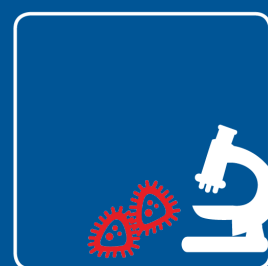


Paolo Caserotti:

I'm still standing – Forebyggelse af fysisk skrøbelighed hos 80+ årige hjemmeboende borgere (ved hjælp af mælkebaseret protein)

I'm still standing – Prevention of frailty in 80+ year old community-dwelling older adults (by means of milk-based protein).



Final report

for collaborative projects funded via the Danish Dairy Research Foundation (DDRF)

1. Title of the project

In Danish: I'm still standing – Forebyggelse af fysisk skrøbelighed hos 80+ årige hjemmeboende borgere (ved hjælp af mælkebaseret protein)

In English: I'm still standing – Prevention of frailty in 80+ year old community-dwelling older adults (by means of milk-based protein).

2. Project manager

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4. Sources of funding

Milk Levy Fund.

Co-funding from the involved partners SDU, Arla Foods, and University College Copenhagen. Additional co-funding: Interreg 5a Deutschland-Denmark grant from the European Fund for Regional Development (grant no. 38-1.0-16) and Odense municipality.

5. Project period

Project period with DDRF funding: Jan 2017 – June 2020

Revised, if necessary: Prolonged to 2021 due to maternity leave

Total project period if sub-project within a larger project: February 2017 – December 2021.

6. Project summary

In Danish:

Baggrund

Belastningen på sundhedssektoren som følge af, at ældre udgør en større andel af befolkningen, afhænger i høj grad af den ældre borgers sundhedstilstand. Underernæring, proteinunderernæring og fysisk skrøbelighed er relaterede tilstande, der hyppigt forekommer hos ældre, og som kan have en negativ indvirkning på den ældre borgers sundhedstilstand. Ernæringsmæssige risikofaktorer kan opstå inden, eller forekomme samtidigt med, der er risiko for underernæring og underernæring. Tidlig screening i forbindelse med forebyggende hjemmebesøg, efterfulgt af målrettede interventioner, giver en mulighed for at forebygge underernæring og fysisk skrøbelighed. Proteintilskud i kombination med træning er blevet foreslået til at modvirke fysisk skrøbelighed. Der er dog behov for mere viden om effekten af en individuelt tilrettelagt ernæringsindsats med proteintilskud (alene eller i kombination med powertræning) rettet mod fysisk skrøbelige, hjemmeboende borgere ≥ 80 år med indikatorer for fysisk skrøbelighed.

Formål

Formålet med dette projekt var, at undersøge forekomsten af proteinunderernæring, sammenhængen mellem dagligt proteinindtag og fysisk skrøbelighed, samt sammenhængen mellem udvalgte, ernæringsmæssige risikofaktorer, proteinunderernæring og fysisk skrøbelighed hos ældre (≥ 65 år) og gamle (≥ 80 år) hjemmeboende borgere. Derudover var formålet at teste effekten af proteintilskud alene, eller i kombination med powertræning, på indikatorer for fysisk skrøbelighed hos gamle, fysisk skrøbelige, hjemmeboende borgere.

Metode

Studiet er baseret på data fra to tværsnitsundersøgelser, med hjemmebesøg hos ældre og gamle, hjemmeboende borgere, i Odense, Esbjerg og Slagelse kommuner. Derudover blev et tofasat, randomiseret kontrolleret forsøg, med tre interventionsarme, studie 2, påbegyndt for at undersøge effekten af 4 måneder med proteintilskud med mejeriprodukter alene, eller i kombination med to ugentlige sessioner med powertræning, sammenlignet med generelle anbefalinger, på indikatorer for fysisk skrøbelighed, hos gamle, skrøbelige, hjemmeboende borgere.

Resultater

Forekomsten af proteinunderernæring var 54 % hos gamle borgere og de ernæringsmæssige risikofaktorer; mundtørhed, nedsat appetit og smerte, var forbundet med odds for proteinunderernæring. Et højere, dagligt proteinindtag var ikke forbundet med fysisk skrøbelighed. Højt BMI var relateret til fysisk skrøbelighed hos gamle borgere, og utilsigtet vægttab, dysfagi, dårlig tandstatus og højt BMI var forbundet med odds for fysisk skrøbelighed hos ældre borgere. Foreløbige resultater fra studie 2 (n=35) viste, at proteintilskud, i kombination med to ugentlige sessioner med powertræning, øgede den maksimale muskelpower, hvorimod interventionen med proteintilskud alene, øgede fedtfri masse, uden forskelle mellem grupperne over tid.

