk of sarcopenia. Anthropometrics will be measured by a nurse. Weight, up to the nearest 0.1 kg, will be measured on a calibrated weighing chair or passive lift without shoes or heavy clothing. Standing height, up to the nearest 0.1 cm, will be measured without footwear if the patient is able to stand. If the patient is unable to stand, knee height will be measured by a sliding calliper between knee and ankle joints positioned at 90 degrees; the estimated height will be calculated using the Chumlea equation. The body mass index (BMI) will be calculated by dividing body weight by height squared (kg/m²). Nutritional status will be assessed by a nurse with the Mini Nutritional Assessment Short Form (MNA-SF) on a scale from 0 to 14 with a lower score indicating a higher risk of malnutrition. Length of stay in geriatric rehabilitation and discharge destination will be retrieved from patient files. Institutionalisation and hospitalisation 6 months after discharge from geriatric rehabilitation will be obtained by calling the patient or the carer. Mortality data will be collected by consulting the Dutch population register.

Sarcopenia diagnosis

The EWGSOP2 sarcopenia definition will be used. Although the use of the SARC-F is recommended as first step, diagnosis will be applied to all patients independent of their SARC-F score because of the poor specificity in identifying geriatric rehabilitation inpatients at risk of sarcopenia. The cut-offs for low handgrip strength are <27 and <16 kg for men and women respectively. If the handgrip strength test cannot be performed, the chair stand test will be used, with low muscle strength defined as failing the pretest (not able to rise from the chair without arms) or a time >15 s. Cut-offs for low muscle mass are appendicular lean mass (ALM)/height² <7.0 kg/m² for men and <5.5 kg/m² for women. Cut-offs for low physical performance are gait speed ≤0.8 m/s or inability to walk. EWGSOP2 sarcopenia stages are defined as such: no sarcopenia (normal muscle strength), probable sarcopenia (low muscle strength but normal muscle mass), confirmed sarcopenia (low muscle strength and low muscle mass, but normal physical performance), severe sarcopenia (low muscle strength, low muscle mass and low physical performance).

Sarcopenia awareness

The survey will be filled in by the patient alone or together with a researcher and is structured as such: (1) prior knowledge of sarcopenia, its causes, consequences and treatment; (2) perception of the importance of muscles for health and independence; (3) willingness to start treatment; (4) barriers/enablers of treatment. The semistructured interviews will be audio-recorded, transcribed verbatim and entered into QSR NVivo (QSR International). The healthcare professionals survey was designed based on previously developed surveys and structured as such: (1) demographics, (2) awareness and understanding of sarcopenia, (3) perception of responsibility to identify and treat sarcopenia, (4) current screening, diagnosis and treatment practices of sarcopenia, (5) barriers/enablers to diagnosis and treatment of sarcopenia. The Qualtrics software (Qualtrics, Provo, Utah, USA) will be used to collect answers. A copy of surveys and interview guides is provided as online supplemental material.

Feasibility of the RCT

Feasibility of the intervention will be assessed based on four parameters (table 3): (1) adherence to the RET expressed as number and percentage of RET sessions attended recorded by physiotherapists; (2) adherence

| Table 3 | Feasibility criteria for the randomised controlled trial |
|---------|-------------------------------------------------------|
| **Primary outcome** | | | |
| Feasibility | High | Medium | Low |
| Adherence to RET, % of sessions attended | During GR | >90 | 80–90 | <80 |
| | Post-GR | >80 | 70–80 | <70 |
| Adherence to ONS, n servings/week | During GR | 12–14 | 10–11 | <10 |
| | Post-GR | 12–14 | 10–11 | <10 |
| Dropout rate, % | During GR | <10 | 10–20 | >20 |
| | Post-GR | <20 | 20–30 | >30 |
| Overall feasibility | | | |
| Participation rate, % eligible patients included | >50 | 25–50 | <25 |

RET, resistance exercise training; GR, geriatric rehabilitation; ONS, oral nutritional supplement.
to the nutritional intervention expressed as number and percentage of prescribed ONS, recorded with an ONS intake diary filled in by the patient with help from a nurse and a researcher will be counting the bottles; (3) dropout rate, defined as the percentage of dropouts during the study period and reason for dropout; (4) participation rate, defined as the percentage of eligible patients included in the study. Overall feasibility will be assessed based on the four feasibility parameters, which will be used as categorical data and dichotomised based on the distribution.

