SLUTRAPPORT/FINAL REPORT
NR. 2020-162

Anne Marie Beck:

Proteinrig mælk for at få gavn af træning af akut syge ældre

A protein-enriched, milk-based supplement to counteract sarcopenia in acutely ill geriatric patients offered resistance exercise training during and after hospitalization – a double-blinded, randomized controlled trial

Mejeribrugets
ForskningsFond

November 2020

Final report

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

1. Title of the project

Danish: Proteinrig mælk for at få gavn af træning af akut syge ældre.

English: A protein-enriched, milk-based supplement to counteract sarcopenia in acutely ill geriatric patients offered resistance exercise training during and after hospitalization – a double-blinded, randomized controlled trial.

2. Project manager

Anne Marie Beck, Senior Researcher, Research Unit of Clinical Nutrition, Herlev and Gentofte Hospital
Borgmester Ib Juuls vej 50, 4th floor. DK-2730 Herlev
E-mail: anne.marie.beck@regionh.dk

3. Other project staff

Daily project manager

Josephine Gade, Ph.D. student, Research Unit of Clinical Nutrition, Herlev and Gentofte Hospital
Borgmester Ib Juuls vej 50, 4th floor. DK-2730 Herlev
E-mail: josephine.gade.bang-petersen@regionh.dk; phone: +45 29 82 75 65

Supervisors

Arne Astrup, Professor, MD, DMSc, Head of Department of Nutrition, Exercise and Sports, Faculty of SCIENCE, University of Copenhagen.
Rolighedsvej 26, 1958 Frederiksberg C
E-mail: ast@nexs.ku.dk; phone: +45 35 33 24 76

Anne Marie Beck, Senior Researcher, Research Unit of Clinical Nutrition, Herlev and Gentofte Hospital
Borgmester Ib Juuls vej 50, 4th floor. DK-2730 Herlev
E-mail: anne.marie.beck@regionh.dk

Anders Vinther, Ph.D., Physiotherapist, Department of Rehabilitation, Herlev and Gentofte Hospital
Herlev Ringvej 75, 2730 Herlev
E-mail: anders.vinther@regionh.dk; phone: +45 26 80 87 10

Britt Christensen, Ph.D., Nutrition Scientist, Arla Strategic Innovation Center, Global Nutrition
Arla Foods amba, Agro Food Park 19, 8200 Aarhus N
E-mail: britt.christensen@arlafoods.com; phone: +45 87 46 66 34

Site responsible

Hanne Forbech Skall, Chief Therapist, Herlev and Gentofte Hospital
Department of Rehabilitation - Herlev Ringvej 75, 2730 Herlev and Kildegårdsvej 28, 2900 Hellerup
E-mail: hanne.forbech.skall@regionh.dk; phone: +45 61 50 00 97

Hanne Elkjær Andersen, Specialist Chief Physician, Medical Department M, Rigshospitalet-Glostrup, Nordre Ringvej 57, 2600 Glostrup

E-mail: hanne.elkjaer.andersen@regionh.dk; phone: +45 38 63 45 98

Finn Rønholt, Chief Physician, Medical Department O and Medical Department C, Herlev and Gentofte Hospital, Herlev Ringvej 75, 2730 Herlev
E-mail: Finn.Roenholt@regionh.dk; phone: +45 38 68 13 13

4. Sources of funding

The Danish Dairy Research Foundation is the head sponsor of this research study. Other funding comes from University of Copenhagen, Department of Nutrition, Exercise and Sports, and The Nordic Kitchen at Herlev and Gentofte Hospital. Furthermore, Arla Foods Amba and Arla Foods Ingredients have funded the study, including sponsoring the intervention products.

5. Project period

Project period with DDRF funding: October 2015 – September 2019.