Konklusioner

Proteinunderernæring er en stor udfordring hos gamle, selvhjulpne, hjemmeboende borgere. Ernæringsmæssige risikofaktorer relateret til proteinunderernæring (mundtørhed, nedsat appetit og smerter) og fysisk skrøbelighed (højt BMI, utilsigtet vægttab, dysfagi og dårlig tandstatus) kan bruges i den tidlige screening, i de primære forebyggende strategier. Derudover kan proteintilskud alene, eller i kombination med powertræning, forbedre indikatorer for fysisk skrøbelighed hos gamle, skrøbelige borgere, der bor i eget hjem.

In English:

Background

A substantial economic burden of the public health care sector in our society is associated with the health status of the ageing population. Malnutrition, in particular protein malnutrition, is highly prevalent in older adults and increases at older age. Malnutrition has often a multifactorial etiology and it is characterized by numerous risk factors such as poor appetite or dysphagia, which may contribute to or co-exist with, or even precede malnutrition. The accumulation of malnutrition status over time represents a serious threat, which may compromise the overall health of older people contributing to the development of several severe geriatric conditions such as physical frailty. Malnutrition may develop from an overall inadequate intake of energy to maintain body mass, but it may also develop from inadequate intake of specific nutrients, that may alter body composition, such as protein malnutrition. Physical frailty may also occur earlier and translate into chronic malnutrition at a later stage. Detecting older adults with malnutrition at an early stage allows tailoring interventions, which may prevent the cumulative degenerative effects on health. Prevalence data on malnutrition and the potential key determinants in the oldest old in Denmark are scarce despite that this is the fastest growing segment in our society (of the Danish population).

The Danish nationally regulated preventive home-visit (PHV) service provides a great opportunity for large scale screening for protein malnutrition and malnutrition in general, as well as key potential risk factors in the older population.

Interventions targeting protein malnutrition and physical frailty have included protein supplementation and structured exercise, in particular strength and power training. However, it is unclear whether and to what extent individualized nutritional supplementation alone or combined with exercise targeting physical pre-frail, very old community-dwelling adults may affect indicators of physical frailty.

Objectives

This project had four main aims which investigated the: i) prevalence of protein malnutrition, ii) association of daily protein intake with physical pre-frail/frail condition iii) association of selected nutritional risk factors with protein malnutrition and physical pre-frail/frail condition in old (≥ 65 years) and very old (≥ 80 years) community-dwelling adults, and iv) effect of protein supplementation alone or in combination with power training in very old physical pre-frail/frail self-reliant community-dwelling adults on indicators of physical frailty.

Methods

Study design:

Aims i, ii & iii (study 1a and 1b): Cross-sectional design with 2 studies with PHV, conducted in the municipalities of Odense, Esbjerg and Slagelse.

Aim iv: A two phased, three-armed, randomized controlled trial (study 2) designed as 4-months of protein supplementation with dairy products alone or in combination with two weekly sessions of power training compared to general recommendations on indicators of physical frailty in very old pre-frail/frail community-dwelling adults.

Results

Prevalence of protein malnutrition was 54% in very old adults. Nutritional risk factors including mouth dryness, reduced appetite, and pain were associated with greater odds of protein malnutrition (study 1a). A higher daily protein intake was not associated with physical pre-frail/frail condition. However, high BMI was associated with physical pre-frail/frail condition in very old adults (study 1b), and unintentional weight loss, dysphagia, poor dental status, and high BMI was associated with odds of physical pre-frail/frail condition in old adults (study 1b). Preliminary results from the study 2 showed that protein supplementation combined with two weekly sessions of power training increased within

group muscle power whereas protein supplementation alone increased within group whole-body lean mass. No between group differences were observed.

Conclusion

Protein malnutrition is highly prevalent in very old self-reliant community-dwelling adults, and it may represent a serious health threat. Nutritional risk factors associated with protein malnutrition (mouth dryness, reduced appetite, and pain) and physical frailty (high BMI, unintentional weight loss, dysphagia, and poor dental status) are associated with protein malnutrition and should be used as early screening in primary preventive strategies. Lastly, protein supplementation alone or in combination with power training may improve indicators of physical frailty, in very old pre-frail/frail community dwelling adults.

7. Project aim

Formål

Formålet med '*I'm still standing*' projekterne var at undersøge forekomsten af proteinunderernæring, sammenhængen mellem dagligt proteinindtag og fysisk skrøbelighed, samt sammenhængen mellem udvalgte ernæringsmæssige risikofaktorer, proteinunderernæring og fysisk skrøbelighed hos ældre og gamle hjemmeboende borgere. Desuden var formålet at undersøge effekten af målrettede interventioner med proteintilskud alene, eller i kombination med træning på indikatorer for fysisk skrøbelighed hos gamle, fysisk skrøbelige, hjemmeboende borgere.

Project aim

The "*I'm still standing*" projects aimed to investigate the prevalence of protein malnutrition, the association of daily protein intake with physical pre-frail/frail condition and the association of selected nutritional risk factors with protein malnutrition and physical pre-frail/frail condition in old and very old community-dwelling adults. In addition, we aimed to investigate the effect of targeted interventions with protein supplementation alone or in combination with training on indicators of physical frailty in pre-frail/frail very old community-dwelling adults.