Muscle mass
Muscle mass will be measured in a supine position by direct-segmental multifrequency bioelectrical impedance analysis (DSM-BIA, InBody S10, Biospace, Seoul, South Korea) by a researcher. DSM-BIA has been validated for assessing segmental and whole body composition against dual energy X-ray absorptiometry.49 DSM-BIA will not be performed in patients with (1) electronic internal medical devices or implants such as cardiac pacemakers; (2) plasters or bandages interfering with the placement of the electrodes; (3) amputation. Muscle mass will be expressed as SMM (kg), SMM index (SMI, kg/m²) by dividing SMM (kg) by height squared (m²),49 relative SMM (%) by dividing SMM (kg) by body weight (kg) *100, ALM/height² (kg/m²) by dividing ALM (kg) by height squared (m²)50 and fat-free mass (%).

Muscle strength
Handgrip strength will be measured with a hand-held dynamometer by a physiotherapist (JAMAR, Sammons Preston, 119 Bolingbrook, Illinois, USA). Patients will be in a sitting position with elbows flexed at 90 degrees, shoulders abducted and forearms in a neutral position without support. Patients will be instructed to squeeze the dynamometer maximally three times for each hand, alternating between the right and the left hand side.51 The maximal value will be reported in kg. The unilateral 1-RM for leg press with the unaffected leg will be measured on a leg press weight training machine by a physiotherapist. Prior to the test, patients will perform a warm-up of unloaded repetitions and loaded repetitions at approximately 50% of their 1-RM. Subsequently, loads will be increased to 80%–90% of the 1-RM and the 1-RM will be estimated using the Brzycki equation based on the number of repetitions correctly performed.52

Physical performance
The SPPB will be conducted by a physiotherapist on a scale ranging from 0 to 12 points, with a higher score indicating higher levels of physical function.53 The SPPB consists of three individual tests: standing balance test, 4-metre walk test and timed chair stand test. The standing balance test will only be performed in patients who are able to stand without support. Balance will be tested for three standing positions (feet together, semi tandem and full tandem) and patients will be instructed to try to hold each position for 10s. The 4-metre walk test will be repeated two times and the fastest time in seconds will be used for analysis and converted to gait speed (m/s). The chair stand test will only be performed in patients who are able to stand without using their arms. Patients will be instructed to raise five times from their chair and the time will be recorded (s).

Functional performance
Functional performance pre-hospital admission and at admission to geriatric rehabilitation will be assessed by an occupational therapist with the Katz index for ADL54 and Lawton and Brody scale for IADL.55 Scores of ADLs and IADLs range between 0–6 and 0–8 points, respectively, with higher scores indicating higher level of independence.

Mobility
Mobility will be assessed by a physiotherapist with the FAC, a 6-point scale with a lower score indicating a higher level of support needed by the patient when walking.56

Malnutrition diagnosis
Malnutrition will be diagnosed according to the GLIM criteria.57 Although the use of a screening tool is recommended as first step, GLIM criteria will be applied to all patients independent of their MNA-SF score because of the poor specificity in identifying geriatric rehabilitation inpatients at risk of malnutrition.58 The phenotypic assessment includes low BMI (<20 kg/m² if <70 years or <22 kg/m² if ≥70 years) and/or reduced muscle mass (SMI ≤10.75 kg/m² and ≤6.75 kg/m² for men and women, respectively)59 and/or non-volitional weight loss (1 to >3 kg in the past 3 months on the MNA-SF). The aetiological assessment includes three domains: (1) any chronic gastrointestinal condition adversely impacting food assimilation or absorption, identified with the CIRS in patients with ≥1 condition in either lower and/or upper gastrointestinal symptoms; and/or (2) disease burden and/or an inflammatory condition, identified with the CIRS in patients with a score of ≥2 in one or more CIRS categories, aligning with severe, significant disability or chronic health problems; and/or (3) reduced food intake for >2 weeks, identified by a score of 0 or 1 to the MNA-SF question, ‘Has food intake declined over the past three months due to loss of appetite, digestive problems, chewing or swallowing difficulties?’. Based on these assessments, the patient will be indicated as ‘malnourished’ (≥1 phenotypic criterium and ≥1 aetiological criterium) or ‘not malnourished’.