6. Project summary

Danish
Formål: Studiet undersøgte, om mælkebaseret proteintilskud (PrS) kunne forstærke det adaptive respons til styrketræning (ST) blandt ældre, geriatriske patienter, mens de var indlagt på geriatrisk afdeling samt efter udskrivelse, hvilket ikke før er undersøgt.
Design: I et randomiseret forsøg med to grupper blev patienter > 70 år rekrutteret fra tre medicinske afdelinger. Deltagerne blev allokeret til en proteingruppe eller en placebogruppe, der henholdsvis modtog PrS (27,5 g valleprotein/d, ≈ 2000 kJ/d) og placeboprodukter (<1,5 g protein/d, ≈ 2000 kJ/d), dagligt som supplement til deres almindelige kost. Begge grupper blev tilbudt et standardiseret, progressivt ST-program, der fokuserede på benmuskulaturen (superviseret dagligt under indlæggelse, og 4x/uge efter udskrivelse som selvtræning). Interventionen startede under indlæggelsen, efter inklusion, og varede til 12 uger efter udskrivelse.
Resultater: 165 deltagere blev inkluderet i undersøgelsen fra april 2016 til september 2017. Undervejs i studiet blev 14 ekskluderet og 10 faldt fra, og således indgik 141 deltagere i de endelige analyser (70 proteingruppe/71 placebogruppe). Begge grupper forbedrede sig signifikant for de fleste endepunkter, men der blev ikke fundet nogen statistisk effekt af PrS for det primære endepunkt (30-s rejse-sætte-sig test, ændringer i gentagelser fra baseline, median (Q1, Q3): (standardtest: 0 (0, 5) (proteingruppe) vs. 2 (0,6) (placebogruppe) og modificeret test (brug af arme tilladt): 2 (0,5) (proteingruppe) vs. 2 (-1,5) (placebogruppe)), og heller ikke for nogle af de sekundære endepunkter (kropsammensætning, muskelstyrke, funktionsmålinger og genindlæggelser, P> 0,05). Det gennemsnitlige samlede proteinindtag var 1,0 (± 0,39) g/kg/d i proteingruppen og 0,8 (± 0,33) g/kg/d i placebogruppen.
Konklusion: PrS, der fører til et samlet proteinindtag på 1,0 g/kg/d, synes ikke at have nogen yderligere effekt, når det tilbydes i kombination med ST.

English
Aim: Not previously explored in geriatric patients, the study investigated if milk-based protein-supplementation (PrS) could increase the adaptive response to resistance-exercise-training (RT) among Danish older adults while admitted to the geriatric ward and after discharge.
Design: In a randomized trial with two groups, older adults >70 years were included from three Medical Departments. Participants were allocated to a protein-group or a placebo-group, receiving PrS (27.5 g whey

protein/d, ≈ 2000 kJ/d) and placebo-products (<1.5 g protein/d, ≈ 2000 kJ/d), respectively, to supplement habitual diet. Both groups were offered a standardized, progressive RT-program for the lower extremities (supervised daily while hospitalized and 4x/week after discharge as self-training). The intervention started during admission, after inclusion, and lasted to 12 weeks after discharge.
Results: 165 participants were included in the study from April 2016 to September 2017. During the study, 14 were excluded and 10 dropped-out, leaving 141 participants in final analyses (70 protein group/71 placebo group). Both groups improved significantly for most endpoints, but no statistical effect of PrS was seen for the primary endpoint (30-s Chair-stand-test, changes in repetitions from baseline, median (Q1,Q3): (standard test: 0 (0.5) (protein group) vs. 2 (0.6) (placebo group) & modified test: 2 (0.5) (protein group) vs. 2 (-1.5) (placebo group)) or any of the secondary endpoints (body composition, muscle strength, functional measures, and readmissions, P>0.05). The average total protein intakes were 1.0 (±0.39) g/kg/d in the protein group and 0.8 (±0.33) g/kg/d in the placebo group.
Conclusions: PrS leading to a total protein intake of 1.0 g/kg/d does not seem to have any additional effect, when offered in combination with RT.