8. Background for the project

The population of older adults is rapidly increasing (Christensen, Doblhammer, Rau, & Vaupel, 2009; Lunenfeld & Stratton, 2013). Indeed, the European population of very old adults (≥ 80 years) is expected to increase by two-and-a-half-fold by year 2100 and thereby accounting for 14.6% of the total population (eurostat, 2021). Older age is associated with increased risk of disease and disabilities (Christensen et al., 2009), and the ageing population may challenge the sustainability of the health care system economically and by shortage of health care personnel (Cylus, 2019). Hence, the consequences of the ageing population highly depend on the health status of the older adults (Cylus, 2019). Community-dwelling adults are vulnerable to overall malnutrition, and particularly protein malnutrition which may severely contribute to physical frailty (Laur, McNicholl, Valaitis, & Keller, 2017; Leij-Halfwerk et al., 2019; Ofori-Asenso et al., 2019). Indeed, frailty and malnutrition share common characteristics and risk factors (Laur et al., 2017). The coexistence of malnutrition and physical frailty may exacerbate the consequences of each condition alone potentially resulting in aggravated health outcomes and reduced ability to live independently (Agarwal, Miller, Yaxley, & Isenring, 2013; Dent et al., 2019; Fried LP, 2009). Nevertheless, there is a potential to prevent or reverse malnutrition, and potentially the role that malnutrition may have on the onset and the development of physical frailty, especially if tackled in an early phase (Ofori-Asenso et al., 2019; Xue, Bandeen-Roche, Tian, Kasper, & Fried, 2021).

Malnutrition has often a multifactorial etiology and it is characterized by numerous risk factors such as poor appetite or dysphagia which may coexist with or be precursors of the malnutrition. Also, the cumulative negative effect of such risk factors over time may not only contribute to the development or impact the severity of malnutritional but also be

precursor of physical frailty syndrome (Laur et al., 2017). Physical frailty characterized by different domains (e.g., fatigue) may also occur earlier and develop a chronic malnutritional status at a later stage.

Despite the remarkable impact of such condition on overall health and on important geriatric syndromes such as frailty, the prevalence on protein malnutrition and the related nutritional risk factors in the oldest old in Denmark is unknown. Also, the association of protein malnutrition and the nutritional factors with pre-frail/frail status in self-reliant community-dwelling adults is limited.

The Danish nationally regulated preventive home-visits service provided to old and very old community-dwelling adults offers a great opportunity for early screening of risk factors of malnutrition and physical frailty which would be otherwise undetectable (Vass, Avlund, Hendriksen, Philipson, & Riis, 2007).

Protein and training may stimulate muscle protein anabolism (Shad, Thompson, & Breen, 2016) and are suggested in the management of physical frailty in older adults (Dent et al., 2019). Nevertheless, more research is needed to fully understand the potential to reverse physical pre-frailty and prevent the transition from physical pre-frail to frail condition by means of protein supplementation alone or in combination with power training in very old community-dwelling adults with physical pre-frail/frail condition.

9. Sub-activities in the entire project period

Study 1a and study 1b were completed and data have been published in peer-review journals.

Study 2 was only partially completed due to the national lock down during the COVID 19 pandemic. Approximately 20% of the originally planned participants finalized the intervention. A Pilot/feasibility article for study 2 is in preparation.

Study 3 was planned as a socio-economic analysis derived by the result of study 2. Unfortunately, due to the low sample size in study 2 (20% of the expected participants) could not be carried out and completed.

Study 1a – cross sectional study, detailed nutritional assessment +80 years community-dwelling adults

A: Development of methods and material for data collection

B: Scientific ethical approval of protocol

C: Recruitment of participants and collection of data

D: Data processing and analysis

E: Writing the manuscript

Study 1b – cross sectional study, screening for nutritional risk factors and physical frailty during the preventive home-visits (PHV)

F: Development of screening guide for data collection

G: Data collection during the nationally regulated preventive home-visits

H: Data processing and analysis

I: Writing of manuscript

Study 2 – clinical study – The phased three arm randomized controlled study

J: Design and preparation for data collection

K: Scientific ethical approval of protocol

L: Recruitment of participants

M: Data processing and analysis

N: Writing the manuscript (in preparation)

Study 4 – New product development for frail elderly

O: Development of consumer questionnaire targeted very old adults

P: Scientific ethical approval of protocol

Q: Recruitment of participants and collection of data

R: Data processing and analysis

	2017				2018				2019				2020				2021			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
				Maternity leave											Maternity leave					
Study 1a																				
A	X	X																		
B			X																	
C			X	X	X	X														
D								X	X	X										
E										X	X	X	X							
Study 1b																				
F	X	X																		
G			X	X	X	X	X	X	X	X	X									
H													X	X						
I																			X	X
Study 2																				
J		X	X	X	X	X	X	X												
K								X												
L									X	X	X	X	X							
M																			X	X
Study 4																				
O	X	X																		
P			X																	
Q			X	X	X	X														
R								x	x	x										