Dietary intake
Dietary intake will be assessed with dietary records for 3 consecutive days (2 weekdays and 1 weekend day) during the first week of admission to geriatric rehabilitation, the week before discharge (monitored by a researcher) and the last week of the 13-week intervention (filled in by the patient). Dietary records will be entered in Evry software

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to achieve functional goals to enable patients to return home and not to improve muscle strength and mass as separate outcomes. Successful implementation of diagnostic and treatment strategies is complex and requires many steps, as well as resources, such as education, protocols and integrated care pathways to guide practice. Also, knowledge is crucial to increase treatment adherence and motivation. We therefore aim to assess sarcopenia awareness and the barriers/enablers of sarcopenia diagnosis and treatment in healthcare professionals, geriatric rehabilitation patients and carers. Moreover, the assessment of muscle, functional and nutritional status of geriatric rehabilitation inpatients will help raise sarcopenia awareness and facilitate the implementation and optimisation of diagnostic and treatment strategies.

The duration of the RET intervention is based on the American College of Sports Medicine guideline for older adults that recommends a minimum of 12 weeks to increase muscle mass and muscle strength. A study investigating the efficacy of a leucine and vitamin D-enriched whey protein-based ONS in sarcopenic older adults reported clinically relevant gains in lean mass after a 13-week intervention. The high energy variety of this ONS (300 kcal vs 150 kcal per serving) will be used as geriatric rehabilitation patients appear to be at risk of both low protein and low energy intake, with an estimated prevalence of malnutrition of 50%. In these patients, adequate energy intake is required for protein-sparing (process by which the body derives energy from sources other than protein) and preserve muscle mass. The ONS will be consumed during breakfast and lunch, given the typically low protein content of these meals. On RET days, one ONS serving will be consumed after the training instead of breakfast or lunch. Muscle mass will be measured using DSM-BIA as DXA is hardly implementable in clinical practice given the high costs, low accessibility and technical expertise required. Assessment of the feasibility of the combined RET and ONS intervention is essential to determine whether geriatric rehabilitation treatment plans should be adapted when sarcopenia is diagnosed.

In conclusion, evidence from EMPOWER-GR is expected to encourage and facilitate the implementation and optimisation of diagnostic and treatment strategies for sarcopenia in geriatric rehabilitation.

DISCUSSION

The number of older adults is increasing and thereby also the demand for geriatric rehabilitation after an acute hospitalisation and accompanied functional decline. Sarcopenia is associated with short-term and long-term mortality in older hospitalised patients and is estimated to be present in more than 50% of geriatric rehabilitation patients. However, geriatric rehabilitation primarily aims to achieve functional goals to enable patients to return home and not to improve muscle strength and mass as separate outcomes. Successful implementation of diagnostic and treatment strategies is complex and requires many steps, as well as resources, such as education, protocols and integrated care pathways to guide practice. Also, knowledge is crucial to increase treatment adherence and motivation. We therefore aim to assess sarcopenia awareness and the barriers/enablers of sarcopenia diagnosis and treatment in healthcare professionals, geriatric rehabilitation patients and carers. Moreover, the assessment of muscle, functional and nutritional status of geriatric rehabilitation inpatients will help raise sarcopenia awareness and facilitate the implementation and optimisation of diagnostic and treatment strategies.

The duration of the RET intervention is based on the American College of Sports Medicine guideline for older adults that recommends a minimum of 12 weeks to increase muscle mass and muscle strength.