7. Project aim

Danish: Sarkopeni (aldersbetinget tab af muskelmasse) er en byrde både for de ældre og samfundet. Det er oplagt at inkludere mejeriprodukter i ''kampen'' mod sarkopeni på grund af den gavnlige effekt på muskelmasse. Men ingen har undersøgt den gavnlige virkning af mælkebaserede produkter blandt dem, der har størst risiko for tab af muskelmasse og dermed funktion, dvs. akut syge ældre. Det er derfor ukendt:

- Om proteinrige mælkeprodukter kan forbedre bevarelse af muskelmasse og muskelstyrke hos akut syge ældre der tilbydes styrketræning.

- Om tilbud af proteinrige mælkeprodukter til geriatriske patienter, der tilbydes styrketræning resulterer i ekstra omkostninger.

- Om proteinrige mælkeprodukter tages godt imod af målgruppen, ikke mindst fordi et væsentligt antal af geriatriske patienter er alvorligt begrænsede i deres evne til at tage sig af deres egen ernæring, bl.a. på grund af deres dårlige kognitive funktion og almentilstand.

Det vil blive undersøgt i et blok-randomiseret, dobbelt-blindet, placebo-kontrolleret, multicenter studie blandt 120 (senere ændret til 165) akut syge geriatriske patienter under og efter indlæggelse. Effektmålene vil fokusere på virkningen på muskelmasse, muskelstyrke, funktion, livskvalitet, omkostninger, og ikke mindst den ældres accept af interventionen.

English: Sarcopenia (age-related loss of muscle mass) is a burden both for the older adults and for society. Due to their beneficial effect on building/maintaining muscle mass, it is important to include dairy products in the fight against sarcopenia. However, no one have investigated the effect of milk-based products among those with greatest risk of losing muscle mass and function, the acutely ill older adults. Thus, it is unknown:

- If protein-rich milk products can improve the maintenance of muscle mass and muscle strength in acutely ill older adults offered resistance exercise training.

- If providing protein-rich milk products for geriatric patients offered resistance exercise training results in additional costs.

- If protein-rich milk products are well accepted by the target group, important because a significant number of geriatric patients are severely restricted in their ability to take care of their own nutrition, due to poor cognitive function and general condition, among other.

This will be studied in a block-randomized, double-blind, placebo-controlled, multicenter study among 120 (later changed to 165) acutely ill geriatric patients during and after hospitalization. The effect targets will

focus on the effects on muscle mass, muscle strength, function, quality of life, costs, and not least the patient's acceptance of the intervention.

8. Background for the project

Sarcopenia is the loss of muscle mass with ageing and is an unavoidable process. This is called primary sarcopenia and is caused by development of anabolic resistance with age. Starting as early as in our forties, the loss of lean body mass (LBM) is about 1 % per year, and this tends to accelerate after the age of 70. The decrease in LBM, and thus muscle strength and power, are important predictors of impaired balance, falls, and mortality. Also, sarcopenia is associated with a 3- to 4-fold increased risk of disability, which in turn is associated with substantial socio-economic and health care spending. Sarcopenia is estimated to affect about 5-10 % of people > 65 years, with the number being as high as 50 % in individuals > 80 years. Worldwide about 200 million people are expected to experience sarcopenia in a degree that could affect their health. Thus, studies on how to counteract sarcopenia are highly relevant.

Acute illness is associated to bed rest and stress metabolism, which further increases the loss of muscle mass and requirements for protein, respectively. Also, acute illness often magnifies the loss of appetite that many older adults suffer from. Disease, inactivity and nutritional intake below requirements are all secondary causes of sarcopenia. Thus, geriatric patients are particularly vulnerable with respect to developing this condition. Even a short hospital stay has been shown to increase the risk of loss of functional capacity and loss of ability to cope with activities of daily living (ADL). For older medical patients it is shown that only one in three have reverted back to their original physical function one year after discharge. Any additional episodes of illnesses and readmissions will result in an accelerated episodic loss of muscle mass and functional abilities. The consequences of the accelerated loss of muscle mass in bed-ridden older adults during acute illness may be further complicated by the fact that up to two-third of the patients can already be characterised as moderately sarcopenic prior to admission. Also, many older adults consume relatively small amounts of protein, due to low appetite as mentioned, and a substantial number of geriatric patients are severely limited in their ability to take care of their own nutrition, due to e.g. their cognitive or general status. Hence, targeted intervention strategies to counteract sarcopenia becomes even more relevant in the acutely ill, older patients.