10. Deviations

Scientific deviations

STUDY 1

Study 1 was remarkably improved during the development of the protocol by creating two sub-studies: study 1a and study 1b. In study 1a we introduced a more detailed and time-consuming method to collect nutritional status in our oldest participants (4 day-food record) in addition to the originally planned food frequency questionnaire. This allowed us to minimize the risk of reporting bias and the risk of misclassification of nutritional status as 4-day food record is currently considered as the gold standard method for nutritional assessment. The method was further enriched by detailed data quality control for each individual food record. The number of participants in study 1 was thereby reduced from 400 participants as originally planned to 147. The study 1b was built on an ongoing European funded large-scale study (WIPP) coordinated by SDU Center of Active and Healthy Ageing. This allowed us to collect highly relevant data on nutritional risk factors and pre-frail/frail status in 1627 community-dwelling older adults from several Danish municipalities through the nationally regulated preventive home-visits the by adding specific questions/questionnaire to the WIPP study.

Study 1a, detailed nutritional assessment:

1. We choose to supplement the Food Frequency Questionnaire with a 4-day food record (three weekdays and one day during the weekend) to i) obtain more detailed information about dietary intake and ii) be less dependent on memory recall. From the 4-day food records information about macronutrients, food choices, meal distribution, snack meals and day to day variation can be extrapolated. We believed that such detailed food habits for this population will be of great value for research and health authorities to promote evidence-based recommendations.
2. In addition to dietary intake additional measures which may be related to malnutrition, unintentional weight loss and frailty status for this population was also added to the original study design. These include assessment of appetite, eating ability, dental status, dysphagia (EAT-10, Eating Symptom Questionnaire) and nutritional status (Eating Validation Scheme, Mini Nutritional Assessment). This contributed to understand the magnitude of the nutritional challenges in this population, identify potential barriers and possibilities for improving nutritional status and provide a road map for product requirements for this specific population.
3. To evaluate the effect of nutritional status and frailty on the participants daily life we added objective measures on physical function (Short Physical Performance Battery), fatigue & fatigability, activities of daily living, depression, pain, and fear of falling. In addition, we assessed physical activity over 7 days by wrist-worn accelerometers.

To have sufficient power to investigate the nutritional and functional measures (as described in change 2 and 3), in addition to the association between frailty and protein intake a **total of 147 participants** was included in the detailed characteristics of the population in study 1a.

Study 1b, nutritional screening during preventive home-visits

In addition to the detailed nutritional assessment, we also wanted to investigate the prevalence of nutritional risk factors and physical frailty in an applied research setup where collection of data was performed by health care personnel during the nationally regulated preventive home-visit. This became possible because we have established a collaboration with another large ongoing study (Welfare Innovation in Primary Prevention), that aimed to identify potential risk factors for loss of function and self-reliance in old community-dwelling adults. A screening tool was developed in a collaboration between health care workers, health care providers, and academia. The SHARE-FI75+ frailty assessment tool was included in this screening as well as questions on unintentional weight loss during the last month, difficulties eating due to dental status or dysphagia, weight, height, recent acute illness, pain, quality of life (EQ-5D), and other risk factors for loss of physical function.

We recalculated the required sample size to make a representative estimation of the prevalence of robust, pre-frail and frail in the community-dwelling old adults and found that a sample size of 358 participants would be required. In addition, a drop-out rate of 20% (n=90) was added and a **total sample size of 448 participants** was required to describe the prevalence of frailty in this specific population. Regardless, we decided to collect data from the entire WIPP cohort and provide a solid representation from different municipalities. **A total of 1627 participants** were screened during their preventive home-visit. Data was collected by health care personnel in the municipalities of Odense, Slagelse, and Esbjerg.

STUDY 2

Unfortunately, despite a remarkable effort and time invested in developing and recruiting participants study 2 was closed before the entire sample finalize the intervention due to the national lock down during the COVID-19 pandemic. Flow chart (Figure 1) shows the different steps of the recruitment and interventions. Four hundred and twenty-two participants were invited, 68 were assessed for nutritional status and directed to either phase 1 (stabilization phase aimed at increasing daily protein intake by minimum nationally recommended) or randomized to three intervention groups. Forty-eight participants were assessed for baseline and 38 completed the study.

Pre-liminary data (under-powered) have been presented to the DDRF at the Coordination Group Meeting on May 30th, 2022. An article based on the learnings and results from the study is in preparation as feasibility study.