A study investigating the efficacy of a leucine and vitamin D-enriched whey protein-based ONS in sarcopenic older adults reported clinically relevant gains in lean mass after a 13-week intervention. The high energy variety of this ONS (300 kcal vs 150 kcal per serving) will be used as geriatric rehabilitation patients appear to be at risk of both low protein and low energy intake, with an estimated prevalence of malnutrition of 50%. In these patients, adequate energy intake is required for protein-sparing (process by which the body derives energy from sources other than protein) and preserve muscle mass. The ONS will be consumed during breakfast and lunch, given the typically low protein content of these meals.

On RET days, one ONS serving will be consumed after the training instead of breakfast or lunch. Muscle mass will be measured using DSM-BIA as DXA is hardly implementable in clinical practice given the high costs, low accessibility and technical expertise required.

Assessment of the feasibility of the combined RET and ONS intervention is essential to determine whether geriatric rehabilitation treatment plans should be adapted when sarcopenia is diagnosed.

In conclusion, evidence from EMPOWER-GR is expected to encourage and facilitate the implementation and optimisation of diagnostic and treatment strategies for sarcopenia in geriatric rehabilitation.

ETHICS AND DISSEMINATION

The Medical Ethics Committee of the Amsterdam UMC, location Vumc, gave exemption for the observational cohort study (2020.350) and approved the study protocol of the RCT (NL74989.029.20). The RCT is registered on the Netherlands Trial Register under identifier NL9444. Written consent is obtained from all participants before inclusion. The research is performed according to the Dutch Medical Research Involving Human Subjects
Act and the Declaration of Helsinki. The data generated during this study will be made available from the corresponding author on reasonable request, within the existing privacy legislations.

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11Dávalos-Yerovi V, Marco E, Annweiler C, et al. Malnutrition in postacute geriatric care: basic ESPEN diagnosis and etiology based diagnoses analyzed by length of stay, in-hospital mortality, and functional rehabilitation indexes. ArchGerontolGeriatr2017;73:69–76.
12Hettiarachchi J, Reijnierse EM, Soh CH, et al. Malnutrition is associated with poor trajectories of activities of daily living in geriatric rehabilitation inpatients: resort. MechAgeingDev2021;197:11550.
13Dávalos-Yerovi V, Marco E, Sánchez-Rodríguez D, et al. Sarcopenia according to the revised European consensus on definition and diagnosis (EWGSOP2) criteria predicts hospitalizations and long-term mortality in rehabilitation patients with stable chronic obstructive pulmonary disease. JAMedDirAssoc2019;20:1047–9.
14Marco E, Sánchez-Rodríguez D, Dávalos-Yerovi VN, et al. Malnutrition according to ESPEN consensus predicts hospitalizations and long-term mortality in rehabilitation patients with stable chronic obstructive pulmonary disease. ClinNutr2019;38:2186–6.
15Xu J, Reijnierse EM, Pacifico J, et al. Sarcopenia is associated with 3-month and 1-year mortality in geriatric rehabilitation inpatients: resort. Ageing2021;50:2147–56.
16Xu J, Wan CS, Ktoris K, Sarcopenia is associated with mortality in adults: a systematic review and meta-analysis. Gerontology2021;1–16.
17Groenendijk I, Kramer CS, den Boer J, et al. Fracture patients in geriatric rehabilitation show poor nutritional status, dietary intake and muscle health. Nutrients2020;12:2528.
18Clark AB, Reijnierse EM, Lim WK, et al. Prevalence of malnutrition comparing the GLIM criteria, ESPEN definition and MST malnutrition risk in geriatric rehabilitation patients: resort. ClinNutr2020;39:3504–11.
19Wójcieszke J, van Wijngaarden J, van den Berg C, et al. Nutritional status and functionality in geriatric rehabilitation patients: a systematic review and meta-analysis. EurGeriatrMed2020;11:192–207.
20Yeung SSY, Reijnierse EM, Trappenburg MC, et al. Current knowledge and practice of Australian and New Zealand health-care professionals in sarcopenia diagnosis and treatment: time to move forward! AustralasJAgeing2020;39:e185–93.
21Reijnierse EM, de van der Schueren MAE, Trappenburg MC, et al. Lack of knowledge and availability of diagnostic equipment could hinder the diagnosis of sarcopenia and its management. PLoSOne2017;12:e0158537.
22Nakahara S, Wakabayashi H, Maeda K, et al. Sarcopenia and cachexia evaluation in different healthcare settings: a questionnaire survey of health professionals. AsiaPacJClinNutr2018;27:167–75.
23Kias N, Bauer J, Boltong A, et al. Awareness, perceptions and practices regarding cancer-related malnutrition and sarcopenia: a survey of cancer clinicians. SupportCareCancer2020;28:5263–70.
24Yaxley A, Miller MD. The challenge of appropriate identification and treatment of starvation, sarcopenia, and cachexia: a survey of Australian dietitians. JNutrMetab2011;2011:1–6.
25Ter Beek L, Vanhauwaert E, Slinde F, et al. Unsatisfactory knowledge and use of terminology regarding malnutrition, starvation, cachexia and sarcopenia among dietitians. ClinNutr2016;35:1450–6.
26Beckwée D, Delaere A, Aelbrecht S, et al. Exercise interventions for the prevention and treatment of sarcopenia. A systematic umbrella review. JNutrHealthAging2019;23:494–502.
27Peterson MD, Rhea MR, Sen A, et al. Resistance exercise for muscular strength in older adults: a meta-analysis. AgeingResRev2010;9:226–37.
26 Martin-Cantero A, Reijnierse EM, Gill BMT, et al. Factors influencing the efficacy of nutritional interventions on muscle mass in older adults: a systematic review and meta-analysis. Nutr Rev 2021;79:315–30.

