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

Laure MG Verstraeten,[1] Janneke P van Wijngaarden,[2] Marina Tol-Schilder,[3] Carel GM Meskers,[4] Andrea B Maier [1,5,6,7]

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For numbered affiliations see end of article.

Correspondence to
Professor Andrea B Maier; a.b.maier@vu.nl

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.

Trial registration number NL9444.

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 sarcopenia[4]; both conditions frequently coexist[5 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),[24 25] protein supplementation[26] and its combination[27–29] have been shown to improve muscle mass and/or muscle strength in older adults. While RET[30] and protein supplementation[31 32] 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[33] 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.

Observational cohort study	Sarcopenia awareness		Feasibility randomized controlled trial
Comprehensive geriatric assessment in 200 geriatric rehabilitation inpatients	Survey in geriatric rehabilitation inpatients[a] + 500 healthcare professionals	Semi-structured interview in 30 geriatric rehabilitation inpatients with sarcopenia + 15 carers	RET and protein supplementation 13-week intervention in 80 hip fracture geriatric rehabilitation inpatients with sarcopenia

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

[a]Patients from the observational cohort study that are able to answer the survey questions in opinion of the researcher and/or physician.

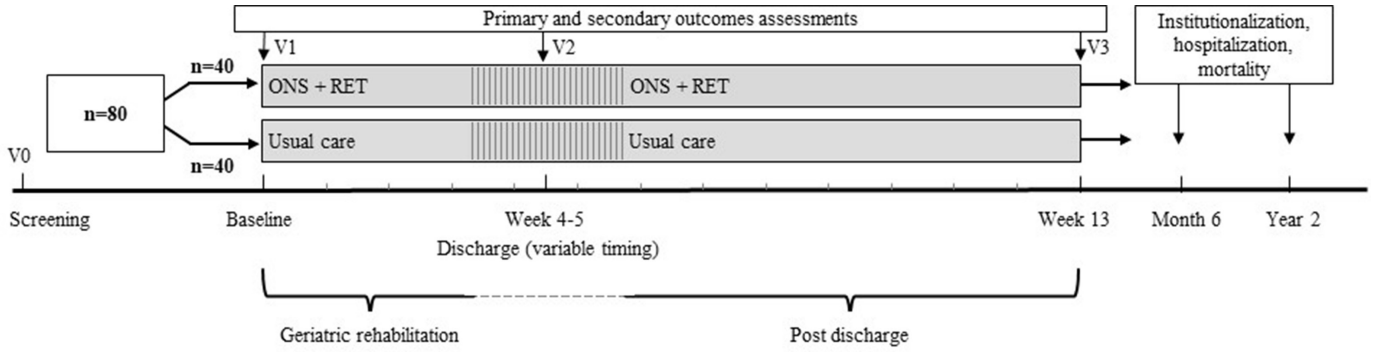

Figure 2 Study diagram of the feasibility randomised controlled trial. ONS, oral nutritional supplement; RET, resistance exercise training; V, visit.

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.[34] 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[35–37] and increase muscle mass, as well as lower extremity function in sarcopenic older adults.[31 38]

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[2 15 39] 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

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

Inclusion criteria	Exclusion criteria
Observational cohort study	
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	
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 m^2)
	Body mass index >40 kg/m^2
	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
	Uncertainty about the willingness/ability of the subject to comply with the protocol
	Participation in other intervention studies
	For BIA measurements only: electronic implant and/or pacemaker*

*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.

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)[40] and 37-point Charlson Comorbidity Index (CCI),[41] in which higher points

Table 2 Study parameters and schedule of assessments of the observational cohort study and feasibility randomised controlled trial

			Feasibility RCT			
Study parameters	**Source or instrument**	**OCS**	**V0**	**V1**	**V2**	**V3**
Patient characteristics						
Age, sex, reason for admission	Patient file	x	x			
Marital status, living situation, ethnicity, education, smoking, alcohol consumption, diet	Patient survey	x		x		
Medication/supplements use	Patient file	x		x	x	x
Comorbidities	CIRS, score 0–56	x		x	x	x
	CCI, score 0–37	x		x	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	x			
Weight	Chair scale/passive lift, kg	x	x		x	x
Body mass index	Weight/height^2, kg/m^2	x	x		x	x
Nutritional status	MNA-SF, at risk yes/no	x		x	x	x
Length of stay in GR	Patient file, days	x			x	
Discharge destination	Patient file	x			x	
Institutionalisation	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	x	x
Fat-free mass	BIA, %	x		x	x	x
Relative skeletal muscle mass	BIA, %	x		x	x	x
Handgrip strength	Hand-held dynamometer, kg	x	x		x	x
Leg press 1-RM	Leg press, kg			x	x	x
Physical performance	SPPB, score 0–12	x		x	x	x
	Chair stand test, s	x		x	x	x
	Gait speed, m/s	x		x	x	x
Functional performance, mobility and quality of life						
Activities of Daily Living	Katz Index, score 0–6	x		x*	x	x
IADL	Lawton and Brody, score 0–8	x		x*	x	x
Mobility	FAC, score 0–5	x		x	x	x
	Patient survey	x		x	x	x
Quality of life	EQ-5D-5L, index/VAS	x		x	x	x
Nutritional status and dietary intake						
Malnutrition	GLIM, n (%)	x		x	x	x
Dietary intake	3-day dietary record			x	x	x
Safety						
Gastrointestinal tolerance	Questionnaire			x	x	x
(Serious) adverse events	(S)AEs log			x	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).[42] The Geriatric Depression Scale (GDS) will be filled in by the patient with a higher score expressing higher depressive complaints (0–15 score).[43] 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.[44] 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.[45] The body mass index (BMI) will be calculated by dividing body weight by height squared (kg/m^2). 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.[46] 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.[3] 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.[47 48] 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)/height^2 <7.0 kg/m^2 for men and <5.5 kg/m^2 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).[3]