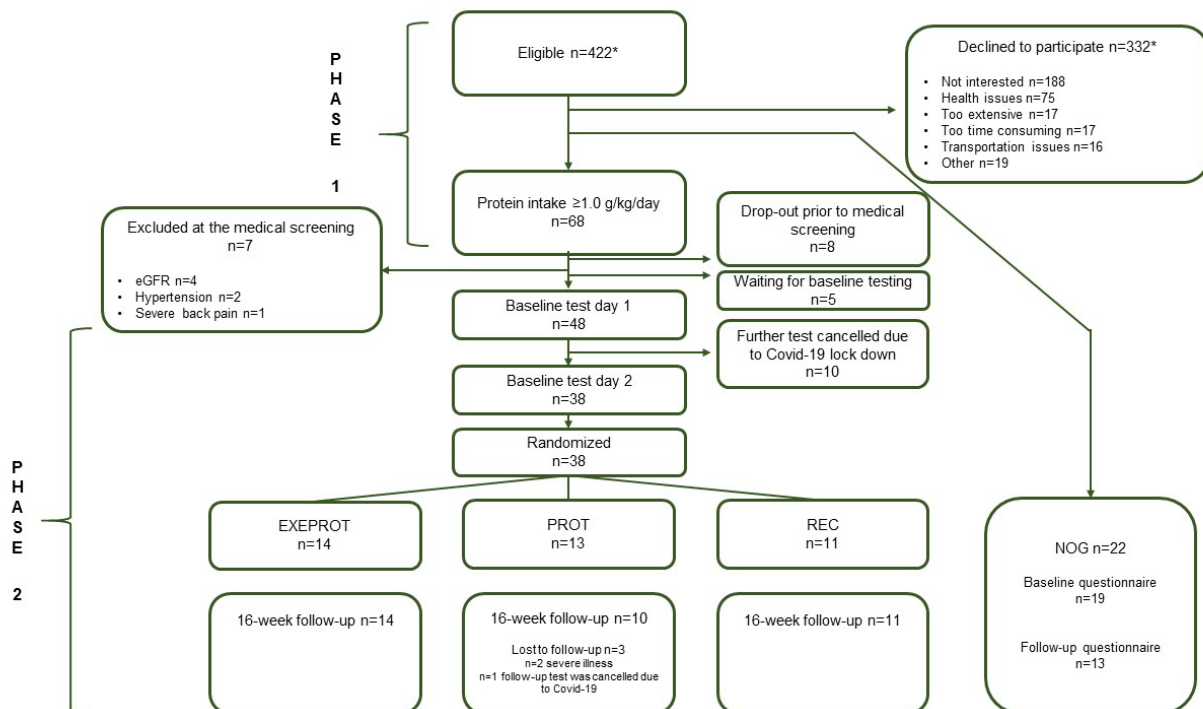


Figure 1. Flow chart for study 2

STUDY 3

Study 3 was planned as a socio-economic analysis derived by the result of study 2. Unfortunately, due to the low sample size in study 2 (20% of the expected participants) could not be carried out and completed evaluation.

STUDY 4

Study 4 was designed to investigate potential needs and opportunities for product development targeting community-dwelling older citizens. We originally used a questionnaire from the ARLA consumer research team on end-users' habits, not specifically designed for very old adults. Our preliminary results indicated that the format of the questionnaire was particularly challenging for our participants, and we decided to design a set of questions to investigate knowledge, habits and willingness to adapt current diet to national recommendations.

Financial deviations

None.

Prolonged project period

The project period has been prolonged twice due to maternity leaves.

11. Project results

STUDY 1a

In this study we found that the prevalence of protein intake below the recommended level (<1.0g/kg/day) was 54% in very old self-reliant community-dwelling adults (n=126, age 86±3.6 years). Participants with a low protein intake were older, had a higher BMI, and higher prevalence of low physical function (evaluated by SPPB-score<9) compared to participants with a normal protein intake (≥1.0 g/kg/day). In addition, participants with low protein intake reported more often to have nausea, diarrhea, and mouth dryness. The dietary patterns of participants with low intake of protein differed by a lower absolute and relative intake of protein during breakfast, a higher day-to-day variability in protein intake, and meal-to-meal variability in protein intake compared to participants with a normal intake of protein. Logistic regression models adjusted for age, sex, BMI-categories, and number of diseases found that reduced appetite (OR 3.06 95%CI 1.23;7.63), mouth dryness (OR 3.41 95%CI 1.51;7.70), and pain (OR1.54 95%CI 1.00;2.36) increased odds of low protein intake. The aggregation of multiple risk factors increased the odds of low protein intake. For the dietary patterns, a day-to-day variability in protein intake (>20%) increased odds of low protein intake independent of age, sex, BMI categories, and number of diseases (OR 2.50 95%CI 1.14;5.48).