27 Hou L, Lei Y, Xu, et al. Effect of protein supplementation combined with resistance training on muscle mass, strength and function in the elderly: a systematic review and meta-analysis. J Nutr Health Aging 2019;23:451–8.

28 Beaudart C, Dawson A, Shaw SC, et al. Nutrition and physical activity in the prevention and treatment of sarcopenia: systematic review. Osteoporos Int 2017;28:1817–33.

29 Gielen E, Beckwée D, Delaere A, et al. Nutritional interventions to improve muscle mass, muscle strength, and physical performance in older people: an umbrella review of systematic reviews and meta-analyses. Nutr Rev 2017;75:121–47.

30 Lee SY, Yoon B-H, Beom J, et al. Effect of lower-limb progressive resistance exercise after hip fracture surgery: a systematic review and meta-analysis of randomized controlled studies. J Am Med Dir Assoc 2017;18:1096.e1–1096.e26.

31 Roncatelli M, Ceccini E, Kelsey C, et al. Improving rehabilitation in sarcopenia: a randomized-controlled trial utilizing a muscle-targeted food for special medical purposes. J Cachexia Sarcopenia Muscle 2020;11:1535–47.

32 van Wijngaarden JP, Wojzischke J, van den Berg C, et al. Effects of nutritional interventions on nutritional and functional outcomes in geriatric rehabilitation patients: a systematic review and meta-analysis. J Am Med Dir Assoc 2020;21:1207–15.

33 Ellis G, Gardner M, Tsiachristas A, et al. Comprehensive geriatric assessment for older adults admitted to hospital. Cochrane Database Syst Rev 2017;9:CD006211.

34 Kamleh AA, Reijnierse EM, Aarden JJ. Optimal resistance exercise training for older adults to increase muscle mass: a systematic review and meta-analyses. Ann Phys Rehabil Med 2021. Submitted for publication.

35 Luking YC, Deutz NEP, Memelink RG, et al. Postprandial muscle protein synthesis is higher after a high whey protein, leucine-enriched supplement than after a dairy-like product in healthy older people: a randomized controlled trial. Nutr J 2014;13:9.