The beneficial effect of resistance exercise training (RT) on counteracting sarcopenia is quite well-established, and the effect of protein supplementation alone has also been documented. The potential benefit of a higher protein intake or supplementation as an addition to offering RT among older adults have also been investigated (mostly 6-12 weeks duration), but findings in individual studies have been contradictory. A systematic review by Malafarina et al. (2013) and a meta-analysis by Cermak et al. (2012) have concluded that in older adults, protein supplementation increases muscle mass, and in some studies also muscle strength, during prolonged RT. However, the evidence is sparse in the frailest older adults, who often have a low dietary protein intake, and based on present findings a hypothesis is that they might benefit even more from a combined intervention. Protein quality is characterized by the amino acid content, digestibility, and bioavailability. Protein from milk has been found to be superior to other protein sources, both in the rested state and following RT, due to its high content of whey protein. Whey protein has a high digestibility and is a 'complete protein' containing all the essential amino acids. It contains a high content of the branched chain amino acid, leucine, which is the key amino acid in triggering muscle protein synthesis. Thus, a milk-based, protein-enriched beverage, which is easily accessible, could be a good supplement to a diet that may be low in protein. To our knowledge, no studies have yet investigated the effect of a protein-enriched, milk-based supplementation in addition to RT among acutely ill very old adults – those at highest risk for accelerated muscle loss, loss of functions, and (further) development of sarcopenia.

9. Sub-activities in the entire project period

October 2015 – April 2016

- Study preparations
    - Drafting of study protocol incl. systematic literature search, development and pilot-testing of resistance training program.
    - Various cooperation agreements e.g. with the three recruitment sites.
    - Various preparations e.g. SOPs, Case-report forms, getting equipment etc.
    - Obtaining approvals from Research Ethic Committee and Data Protection Agency.
    - Registering study in Clinical.trials.gov database.
    - Hiring of project staff.

April 2016 – June 2018

- Active study period: Recruitment, intervention, test-visits (data collection)
    - September 2017: Last patient recruited.
    - December 2017: Last participant's test visit (end of interventions).
    - June 2018: Last 6-months follow-up registrations.
- Project management:
    - Daily coordination and hiring of extra daily research assistants.
    - Hiring and coordination of weekend trainers.
    - Protocol amendments to Research Ethic Committee.
- Other:
    - March 2018: Publication of systematic review (relevance to study topic).
    - April 2018: Publication of study protocol.
    - Continuous: Oral communication/presentations and knowledge sharing about the project.

June 2018 – August 2018

- No activities due to maternity leave.

August 2018 – September 2019

- Data analyses and publications, incl. Ph.D. thesis.
- Oral communication/presentations and knowledge sharing about the project.

10. Project results

Recruitment

Recruitment lasted from April 2016 to September 2017. A total of 2351 patients were screened to find 165 participants who were eligibly and willing to participate. During the study, 14 were excluded and 10 dropped out, leaving 141 participants in the final intention-to-treat (ITT) analyses where participants are analyzed according to the group they were allocated to irrespective of they were compliant to the intervention or not (70 protein group/71 placebo group).

Baseline characteristics

The groups were comparable at baseline for all measured characteristics, such as admission diagnoses and comorbidities, and for endpoint performance. The average age was 85.3 (±6.2) years and 84.2 (±6.3) years, and the BMI was 25.1 (±4.2) and 25.8 (±5.2) in the protein and placebo group, respectively. Furthermore, the median duration of the study intervention was similar between the groups, as the length of intervention during hospitalization was comparable (protein group: 5 (4, 8) days & placebo group: 5 (3, 8) days).