STUDY 1b

Prevalence of physical robust, pre-frail and frail was 47.4%, 49.9% and 2.7%, respectively. Prevalence of physical pre-frail and frail condition increased with increasing age. Nutritional risk factors were associated with pre-frail/frail conditions. In particular, having one, two or more nutritional risk factor increased the odds of being physical pre-frail/frail condition in old self-reliant community-dwelling adults (n=1430, age 81.2±5.8 years) (OR 1.39 95%CI 1.07;1.80 and OR 2.67 95%CI 1.76;4.04, respectively). Furthermore, the nutritional risk factors unintentional weight loss (OR 1.97 95%CI 1.06;3.68), poor dental status (OR 2.50 95%CI 1.10;5.66), dysphagia (OR 1.93 95%CI 1.12;3.31), and high BMI (OR1.72 95%CI 1.29;2.30) independently increased the odds of physical pre-frail/frail conditions. In the very old self-reliant community-dwelling adults only high BMI alone independently increased odds of physical pre-frail/frail condition (OR 1.72 95%CI 1.16;2.53). Regardless, when two or more nutritional risk factors were present, the odds of being physical pre-frail/frail increased significantly (n=860) (OR 2.56 95%CI 1.45;4.52). Subgroup analyses (n=121) revealed that higher protein intake reduced odds of physical pre-frail/frail condition in very old participants independent of age and sex (OR 0.22, CI: 0.05-0.97). However, this finding was not significant when additionally adjusted for chronic conditions (OR 0.23, CI: 0.05-1.09).

STUDY 2

Recruitment for study 2 was initiated in February 2019. On the 11th of March 2020, the study was temporarily paused due to a national lock down caused by the Covid-19 pandemic. Even when society reopened research activities with older adults were still shut down. By July 2021 the study was officially ended. Selected preliminary results are presented here below.

Recruitment

Four hundred and twenty-two participants were invited, 68 were assessed for nutritional status and directed to either phase 1 (stabilization phase aimed at increasing daily protein intake by minimum nationally recommended) or randomized to three intervention groups. Forty-eight participants were assessed for baseline and 38 were randomized to the Exercise plus protein (EXEPROT, n=14), protein (PROT, n=13) and recommendation (REC, n=11) groups. Thirty-five participants completed the study (Figure 1).

Outcome measures

No significant between group differences following the interventions were detected for maximal muscle power, repeated chair rise, lean mass, or body weight from baseline to 16-week follow-up. Nevertheless, significant within group changes were observed for maximal muscle power (W, W/kg and W/kg lean mass) in the EXEPROT intervention arm, and for whole-body lean mass in the PROT intervention arm. The average changes in maximal power corresponded to over 30%, 19%, and 12% from baseline values in the EXEPROT, PROT and REC intervention arms, respectively. The average changes in whole-body lean mass corresponded to approximately 1%, 3%, and 1% from baseline values in the EXEPROT, PROT and REC interventions arms, respectively.

Significant within group increase in protein intake was observed for PROT ($p=0.005$) from baseline to 16-week follow-up. EXEPROT and REC did not change in protein intake from baseline to the 16-week follow-up.

STUDY 4

We have collected data from 142 participants on different questions *ad hoc* designed to evaluate consumers' habits. Selected results are reported here below in table 1.

Table 1. Questions designed to evaluate consumers' habits.

Question 1: What is the recommendation for protein intake for elderly (over 65 years) compared to younger (below 65 years) Tick one box	
It is recommended that elderly eat less	7%
It is recommended that elderly eat the same	28.2%
It is recommended that elderly eat more	37.3%
Not sure	27.5%
Question 2: If you for health reasons were recommended to change your dietary habits, how likely would you be to do so? Tick one box	
To a high degree	31%
To some degree	57.8%
To a low degree	3.5%
Not at all	2.8%
Not sure	4.9%
Question 3: If you were recommended to eat more dairy products to maintain your muscle strength, how likely would you follow this recommendation? Tick one box	
To a high degree	38%
To some degree	46.5%
To a low degree	6.3%
Not at all	5.6%
Not sure	3.5%

Question 4: How do you perceive that the following food groups affect your health? Please tick the box that best reflects your experience for the different food groups						
	Very positive	Positive	Neutral	Negative	Very negative	Don't know
Dairy products						
Milk	24.1%	39.9%	18.1%	0.8%	0.8%	16.5%
Cheese	30.4%	48.9%	9.6%	0	0	11.1%
Yoghurt	31.3%	39.6%	10.5%	0	1.5%	17.2%
Other sources of protein						
Fish	39.3%	34.1%	12.6%	0	0	14.1%
Red meat (beef, pork)	10.2%	20.3%	28.1%	11.7%	7.8%	21.9%
Poultry (chicken, turkey)	24.8%	45.3%	13.1%	0.7%	0.7%	15.3%
Egg	27.8%	41.4%	16.5%	0	2.3%	12.0%
Beans, lentils, chickpeas	24.4%	23.5%	14.4%	1.5%	2.3%	34.1%