36 Kramar IF, Verdijk LB, Hamer HM, et al. Impact of the macronutrient composition of a nutritional supplement on muscle protein synthesis rates in older men: a randomized, double blind, controlled trial. J Clin Endocrinol Metab 2015;100:4124–32.

37 Chatel A, Verschueren SM, Tournay H, et al. Supplemented breakfast with a vitamin D and Leucine-enriched whey protein nutritional drink enhances postprandial muscle protein synthesis and muscle mass in healthy older men. J Nutr 2017;147:2262–71.

38 Bauer JM, Verlaan S, Bautmans I, et al. Effects of a vitamin D and leucine-enriched whey protein nutritional supplement on sarcopenia of older adults, in the provide study: a randomized, double-blind, placebo-controlled trial. J Am Med Dir Assoc 2015;16:740–7.

39 Deforge RT, Cormack C, Byrne K, et al. Barriers and facilitators to recommendation adherence following discharge from geriatric rehabilitation. Top Geriatr Rehabil 2008;24:345–53.

40 Miller MD, Paradis CF, Houck PR, et al. Rating chronic medical illness burden in geropsychiatric practice and research: application of the cumulative illness rating scale. Psychiatry Res 1992;41:237–48.

41 Charlson ME, Pompei P, Ales KL, et al. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. J Chronic Dis 1987;40:373–83.

42 Folstein MF, Folstein SE, McHugh PR. "Mini-mental state": A practical method for grading the cognitive state of patients for the clinician. J Psychiatr Res 1975;12:189–98.

43 Yessavage JA, Erlik LB, Rose TL, et al. Development and validation of a geriatric depression screening scale: a preliminary report. J Psychiatr Res 1982;17:37–49.

44 Malmstrom TK, Morley JE. SARC-F: a simple questionnaire to rapidly diagnose sarcopenia. J Am Med Dir Assoc 2013;14:531–2.

45 Chumlea WC, Heymsfield SB, Steinbaugh MH. Estimating stature from knee height for persons 60 to 90 years of age. J Am Geriatr Soc 1985;33:116–20.

46 Rubenstein LZ, Harker JO, Saliva A, et al. Screening for underevaluation in geriatric practice: developing the short-form mini-nutritional assessment (MNA-SF). J Nutr Health Aging 2001;5:366–72.

47 Dedeyne L, Reijnierse EM, Pacifico J, et al. SARC-F is inaccurate to identify geriatric rehabilitation inpatients at risk for sarcopenia: resort. to recommendation adherence following discharge from geriatric rehabilitation. Top Geriatr Rehabil 2021;1:1–9.

48 Voelker SN, Michalopoulos N, Maier AB. The reliability of the SARC-F and its concurrent validity as a screening tool to identify adults at risk of sarcopenia: a systematic review and meta-analysis. J Am Med Dir Assoc 2021;22:1864–76.

49 Ling CHY, de Craen AJM, Slagboom PE, et al. Accuracy of direct segmental multi-frequency bioimpedance analysis in the assessment of total body and segmental body composition in middle-aged adult population. Clin Nutr 2011;30:610–5.

50 Gonzalez-MC, Heymsfield SB. Bioimpedance analysis for diagnosing sarcopenia and cachexia: what are we really estimating? J Cachexia Sarcopenia Muscle 2017;8:187–9.

51 Reijnierse EM, de Jong N, Trappenburg MC, et al. Assessment of maximal handgrip strength: how many attempts are needed? J Cachexia Sarcopenia Muscle 2017;8:466–74.

52 Buzycy M. Strength testing—predicting a one-rep max from reps-to-fatigue. J Phys Educ Recreat Dance 1993;64:38–90.

53 Guralnik JM, Simonsick EM, Ferrucci L, et al. A short physical performance battery assessing low extremity function: association with self-reported evaluation of health, and mortality in older adults: a user’s guide to recommendations to clinicians. J Gerontol 1994;49:M85–94.