Compliance and total protein intakes
The average compliance (intake in percentage of total dosage) to the intervention products for the whole intervention period was 63.4 (±30.4) % in the protein group and 56.7 (±38.7) % in the placebo group. In general, the compliance was higher during hospital admission than after discharge. Regarding the resistance exercise training (RT), there were no differences in the training compliance between groups, and the same picture of compliance was evident throughout the study intervention, as with the supplements. During hospitalization, almost all participants followed the protocol and trained daily. After discharge, only about 50 % in both groups followed the protocol and trained 4 or more times per week. After discharge, no differences between groups were observed for other physical activities. No side-effects to consumption of the intervention products or the RT were observed.

Protein (total g/kg/d) and energy (kJ/d) intakes were registered for participants during the study intervention. During hospitalization, intake was registered for up to four days depending on length of stay. For the 12-week period after discharge, protein- and energy intake was estimated based on the average of four 24-hour dietary recall interviews performed at home visits. Considering the total intervention period, the average total protein and energy intakes were 1.0 (±0.39) g/kg/d and 6.8 (IQR: 5.9 to 7.5) MJ/d in the protein group and 0.8 (±0.33) g/kg/d and 6.9 (IQR: 5.4 to 8.0) MJ/d in the placebo group, which was significantly different, but for both groups still much below the protein recommendations for acutely or chronically ill older adults (1.5-2.0 g/kg/d). The dietary intakes were generally less during hospitalization than after discharge.

Primary and secondary endpoints
For the primary endpoint, the 30-s chair-stand-test, no effect of protein supplementation was found when looking at changes in repetitions from baseline (median (Q1,Q3): standard test: 0 (0,5) (protein group) vs. 2 (0,6) (placebo group) & modified test (use of arms allowed): 2 (0,5) (protein group) vs. 2 (-1,5) (placebo group)). Looking into if participants improved or not, for the 12-week period after discharge, more participants in the placebo group improved (protein group: 60.6 % vs. placebo group: 76.8 %, P=0.042). There were no differences when comparing how many participants could stand without the use of their arms.

For the secondary endpoints; body composition measures (total and segmental lean body mass in kg and total fat mass), BMI, hand grip strength, DEMMI-score (functionality), 4-m gait speed, Barthel score (independent functionality), MMSE score (cognition), quality of life (index score as well as a score on a Visual Analogue Scale), no significant differences were observed between the two groups (P>0.05), except for hand grip strength during the period 12-weeks after discharge, where the placebo group had significantly higher improvements compared to the protein group (1.4 (-0.7, 3.5) vs. 0.1 (-2.3, 2.4), P=0.026).

Per protocol (PP) analyses was also performed, including only those with a high compliance (average intake ≥ 75 % of the intervention products for the total intervention period). During hospital admission, this was 84 % (n=61) in the protein group and 81 % (n=61) in the placebo group, which dropped to 44 % (n=31) and 41 % (n=29) in the protein- and placebo group, respectively, during the 12-week period after discharge. Summing up, considering the total intervention period, 46 % (n=32) in the protein group and 42 % (n=30) in the placebo group were highly compliant. For the primary as well as for the secondary endpoints, considering the entire intervention period, the only statistical significant differences were in favor of the placebo group, who had a significantly larger increase in BMI (median (Q1, Q3), protein group: 0.19 (-0.57, 1.04) vs. placebo group: 0.88 (0.33, 1.50), P=0.050), 4-m gait-speed (median (Q1, Q3), protein group: 0.03 (-0.11, 0.23) m/s vs. placebo group: 0.20 (0.08, 0.33) m/s, P=0.026), and a significantly higher increase in Barthel score (median (Q1, Q3), protein group: 13 (2, 21) vs. placebo group: 21 (9, 39), P=0.033). However, considering the total amount of statistical analyses performed, among other, we believe these are spurious findings. Thus, overall, the PP analyses did not change the study conclusions considerably.

Generally, for both the ITT and PP analyses, looking within groups, the majority of participants improved significantly for most endpoints from recruitment to final testing.