12. The relevance of the results, including relevance for the dairy industry

Our findings highlight that daily protein intake as recommended by national health care authorities is a serious challenge for a very large number of very old community-dwelling adults (54%). According to such guidelines we categorized over 50% of our community-dwelling older adults as protein malnourished. Importantly, this indicates that a systematic screening for protein malnutrition should be included in primary preventive strategies to prevent the negative health outcomes common to the malnutrition status. However, currently no feasible screening tool for protein malnutrition exist. Numerous nutritional screening tools for primary preventive setting exist. However, since protein malnutrition may not present with the same symptoms (e.g., unintentional weight loss, reduced dietary intake) or risk factors as energy malnutrition this type of malnutrition may potentially be overlooked by the existing nutritional screening tool. Hence, currently protein malnutrition may largely be undetected in primary prevention and older adults identified with malnutrition risk may only represent a small proportion of the nutritional challenges in self-reliant community-dwelling adults. **Thus, more research is needed in order to develop a reliable tool for detecting protein malnutrition at an early stage.**

In addition, in study 4 knowledge about protein recommendations were assessed by self-reported questionnaires. Majority of participants (62.7%) replied that they either did not know the nutritional recommendations on protein intake for older adults or that they believed that older adults are recommended similar or lower intakes of protein compared to younger. Nevertheless, 88.7% of participants in study 1 replied that they certainly or to some degree would change dietary habits if recommended out of health concerns. **These results indicate that there is an opportunity to increase knowledge of the importance of protein intake in the ageing population and that most of the very old adults would be ready to make changes if health benefits are clearly explained.**

The results on dietary patterns have practical implications for health care personnel performing e.g. the preventive home-visits, nutritional specialists or dieticians involved in the nutritional guidance of very old adults. Recommendation on incorporating protein-rich products on daily basis may reduce day-to-day variability of protein and increase total protein intake. In addition, total and relative protein intake at breakfast was lower in participants with protein malnutrition and may offer an opportunity to increase intake at this meal. Further, the nutritional risk factors are important to assess and consider in the guidance of older adults to increase intake e.g., adjustments in the texture to consider mouth dryness and/or dysphagia, enrichment of the diet when appetite is reduced, or participants report weight loss. **Thus, increased focus on protein malnutrition in the primary preventive sector is needed and may have a remarkable impact on overall health in this population.**

Lastly, the preliminary results from study 2 indicate that off-the-shelf dairy products generally were well-accepted may have an impact on lean mass in very old community dwelling adults with pre-frail/frail condition. However, remodeling of habitual diet should be closely monitored. In addition, combining protein supplementation with power training was a feasible way to facilitate clinical meaningful changes in muscle power an important indicator of physical frailty. These preliminary results indicate that these interventions have the potential to improve indicators of physical frailty in pre-frail/frail very old adult identified at the preventive home-visits and this offers an opportunity for health care providers to tackle the negative physical health outcomes that may follow the physical frailty phenotype in very old adults.

From the perspective of the dairy industry, the results from this study are interesting. We have identified a target group of the Danish population which is in high needs of increasing daily protein intake. We have demonstrated that breakfast may be particularly important time of the day to ensure an overall high daily protein intake. Increasing dairy intake during breakfast may contribute to prevent protein malnutrition in very old citizens. In addition, despite more evidence is needed, our very preliminary data indicates that incorporating off-the-shelf dairy product may be feasible and translate into larger lean mass.

13. Communication and knowledge sharing about the project

Papers in international journals:

- Buhl et al. 2020: *Effects of high-protein diet combined with exercise to counteract frailty in pre-frail and frail community-dwelling older adults: study protocol for a three-arm randomized controlled trial.* *Trials.* 2020; 21:637 <https://doi.org/10.1186/s13063-020-04572-z>
- Buhl et al. 2022: *Prevalence of low protein intake in 80+-year-old community-dwelling adults and association with dietary patterns and modifiable risk factors: a cross-sectional study.* *British Journal of Nutrition.* 2022; 127(2): 266-277. <https://doi.org/10.1017/S0007114521000799>
- Buhl et al. 2022: *Relationship between physical frailty, nutritional risk factors and protein intake in community-dwelling older adults.* *Clinical Nutrition ESPEN.* 2022; 49: 449-458. <https://doi.org/10.1016/j.clnesp.2022.03.004>
- Buhl et al. 2023: *Association between Malnutrition Risk Factors and Physical Function in Community-Dwelling Adults ≥80 Years.* *Journal of Ageing and Longevity.* 2023; 3(1):33-45. <https://doi.org/10.3390/jal3010003>
- In preparation: *High-protein diet alone or in combination with exercise in very old frail community-dwelling adult – a feasibility study*
- In preparation: *Validation of the Danish version of the Protein Screener 55+ (Pro⁵⁵⁺) in community-dwelling adults ≥80 years*

Easily read papers:

- Sussi Friis Buhl, Anne Marie Beck, Britt Christensen & Paolo Caserotti (2017) Ældre tester ekstra mælkeprotein. Mælkeritidende nr. 25-26: 12-13. https://maelkeritidende.dk/sites/default/files/udgivelser/Forskningsartikler/sider_fra_mt_25-26_2017.pdf
- Sussi Friis Buhl, Anne Marie Beck, Britt Christensen & Paolo Caserotti (2023) Utilstrækkeligt proteinindtag hos ældre. Mælkeritidende nr. 3: 22-23. https://maelkeritidende.dk/sites/default/files/udgivelser/Forskningsartikler/sider_fra_maelkeritidende_nr_3_2023_hoej_forskning_slut.pdf

Oral and poster presentations at scientific conferences, symposiums etc.:

- Oral presentation by Sussi Friis Buhl at the 10th Conference by the European network for the promotion of health-enhancing physical activity (HEPA Europe), Odense, Denmark: *Association between energy intake and physical activity in Danish weight-stable +80 year old community-dwelling adults- preliminary results from the I'm still standing study*. August 2019.
- Oral presentation by Sussi Friis Buhl at the National conference on ageing and society by the Danish Gerontological Society (DGS), Middelfart, Denmark: *Is malnutrition a challenge in community-dwelling adults +80 years. Results from I'm still standing and WIPP*. October 2019.
- Oral presentations by Sussi Friis Buhl at the Arla Nutrition Seminar 2019. Copenhagen and Aarhus, Denmark: *I'm still standing – Nutritional challenges in the oldest old*. October & November 2019.
- Poster presentation by Sussi Friis Buhl at the annual meeting in the Danish Society for Clinical Nutrition (DSKE): *Prevalence of low protein intake in 80+year-old community-dwelling adults and association with dietary patterns and modifiable risk factors*. May 2021.
- Oral presentation by Sussi Friis Buhl at the webinar "Prevention of unplanned weight loss in frail older adults" by the Danish Health Authority and the knowledge bank for better meals for older adults, Copenhagen, Denmark: *Protein intake in older adults above 80 years – challenges and opportunities*. June 2021.
- Oral presentation by Sussi Friis Buhl at the 26th Nordic Conference of Gerontology, Odense, Denmark: Presentation and Abstract: *Relationship between physical frailty, nutritional risk factors and protein intake in self-reliant community-dwelling adults*. June 2022.
- Poster presentation Sussi F. Buhl, Nanna H. Svensson, Mathias Skjødt, Trine Thilising, Jens Søndergaard, Fereshteh Baygi & Paolo Caserotti. Prevalence of sarcopenia and sarcopenic obesity and association with protein intake in self-reliant community-dwelling adults +75 years submitted to the National conference of the Danish Gerontological society (Nov 2023).

Oral presentations at meetings:

- Oral presentation by Sussi Friis Buhl at Wednesday café meeting at Munkebjerg Church, Odense an opportunity for older adults to meet up for social activities and presentation on topics related to health, culture, well-being etc.: *Food for muscles*. November 2019.
- Oral presentation by Sussi Friis Buhl at the workshop for the Danish National Quality database for frail old patients (DÆSP) held by the Danish Society for Geriatrics, Odense, Denmark: *Nutrition and the frail old patient/citizen*. September 2021.
- Oral presentation by Sussi Friis Buhl at the virtual workshop "Assessing Intake of Food and Dietary Supplements in Older Adults: a Workshop Series" held by the National Academies of Sciences, Engineering and Medicine: *Nutritional Challenges in Vey Old Danish Adults*. April 2022

- Oral presentation by Sussi Friis Buhl at Seniorhuset, Odense "Food and healthy ageing" workshop on healthy ageing supported by Gigeforeningen, PTU, Dansk Handikap & Røde Kors. October 2022.

Papers in preparation:

Anne Marie Beck, Ilaria M Piccinini, Sussi Friis Buhl Britt Christensen & Paolo Caserotti. Adherence to nutritional supplementation with commercially available dairy products: a feasibility study (expected end of 2023).

Sussi Friis Buhl, Gry Kock, Anne Marie Beck, Mathias Skjødt Hanneke A. H. Wijnhoven, Marjolein Visser, Eleanor Boyle, & Paolo Caserotti. Validation of The Protein Screener 55+ for assessment of inadequate protein intake in Danish community-dwelling adults +80 years (expected end of 2023).

Awards

Sussi Friis Buhl was awarded as best oral presentation at the 26th Nordic Conference of Gerontology, Odense, Denmark: Presentation and Abstract: *Relationship between physical frailty, nutritional risk factors and protein intake in self-reliant community-dwelling adults*. Funding source (**The Danish Dairy Research Foundation**) was declared. June 2022.

14. Contribution to PhD and master education

PhD thesis:

- Sussi Friis Buhl 2021: Protein malnutrition and nutritional risk factors in old and very old self-reliant community-dwelling adults: association with physical frailty and reversibility with protein supplementation and power training. The I'm still standing study.

Master thesis:

- Ebbe Troels Bjarup Kriescher 2023: The Effects of Combined Resistance training and Protein supplementation on physical function, muscle strength, and muscle power in pre-frail frail community dwelling older adults.

15. References

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