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[18 19 21] 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

Feasibility		High	Medium	Low
Primary outcome				
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				
Secondary outcome				
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 categorial 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/m^2) by dividing SMM (kg) by height squared (m^2),[49] relative SMM (%) by dividing SMM (kg) by body weight (kg)*100, ALM/height^2 (kg/m^2) by dividing ALM (kg) by height squared (m^2)[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 adducted 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 10 s. 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 ADL[54] 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/m^2 if <70 years or <22 kg/m^2 if ≥70 years) and/or reduced muscle mass (SMI ≤10.75 kg/m^2 and ≤6.75 kg/m^2 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 ≥3 in one or more CIRS categories, aligning with severe, significant disability or chronic health problems[60]; 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

(https://www.evry.nl/), which enables calculation of macronutrient and micronutrient intake.

Quality of life

The EQ-5D-5L will be completed by the patients to measure health-related quality of life.[61] The tool will be used both as an index[62] and as a Visual Analogue Scale (VAS) between 0 and 100, with a higher score indicating higher self-perceived health.

Safety

Safety will be assessed by monitoring and documenting (serious) adverse events throughout the study period. Also, tolerance of the ONS will be monitored at each visit with a gastrointestinal tolerance questionnaire.

Patient and public involvement

Healthcare professionals and patients were involved in the design of the sarcopenia awareness surveys. Moreover, physiotherapists were involved in the design of the RET protocol. Lastly, healthcare professionals and patients will be involved to evaluate the feasibility of the intervention.

Data analysis

Descriptive statistics will be used to present the patient characteristics and data collected in the patient and healthcare professional surveys. Variables being normally distributed will be reported as mean with SD, variables being skewed as median with IQR and categorical variables as frequency (n) with percentage (%). For the observational cohort study, logistic or linear regression models will be used to assess associations between sarcopenia and secondary outcomes. Feasibility of the intervention will be summarised using descriptive statistics. Other outcomes of a continuous type will be analysed using a repeated measures (change from baseline at discharge and week 13) linear mixed model with fixed factors for baseline, treatment, time and sex, and an interaction term between treatment and time will be applied to assess the effect of the intervention. Outcomes of a categorical type will be analysed using a logistic model. Statistical background assumptions for the application of models will be checked. In case assumptions are not met, data transformations, link functions and non-parametric statistics will be considered. P values <0.05 will be considered statistically significant. All statistical analyses will be performed using the Statistical Package for the Social Sciences (IBM SPSS Advanced Statistics V.25.0: IBM).

DISCUSSION

The number of older adults is increasing[63] and thereby also the demand for geriatric rehabilitation after an acute hospitalisation and accompanied functional decline.[64 65] Sarcopenia is associated with short-term[66] and long-term[67] mortality in older hospitalised patients and is estimated to be present in more than 50% of geriatric rehabilitation patients.[2] 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.[64]

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.[68] 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.[69] 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.[38] 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,[17] with an estimated prevalence of malnutrition of 50%.[15 16] 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.[70] On RET days, one ONS serving will be consumed after the training instead of breakfast or lunch.[71] 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.[72] 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.[73] The data generated during this study will be made available from the corresponding author on reasonable request, within the existing privacy legislations.

Author affiliations
[1]Department of Human Movement Sciences, Age Amsterdam, Vrije Universiteit Amsterdam, Amsterdam Movement Sciences, Amsterdam, Netherlands
[2]Specialized Nutrition, Danone Nutricia Research, Utrecht, Netherlands
[3]Center of Excellence in Geriatric Rehabilitation, Cordaan, Amsterdam, Netherlands
[4]Department of Rehabilitation Medicine, Amsterdam University Medical Center, Amsterdam Movement Sciences, Amsterdam, Netherlands
[5]Healthy Longevity Translational Research Program, Yong Loo Lin School of Medicine, National University of Singapore, Singapore
[6]Department of Medicine and Aged Care, AgeMelbourne, The Royal Melbourne Hospital, The University of Melbourne, Parkville, Victoria, Australia
[7]Centre for Healthy Longevity, AgeSingapore, National University Health System, Singapore

Twitter Andrea B Maier @andreabmaier

Contributors ABM, CGMM, JPvW and MT-S designed and initiated the trial. ABM is the principal investigator. ABM, CGMM, JPvW, MT-S and LMGV planned and coordinated the study. LMGV is responsible for data collection and management and drafted the manuscript. All authors critically reviewed the manuscript and approved the final draft.

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Competing interests JPvW reports that she is an employee of Danone Nutricia Research. The other authors declare that they have no competing interests.

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ORCID iD
Andrea B Maier http://orcid.org/0000-0001-7206-1724

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