Subgroup analyses

To investigate if certain subgroups in the study population benefitted more from the protein supplementation during prolonged RT, two subgroup analyses were made, which was part of the original data analysis plan. Hypotheses exist that those who are most weak, or with a low habitual consumption of protein, might benefit more from a combined intervention. Thus, we planned to compare the protein group with the placebo group looking only at those who at baseline were at nutritional risk (according to the NRS-2002 screening tool) and who were sarcopenic (according to the EWGSOP2 definition). At baseline, the number of participants at nutritional risk were 15 and 25 in the protein group and placebo group, respectively, and in the protein group, 25 were sarcopenic, while 21 were sarcopenic in the placebo group. Both subgroup analyses did not result in any significant effects between groups.

Cost-effectiveness

No direct calculations of costs were made, but the following endpoints were regarded as indirect measures.

Admission to hospital, length of hospital stay, and mortality

During the study intervention, no differences in any of these endpoints were found between groups. During the follow-up period, 6 months after the last test visit, significantly more was found to die in the protein group (P=0.032). However, it is considered a spurious finding unrelated to study participation. Most participants died during admission to hospital with admission diagnoses on the top three list of most encountered diagnoses in geriatric patients on a nationwide basis, and the mortality rate was actually much lower than expected for the present study population. Furthermore, potential confounding factors, that could influence the results, were not monitored during the follow-up period.

Residence, home care, and use of gait aids

These variables were compared for changes occurring throughout the total intervention period. Most participants in both groups lived in own house/apartment (protein group: 91.4 % vs. placebo group: 97.2 %), and only a couple of participants in both groups had moved to a nursing home/sheltered housing (protein group: 4.3 % vs. placebo group: 2.8 %, p=0.681) at the end of their intervention period, which was not different between groups. The number of participants receiving help/any kind of home care increased during the intervention period in both groups (protein group: 61.4 % to 71.4 % (p=0.210) & placebo group: 63.4 % to 74.6 % (P=0.147)) without being different between groups (P=0.807). This was also the case for the origin of help, e.g. practical, personal, or both (P>0.05). Despite an increasing need of help, a decrease in the number of participants who needed gait aids (expected to reflect the degree of independence) during the intervention period was found in both groups. This was only a significant change within the placebo group (protein group: 71.4 % to 60.0 % (P=0.154) & placebo group: 80.3 % to 63.4 % (P=0.025)) and did not differ between groups (P=0.352).

Collectively, from the findings outlined above, we did not find evidence that providing geriatric patients with protein supplementation is cost-effective.

Acceptance of protein-rich milk-products by the target group

At the final testing, 12 weeks after discharge, or earlier if dropping out, participants were asked to evaluate the intervention products. The evaluation revealed that in general, the study products were liked by the participants: 54 % in the protein group and 47 % in the placebo group rated the liking as ‘a lot’ or ‘very much’, while only 9 % and 12 % in the protein and placebo groups, respectively, did not like the products at all. However, 38 % in the protein group and 48 % in the placebo groups experienced taste fatigue during the intervention period, of which 16 % and 14 % rated it as ‘often’ or ‘very often’. This might be explained by the fact that only one flavor was available during the study intervention. 38 % in the protein group and

19 % in the placebo groups thought the products were highly or extremely satiating. Combined, these results might explain why the average consumption of the intervention products was lower than expected.

For further details about the study and study results, including discussion about possible reasons for lack of effect, refer to Gade et al. (2019), https://pubmed.ncbi.nlm.nih.gov/29391380/ and https://pubmed.ncbi.nlm.nih.gov/31337448/

Conclusion
No additive effect of milk-based protein supplementation during hospital admission and 12 weeks after discharge was found in geriatric patients, who were offered standardized RT. This finding might be explained by the fact that the total protein intake in the protein group only reached 1.0 g/kg/d, which is substantially lower than the current recommendations. However, the study did find significant improvements in both groups for most endpoints and supports the established knowledge of RT as a strategy to counteract sarcopenia and increase quality of life. As no additive effects were found, the study does not offer evidence that providing geriatric patients with protein supplementation is cost-effective. However, the milk-based protein supplementation was tolerated and generally liked by the participants and did significantly increase the total protein intake in the protein group compared to the placebo group.