54 Katz S, Downs TD, Cash HR, et al. Progress in development of the index of ADL. Gerontologist 1970;10:20–30.

55 Lawton MP, Brody EM. Assessment of older people: self-maintaining and instrumental activities of daily living. Gerontologist 1969;9:179–86.

56 Holden MK, Gill KM, Magliozzi MR, et al. Clinical gait assessment in the neurologically impaired. Phys Ther 1984;64:35–40.

57 Sand T, Jensen DK, GML GL. GM criteria for the diagnosis of malnutrition - A consensus report from the global clinical nutrition community. Clin Nutr 2019;38:1–9.

58 Marshall S, Young A, Bauer J, et al. Nutrition Screening in Geriatric Rehabilitation: Criterion (Concurrent and Predictive) Validity of the Malnutrition Screening Tool and the Mini Nutritional Assessment-Short Form. J Acad Nutr Diet 2016;116:795–801.

59 Janssens I, Baumgartner RN, Ross R, et al. Skeletal muscle cutpoints associated with elevated physical disability risk in older men and women. Am J Epidemiol 2004;159:413–21.

60 Berthia CA, Rainfair M, Mathoulin-Pellissier S, et al. Screening older cancer patients: first evaluation of the G-8 geriatric screening tool. Ann Oncol 2012;23:2166–72.

61 Herdmann M, Gudex C, Lloyd A, et al. Development and preliminary testing of the new five-level version of EQ-5D (EQ-5D-5L). Qual Life Res 2017;26:2203–15.

62 Versteegh MM, Vermeulen KM, Evers SMAA, et al. Dutch tariff for the five-level version of EQ-5D. Value Health 2016;19:343–52.

63 United Nations Department of Economics and Social Affairs Population Division. World population prospects 2019: highlights. New York: United Nations, 2019.

64 van Balen R, Gordon AL, Schols JMGA, et al. What is geriatric rehabilitation and how should it be organized? A Delphi study aimed at reaching European consensus. Eur Geriatr Med 2019;10:977–87.

65 Cund S, Gordon AL, van Balen R, et al. European consensus on core principles and future priorities for geriatric rehabilitation: consensus statement. Eur Geriatr Med 2020;11:233–8.

66 Verlaan S, Van Ancum JM, Piek R, et al. Muscle Measures and Nutritional Status at Hospital Admission Predict Survival and Independent Living of Older Patients - the EMPOWER Study. J Frailty Aging 2017;6:161–6.

67 Scheerman K, Meskers CGM, Verlaan S, et al. Sarcopenia, low handgrip strength, and low absolute muscle mass predict long-term mortality in older hospitalized patients: an observational inception cohort study. J Am Med Dir Assoc 2021;22:816–20.

68 Boussquet JH, Schüinemann HJ, Togias A, et al. Next-Generation ARIA care pathways for rhinitis and asthma: a model for multimorbidity chronic diseases. Clin Transl Allergy 2019;9:44.

69 American College of Sports Medicine. American College of sports medicine position statement. progression models in resistance training for healthy adults. Med Sci Sports Exerc 2009;41:687–708.

70 Bauer J, Biolo G, Cederholm T. Evidence-Based recommendations for optimal dietary protein intake in older people. a position paper from the PROT-AGE Study Group. J Am Med Dir Assoc 2013;14:542–59.

71 Verreijen AM, Verlaan S, Engberink MF, et al. A high whey protein-, leucine-, and vitamin D-enriched supplement preserves muscle mass during intentional weight loss in obese older adults: a double-blind randomized controlled trial. Am J Clin Nutr 2015;101:279–86.

72 Marra M, Sammarco R, De Lorenzo A, et al. Assessment of body composition in health and disease using bioelectrical impedance analysis (BIA) and dual energy X-ray absorptiometry (DXA): a critical review. Contrast Media Mol Imaging 2019;15:91–100.

73 World Medical Association. Declaration of Helsinki. Ethical principles for medical research involving human subject. 64th WMA General assembly in Fortaleza, Brazil: World Medical Association. JAMA 2013;310:2191–4.