More studies are necessary to establish the importance of different aspects of the study design e.g. specific populations being investigated and characteristics of the protein supplementation (amount, timing of intake) and RT interventions (duration/amount, specific exercises ect.). Also, identification of ways to increase the total protein intake in geriatric patients is of relevance and a challenge since their appetite is often very low.

11. Deviations

11.1 Scientific: The power calculation and participants needed in the study was increased from 120 to 165 due to lower compliance than expected in the initial phase of the study, and a wish of maintaining statistical power in both the intention-to-treat and the per-protocol analyses - the latter only including those participants who consumed 75 % or more of the total intervention dose.

11.2 Financial: None to declare.

11.3 Timetable: No deviations.

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

The result of the study might be included in systematic reviews and meta-analyzes and in this way could indirectly help to influence future guidelines, recommendations and information efforts regarding the prevention and treatment of sarcopenia in older patients. The study shows that to a certain extent it is possible to get the very fragile population of older patients to strength train and consume protein supplements. However, an intensified effort is needed to get them to consume protein in the amounts that probably are needed to see an extra muscle building effect. It is therefore relevant to investigate how to help older adults, especially the sick and those with low appetite, to reach to the recommended amounts of protein, thru foods, and drinks.

In the PEPOP-study we found a decrease in muscle mass in both groups during the initial hospitalization, even though both groups participated in daily resistance exercise training and received additional calories with or without protein supplementation. This is a major concern, as the Medical department do not want to discharge their patients in a worse shape than when they arrived. We believe that the lack of effect of

the milk-based protein supplementation was due to a total protein intake of 1.0 g/kg/d to far below the requirements of 1.5-2.0 g/kg/d for acutely/chronic ill older adults. The protein supplementation significantly increased the participants total protein intake, but the protein intake from their diet was lower than expected, and too low to reach the protein recommendations. After discharge we found a general increase in muscle mass, thus we believe it will be possible to at least counteract the loss of muscle mass during hospitalization if the patients get the proper amount of protein. Hence a possible new research area could be focusing on geriatric patients only during the hospital stay.

13. Communication and knowledge sharing about the project

Papers in international journals:
Gade J, Beck A, Andersen HE, Christensen B, Rønholt F, Klausen TW, Vinther A, Astrup A. Protein supplementation combined with low-intensity resistance training in geriatric medical patients during and after hospitalization: a randomized, double-blind, multicenter trial. Br J Nutr. 2019:122:1006-1020.
DOI: https://doi.org/10.1017/S0007114519001831

Gade J, Beck AM, Bitz C, Christensen B, Klausen T W, Vinther A, Astrup A. Protein-enriched, milk-based supplement to counteract sarcopenia in acutely ill geriatric patients offered resistance exercise training during and after hospitalization: study protocol for a randomised, double-blind, multicentre trial. BMJ Open 2018;8:e019210. doi:10.1136/bmjopen-2017-019210

Easily read papers:
Gade J, Beck A. 'Sunde ældre med protein og træning - Kan mælkebaseret protein forstærke effekten af styrketræning, hos ældre patienter over 70 år?' Mælkeritidende 2016; nr. 15-16, s. 8-9

Beck A, Gade J. ''Mælkeproteiner gav ikke ældre større muskelmasse''. Mælkeritidende 2020; nr. 1, s. 14-15

Student theses:
Josephine Gade Bang-Petersen. 2019. Sarcopenia and Geriatric Medical Patients. Screening of risk, protein supplementation combined with resistance training, and measurement of body composition. Ph.D. thesis, University of Copenhagen.

Oral presentations at scientific conferences, symposiums etc.:
13 November 2016: Oral presentation of study, Wagening University - Mini-symposium with other Ph.D. students in the same research field.

13 December 2016: Oral presentation: Theme of the day: 'Nutrition, physical activity and muscles' – Organized by DAPEN, The Danish Society for Clinical Nutrition and Metabolism, Aarhus. Presentation of the research project PEPOP.

18 June 2017: Seminar at KU, NEXS (half-way through PhD). Presentation of study (status, etc.) to supervisors and other interested researchers at KU.

30 October 2018: (Ph.D. student) A day in the name of science, 'Research day' at Herlev and Gentofte hospital. Oral presentation of PEPOP-study.

23-25 May 2019: (Ph.D. student) IAGG-Conference (International Association of Gerontology and Geriatrics – European Region), Gothenburg, Sweden. Oral presentation of PEPOP-study

17 December 2019 (Ph.D. student): Oral presentation of study results at the Ph.D defence

Oral presentations at meetings:
December 2018: (Ph.D. student) Oral presentation of PEPOP-study given to members of 'Ældremadsnetværket' (Venue: Miljø- og Fødevarestyrelsen, Glostrup. Arranged by University College Copenhagen).

December 2018: (Ph.D. student) Oral presentation of PEPOP-study to the Executive Board of LIVSKRAFT (venue, NEXS, Copenhagen).

December 2018: (Ph.D. student) Internal presentation of PEPOP-study for Arla Protino sales group.

February 2019 and April 2019 (Ph.D. student) Oral presentation of study results to the staff at the medical department where recruitment took place.

March 2019 (Ph.D. student) Danish Dairy Research Foundation Health & Nutrition Steering committee meeting – final oral presentation of study results.

April 2019 (Ph.D. student) Presentation of the research project at University College Copenhagen to teachers within the nutrition area (guest lecturer, journal club).

November 2019 (Ph.D. student): Internal presentation of PEPOP-study for Arla Protino sales group.

Other:
March/April 2016: (Ph.D. student) Ph.D. course: INTERNATIONAL AND INTERDISCIPLI-NARY PhD COURSE - Food, Health and Philosophy in East and West - cross roads among science, culture and business. Oral presentation of the study for the other course participants.

June 2016: (Ph.D. student) PhD Course: Older People - Food, Health, Eating, Meals and Nutrition. Applying different methodological and scientific approaches. Oral and written presentation of the study for the other course participants.

March 2017: (Ph.D. student) AOF – Lecturer in the subject 'How do I stay strong, self-reliant and mentally healthy in my old age?' - a total of 3 times (included presentation of the PEPOP-study).

March 2017: (Ph.D. student) Presentation of the research project PEPOP at Metropol to teachers within the nutrition area (guest lecturer, journal club)

April 2017: (Ph.D. student) 'Academic theme afternoon' for employees at the Dietetic and Nutritional Research Unit. Presentation of PEPOP-study, including sub-study and systematic review process in a related area.

May 2017: (Ph.D. student) Teaching at Metropol at the course 'Life cycle, Nutrition and health' in the sub-area 'older adults' (Nutritional requirements, nutritional risk screening, and PEPOP-study).

August 2017: (Master student) Master thesis and oral presentation, including presentation of the PEPOP study.

June 2017: (Ph.D. student) Teaching at KU at the course 'Nutrition and Physical Activity for the Improvement of Health in the Aged'. Nutritional Risk screening and presentation of the PEPOP study.

14. Contribution to master and PhD education

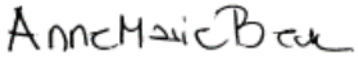
The research study has supported the education of a Ph.D. student. Furthermore, a Master student in Clinical Nutrition (NEXS, KU) has been involved with the study.

15. New contacts/projects

During the project period, scientific contact has been established with 2 research groups which both have an interest in older people's nutrition. It is LIVSKRAFT at the University of Copenhagen https://food.ku.dk/nyheder/2017/artikel-om-livskraft--center-for-gode-aeldreliv/ and University College Copenhagen https://www.kp.dk/forskning-og-udvikling/aeldres_maaltider/ , see section 13. In addition, contact have been established to CopenAge (Copenhagen Center for Clinical Age Research) https://copenage.ku.dk/english/. However, at present there are no plans for further developments/applications of the results.

16. Signature and date

The project is formally finalised when the project manager and DDRF-representative (e.g. steering committee leader) have signed this final report.

Date: 10 November 2020 Signature, Project manager: 

Date: 8 November 2020; Signature, DDRF-representative: