NOURISH THE MUSCLE
Nutritional Supplementation in Sarcopenia
Chapter 2

HIGH PREVALENCE OF PHYSICAL FRAILTY AMONG COMMUNITY-DWELLING MALNOURISHED OLDER ADULTS
- A systematic review and meta-analysis

*Sjors Verlaan, Gerdien C. Ligthart-Melis, Sander L.J. Wijers, Tommy Cederholm, Andrea B. Maier, Marian A.E. de van der Schueren*

*Journal of the American Medical Directors Association 2017*


**ABSTRACT**

**Background**
Malnutrition and frailty are two geriatric syndromes that significantly affect independent living and health in community-dwelling older adults. Although the pathophysiology of malnutrition and physical frailty share common pathways, it is unknown to what extent these syndromes overlap and how they relate to each other.

**Methods**
A systematic review was performed resulting in a selection of 28 studies that assessed both malnutrition and frailty in community-dwelling older adults. Furthermore, a meta-analysis was performed on 10 studies that used Mini Nutritional Assessment (MNA) and the Fried frailty phenotype to estimate the prevalence of malnutrition within physical frailty and vice versa.

**Results**
In the systematic review, 23 of the 28 studies focused on the physical frailty phenotype, of which 19 followed the original Fried phenotype. For malnutrition screening, 25 studies used the MNA (long or short form). Fifteen studies analyzed the association between malnutrition and frailty, which was significant in 12 of these. The meta-analysis included 10 studies with a total of 5447 older adults. In this pooled population of community-dwelling older adults (mean (SD) age: 77.2 (6.7) years), 2.3% were characterized as malnourished and 19.1% as physically frail. The prevalence of malnutrition was significantly associated with the prevalence of physical frailty (p<0.0001). However, the syndromes were not interchangeable: 68% of the malnourished older adults was physically frail, whereas only 8.4% of the physically frail population was malnourished.

**Conclusions**
The systematic review and meta-analysis revealed that malnutrition and physical frailty in community-dwelling older adults are related, but not interchangeable geriatric syndromes. Two out of three malnourished older adults were physically frail, whereas close to 10% of the physically frail older adults was identified as malnourished.

**INTRODUCTION**
As the global population ages, there is increasing attention for geriatric syndromes, which significantly impact independent living, quality of life, and health care consumption. Malnutrition and frailty are two important geriatric syndromes in community-dwelling older adults, and both have a clear nutrition-related component. Malnutrition is defined by the European society for clinical nutrition and metabolism (ESPEN) as “a state resulting from lack of uptake or intake of nutrition causing altered body composition (decreased fat free mass and body cell mass), leading to diminished physical and mental function and impaired outcome from disease” (1, 2). In older adults, malnutrition has been shown to contribute to loss of autonomy, lower quality of life, higher frequency of hospital admissions and mortality (3). Several nutritional screening tools are being used to detect malnutrition. Among the most commonly used tools are the MUST (4), MNA (3), SGA (5), SNAQ (6), and NRS-2002 (7). Weight loss and nutritional intake are common domains in most tools. For free-living older populations, the MNA is a well-established and widely used tool (3) that assesses nutritional intake, involuntary weight loss, mobility, psychological stress or acute disease, neuropsychological problems, and BMI or calf circumference. Patients are
Frailty is the cumulative decline across multiple physiological systems, which increases an individual’s vulnerability for developing dependency, morbidity and/or mortality when exposed to a stressor (8, 9). Several domains within the frailty context can be distinguished, among others physical and cognitive impairment, psychological risk factors, and social determinants (10, 11). Some of the frailty tools exploit a more holistic approach, including co-morbidities and mental characteristics, e.g. the Rockwood Frailty Index (10), or the Tilburg Frailty Index (12). Specifically, physical frailty has been defined as “a medical syndrome with multiple causes and contributors that is characterized by diminished strength, endurance, and reduced physiologic function that increases an individual’s vulnerability for developing increased dependency and/or death” (9). The most studied physical frailty model is the Physical Frailty Phenotype developed by Fried et al. (13), consisting of 5 domains: weight loss, exhaustion, weakness, slowness, and reduced physical activity. This tool classifies patients as either robust (none of the domains below threshold), pre-frail (one or two domains below threshold), or frail (three or more domains below threshold). Several scales have been developed that are derived from this phenotype model, including the Study of Osteoporotic Fractures scale (SOF) (14) and the FRAIL scale (15).

Malnutrition and physical frailty share common pathophysiology and screenings tools include overlapping items, such as weight loss and impaired physical function. Furthermore, malnutrition holds an important place within the conceptual physical frailty phenotype developed by Fried et al (13). Weight loss is seen as a modifiable risk factor for physical frailty (16). Therefore, debate exists about how close the link between both syndromes is, and to what extent they co-exist or are overlapping phenomena.

Our aim was to assess whether malnutrition and frailty in community-dwelling older adults are associated and/or interchangeable syndromes. Therefore, we systematically reviewed studies that assessed both syndromes. Furthermore, we performed a meta-analysis to estimate the prevalence of malnutrition within physical frailty and vice versa, based on the studies that used MNA and Fried physical frailty phenotype.

**METHODS**

**Literature search**

We searched for studies (both full text and abstracts) assessing both malnutrition and frailty in community-dwelling older adults. PRISMA principles were followed in the systematic review and meta-analysis (17). Records were retrieved through Pubmed (1900-2016), Medline (1946-2016), Embase (1947-2016) and CAB Abstracts (1910-2016). Records from Medline, Embase and CAB Abstracts were retrieved using the following search terms: Ti,ab((malnutrition OR malnourish* OR “nutritional status” OR undernourish*) AND (frailty OR frail OR “physically frail” OR “physical frailty” OR “pre-frail” OR “pre-frailty”) AND (elderly OR “older people” OR “older adults” OR aged OR aging OR ageing OR “old age” OR retired OR pensioner* OR geriatric*)), whereas records from Pubmed were retrieved using the following search terms: Ti,ab((malnutrition OR malnourish OR malnourished OR “nutritional status” OR undernourish OR p/0 frail* OR “pre-frail” OR “pre-frailty”) AND (frailty OR frail OR physical* OR “physically frail” OR “physical frailty” OR “pre-frail” OR “pre-frailty”) AND (elderly OR “older people” OR “older adults” OR aged OR aging OR ageing OR “old age” OR retired OR pensioner* OR geriatric*)),
OR pensioner OR pensioners OR geriatric OR geriatrics OR geriatrician)). The search was limited to titles and abstracts only, without restriction for language or publication date. The last search was run on 4 May 2016 (Medline, Embase and CAB Abstracts) and on 30 May 2016 (Pubmed). Duplicate records were removed. The search and selection process is summarized in Figure 1.

**Systematic review**

A total of 727 unique records were retrieved using the search strings described above. The first selection was made by two investigators (SLJW, DS) independently in a standardized manner, by screening titles and abstracts. Inclusion criteria for the first selection were: containing both a) screening for malnutrition and b) frailty assessment. Based on these criteria, 89 potentially eligible records were identified. Subsequently, full text articles or abstracts, if the results were not published as full articles, were reviewed independently in a standardized manner by 3 authors (SV, SLJW and GCLM). Disagreements between reviewers were resolved by consensus. Articles were excluded in this second step if they focused on: a) study populations selected for a specific disease, b) institutionalized study populations, c) hospital-

---

**Figure 1: PRISMA flowchart of study selection for systematic review and meta-analysis**

- Records identified through database searching (n=931)
- Records after duplicates removed (n=727)
- Records screened (n=727)
- Full-text articles (n=55) and abstracts (n=34) assessed for eligibility (n=89)
- Studies included in qualitative synthesis (systematic review) (n=28, 24 full-text, 4 abstracts)
- Studies included in quantitative synthesis (meta-analysis) (n=10 full-text, 1*)
- Full-text and abstracts articles excluded, with reasons (n=61):
  - Participants selected for a specific disease (n=30)
  - Institutionalized study population (n=8)
  - Hospitalized study population (n=8)
  - No results available on frailty and/or malnutrition status (n=2)
  - Same study population described in other article (n=13)

*Codes represent reason for in- and exclusion meta-analysis, detailed in Table 1*
talized study populations, or if d) no results were available on frailty and/or malnutrition status, and if e) the same population was described in other articles.

A total of 28 studies were included in the systematic review (18-45). GCLM extracted data regarding study design, country, selection method, sample size and gender, age, malnutrition tool and status, frailty tool and status, and results on association regarding malnutrition and frailty, as presented in Table 1. This was checked independently by SLJW and SV; any disagreement was resolved through discussion.

**Meta-analysis**

**Selection**

Studies were excluded if participants were pre-selected for malnutrition or frailty (6 studies, (22, 31, 35, 40, 42, 45)), since the aim of the current study was to analyze a general “representative” community-dwelling population. Moreover, it was shown that different or adapted screening tools introduce variation, which made it impossible to compare prevalence rates among studies (46). Since most studies applied the MNA (long or short form) and Fried phenotype to classify nutritional status and physical frailty, respectively, we decided that only the 13 studies that applied the MNA, together with the Fried phenotype were eligible for inclusion in the quantitative meta-analysis (19, 20, 24, 25, 28, 29, 32-34, 36, 38, 39, 43).

For selected studies, additional data were requested from the authors if not provided in the original article. We asked for absolute numbers of participants in nutritional status categories ‘normal’, ‘at risk of malnutrition’ and ‘malnourished’ and the physical frailty categories ‘robust’, ‘pre-frail’ and ‘frail’ (19, 25, 28, 32-34, 36, 38, 39, 43) and mean age (±SD) of the population (20, 24, 43). Three authors provided data of more (36) or fewer (38, 43) participants than included in the article. In those cases, the numbers provided by the authors were used for the meta-analysis (Table 2), and explicated in the footnotes. For three studies, we did not receive the requested data. As a result, 10 studies, which have all been published as full articles, 9 in English, one in Spanish, were included (19, 20, 24, 29, 33, 34, 36, 38, 39, 43) in the meta-analysis.

**Statistics**

Both malnutrition and physical frailty consisted of three ordered categories: normal nutritional status, at risk of malnutrition and malnourished versus robust, pre-frail and frail, respectively. Therefore, we applied the Cochran-Mantel-Haenszel test to analyze the association between physical frailty and nutritional status per study with ‘no association’ as 0-hypothesis and ‘general association’ as alternative hypothesis. The same was tested after pooling the ten selected studies by using the stratified Cochran-Mantel-Haenszel test with ‘study’ included as stratum. The association between physical frailty and nutritional status was regarded as significant when p-values were < 0.05.

**RESULTS**

**Systematic review**

Characteristics of the 28 studies included in the systematic review are summarized in Table 1. For malnutrition screening, 25 studies used the MNA (long or short form); the other three studies used Mini Nutritional Status, DETERMINE, and Dietary Screening Tool. In 23 of the studies, the physical frailty phenotype was studied, of which 19 followed the original Fried phenotype; the other studies used modified Fried criteria, SOF (2x) and FRAIL scale. The remaining five studies followed a broad frailty model, using the TFI (2x), Edmonton, Rockwood, and
Kihon, which included more than only physical characteristics. Fifteen studies addressed the association between malnutrition and frailty (18, 20-24, 28-30, 32-34, 37, 41, 45). In 12 of these 15 studies, the authors concluded that there was a significant association between malnutrition and frailty (18, 20-24, 28, 29, 32-34, 41). Six studies indicated a causal relationship as malnutrition was considered to be a risk factor for the development of frailty (18, 21, 24, 32, 34, 41).

**Meta-analysis**

A total of 5447 older adults from 10 studies (19, 20, 24, 29, 33, 34, 36, 38, 39, 43) was included in the meta-analysis. Mean age of the analyzed population was 77.2 (6.7) years. In this pooled population of community-dwelling older adults, 128 (2.3%) were characterized as malnourished and 1036 (19.0%) as at risk for malnutrition; 1041 (19.1%) as physically frail and 2810 (51.6%) as pre-frail.

The Cochran-Mantel-Haenszel tests of the individual study data and after pooling of the ten selected studies showed that the prevalence of malnutrition was significantly associated with the prevalence of physical frailty (p<0.0001) ([Table 2](#)).

**Figure 2** shows the pooled results regarding the classifications of nutritional status versus physical frailty in these community-dwelling older adults. The prevalence of physical frailty was higher when nutritional status was less favorable: 11.9% frail in the well-nourished group (510/4283), 42.9% frail in the group that is at risk of malnutrition (444/1036), and 68.0% frail in the malnourished group (87/128). The prevalence of malnutrition was higher in more physically frail groups, although with lower rates: 0.5% malnutrition in the robust group (8/1596), 1.2% in the pre-frail group (33/2810), and 8.4% in the frail group (87/1041). The prevalence of risk of malnutri-
High prevalence of physical frailty among community-dwelling malnourished older adults

The results from the systematic review (28 studies) and meta-analysis (10 studies) suggest that malnutrition and physical frailty are related, but not interchangeable syndromes in the community setting. Older malnourished people with an average age of 77 years were likely to be physically frail, but only a small percentage of the physically frail older people in the community was identified as malnourished.

**General prevalence of malnutrition and physical frailty in the community**

The pooled prevalence in the current meta-analysis revealed an overall malnutrition prevalence of 2.3% and risk of malnutrition prevalence of 19.0% in community-dwelling older adults. These findings are comparable to the pooled prevalence of malnutrition of 3.1% and risk of malnutrition of 26.5% found in a recent meta-analysis by Cereda et al. (47).

Regarding physical frailty, Kane et al. (48) showed an overall physical frailty prevalence of 14% in pooled data of 123 studies in community-dwelling adults above 65 years of age. A systematic review by Collard et al. (49) showed a pooled physical frailty prevalence of 9.9% in 44,894 community-dwelling older participants (≥65 years) and clearly indicated a significant increase in prevalence with age. In our systematic review, most of the studies we included report physical frailty percentages above 10%, which resulted in a pooled prevalence of 19.1% in the meta-analysis. The relative old age of the populations studied might explain this higher prevalence. Several of the studies within the systematic review showed a substantially higher prevalence of physical frailty, mainly because of the use of different frailty-tools (21, 44), or the pre-selection of participants for frailty (31, 42) or malnutrition (35).

**Prevalence of physical frailty in malnourished older adults**

The results of the current meta-analysis showed that two thirds (68%) of the malnourished older adults were also physically frail, and a quarter (25.8%) pre-frail. Thus, malnutrition is a relevant contributor towards increased vulnerability for developing negative health outcomes, loss of independence and mortality, as suggested previously (20, 21). Improving nutritional intake seems to be a prerequisite to manage these malnourished patients and their diseases. Care plans, adequate provision of food, and optimizing stimuli for appetite are essential (50). A protein intake of 1.2 to 1.5 g/kg body weight/day is recommended for a geriatric frail population (51) in combination with an adequate amount of energy to maintain energy balance. These recommendations are particularly challenging for already malnourished people.

**Prevalence of malnutrition in physically frail older adults**

On the other hand, the results of the meta-analysis indicated that less than 10% of the physically frail community-dwelling persons aged 75 to 80 years was malnourished. Moreover, half of the total community-dwelling older population displayed a normal nutritional status while being pre-frail (42%) or frail (9%). Despite their normal nutritional status overall, these (pre-) frail older adults might still have inadequate intake of certain nutrients, such as protein and vitamin D, so called qualitative malnutrition (50).

In addition to malnutrition, another key element of physical frailty is considered to
be sarcopenia, which is the age-related decline of muscle mass, strength, and function (52). The muscle is the biological substrate for both physical frailty and sarcopenia. Muscle loss leads to functional decline, such as impaired walking speed and muscle weakness (52). Therefore, pre-frail and frail people may benefit from targeted interventions to maintain or improve muscle mass and function. Resistance exercise is the foremost strategy to offset sarcopenia (53). In addition, there are indications that such interventions would be augmented by a combination with an adequate protein intake of 20 to 40 grams of protein after each session to optimize the effectiveness of the training (51, 54).

**Strengths and limitations**

A strength of this systematic review and meta-analysis is the systematic approach following the PRISMA principles. The systematic review revealed that the majority of studies that assessed both malnutrition and frailty in community-dwelling older adults used the Fried phenotype and MNA respectively. That allowed us to compare the subclasses of malnutrition and physical frailty in a meta-analysis using a 3x3 approach, which provided quantitative insights in the at-risk populations as well. On the other hand, the limitation of that approach was that studies that used other screening tools could not be included in the meta-analysis. The studies that described a pre-selection of participants based on the presence of either malnutrition or frailty, were not included in the meta-analysis. We cannot exclude, however, that the participants in the included population based studies in the meta-analysis did show some level of pre-selection due to a recruitment bias, which might provide an explanation for the high overall prevalence of physical frailty in the meta-analysis. Furthermore, we did not include the psychological and social components of frailty in the scope of our search, which may also be associated with an inadequate dietary intake in the community-dwelling elderly.

**CONCLUSIONS**

This systematic review and meta-analysis indicated that malnutrition and physical frailty often coincide in community-dwelling elderly with a potentially detrimental impact on independent living, co-morbidities, and thus on quality of life. The prevalence of physical frailty, however, is much higher than the prevalence of malnutrition, 20% versus 2.5% respectively, indicating that these syndromes are not interchangeable. Moreover, two out of three malnourished older adults were physically frail, whereas close to 10% of the physically frail older people in the community was identified as malnourished.

**Acknowledgements**

We would like to thank all authors who kindly provided additional data for the meta-analysis: Dr. Beaudart (19), Dr. Abizanda Soler (33), Dr. Millán Calenti (34), Dr. Serra Prat (36), Dr. Castrejón Pérez (38), Dr. Satake (39), Dr. Turusheva (43). From Nutricia Research, we would like to thank Daan Snoeks (DS) for performing the literature search and Marion Kaspers for performing the statistical analyses.
## TABLES chapter 2

**Table 2:** Analysis of the association between malnutrition and physical frailty for individual studies and pooled data in the meta-analysis

<table>
<thead>
<tr>
<th>Paper</th>
<th>n</th>
<th>Age (mean (SD))</th>
<th>DF</th>
<th>Value</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beaudart, 2015 (19)</td>
<td>534</td>
<td>73.5 (6.2)</td>
<td>4</td>
<td>65.274</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Bollwein, 2013 (20)</td>
<td>206</td>
<td>83 (75-96)*</td>
<td>2</td>
<td>41.552</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Eyigor, 2015 (24)</td>
<td>1126</td>
<td>Not disclosed</td>
<td>4</td>
<td>190.802</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Jürschik, 2014 (29)</td>
<td>512</td>
<td>81.2 (5.0)</td>
<td>4</td>
<td>94.566</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Martinez Reig, 2014 (33)</td>
<td>678</td>
<td>78.0 (5.7)</td>
<td>4</td>
<td>86.938</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Maseda, 2016 (34)</td>
<td>749</td>
<td>75.8 (7.2)</td>
<td>4</td>
<td>38.510</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Papiol, 2015 (36)</td>
<td>298</td>
<td>80.3 (3.5)</td>
<td>4</td>
<td>18.046</td>
<td>0.0012</td>
</tr>
<tr>
<td>Ruiz-Arregui, 2013 (38)</td>
<td>583</td>
<td>79.5 (7.1)</td>
<td>4</td>
<td>93.555</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Satake, 2015 (39)</td>
<td>164</td>
<td>76.4 (6.2)</td>
<td>4</td>
<td>18.740</td>
<td>0.0009</td>
</tr>
<tr>
<td>Turusheva, 2016 (43)</td>
<td>597</td>
<td>74.5 (5.9)</td>
<td>4</td>
<td>53.887</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td><strong>Pooled data</strong></td>
<td>5447</td>
<td><strong>77.2 (6.7)</strong></td>
<td>4</td>
<td><strong>628.160</strong></td>
<td>&lt;.0001</td>
</tr>
</tbody>
</table>

- * Median (min-max) presented, as mean (SD) was not available
- † Combined data available for 512 older people
- ‡ n=126 described in article, supplemental data obtained from author
- † n=124 described in article, data obtained from author contained less subjects
- ‡ n=611 described in article, data obtained from author contained less subjects
- † Based on n=4115, Bollwein and Eyigor excluded as no mean (SD) was available
### Table 1: Characteristics of the study populations, and the prevalence of malnutrition and frailty in the studies included in the systematic review

<p>| Source          | Study design         | Country     | Selection                                                                 | Sample Size | Age (mean ± 5D) | Malnutrition tool and status | Frailty tool and status | Result on association regarding (R|M* &amp; (P)F*) | Code in flowchart (figure 1) |
|-----------------|----------------------|-------------|---------------------------------------------------------------------------|-------------|-----------------|------------------------------|------------------------|-----------------------------------------------|---------------------------------|
| Akin, 2015 (18) | Cross-sectional population based | Turkey      | Randomly selected from health centers                                      | 906         | 71.5 (5.6)      | MNA-LF 2.8% M 41.4% RM       | Modified Fried (no physical activity) 27.8% F 34.8% PF | Increased malnutrition risk in (pre-) frail (p&lt;0.001) | E2                              |
| Beaudart, 2015 (19) | Prospective longitudinal | Belgium     | Outpatient clinics and general advertisement                              | 534         | 73.5 (6.16)     | MNA-LF 1.9% M 85.6% RM       | Fried 15.5% F, 47.9% PF | Not disclosed in article               | I                               |
| Bollwein, 2013 (20) | Cross-sectional | Germany     | Day-clinic, rehabilitation center and newspaper advertisement             | 206         | Median (min-max): 83 (75-96) | MNA-LF 0% M 15.1% RM         | Fried 15.5% F 39.8% PF | Increased malnutrition risk in (pre-) frail (p&lt;0.001) | I                               |
| Boulos, 2016 (21) | Cross-sectional | Lebanon      | Randomly selected from local authority databases                         | 1200        | 75.3 (7.1)      | MNA-LF 8.0% M 29.1% RM       | SOF+ 36.4% F 30.4% PF | Significant association between frailty and poor nutritional status (p&lt;0.001) | E2                              |
| Brandts, 2013 (22) (Abstract only) | Cross-sectional | Country: not specified | Older individuals &gt; 75 year, selected by general practitioners when considered (possibly) frail | 66          | 83 (5)          | MNA 33% (R|M)               | TFI6 56.1% (P)F | Significant correlation between frailty and (risk of) malnutrition (MNA) (R² = 0.35; p = 0.007) | E1                              |
| Chang, 2016 (23) | Cross-sectional | Taiwan       | Primarily approached using                                               | 152         | 80.9 (7.7)      | MNA-LF 3.3% M 34.9% RM       | SOF+ 0% F 40.1% PF | Pre-frail had a lower total MNA score than | E2                              |</p>
<table>
<thead>
<tr>
<th>Source</th>
<th>Study design</th>
<th>Country</th>
<th>Selection</th>
<th>Sample Size</th>
<th>Age (mean ± SD)</th>
<th>Malnutrition tool and status %M, %RM</th>
<th>Frailty tool and status %F, %PF</th>
<th>Result on association regarding (RM* &amp; (P)F)</th>
<th>Code in flowchart (figure 1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eyigor, 2015 (24)</td>
<td>Cross-sectional multi-center</td>
<td>Tukey</td>
<td>Outpatients (≥65y) from Physical Medicine and Rehabilitation clinics at 13 centers were recruited</td>
<td>1126 (65.7% female)</td>
<td>66.5% between 65 and 74</td>
<td>MNA-LF 5.3% M 27.5% RM</td>
<td>Fried 39.2% F 43.3% PF</td>
<td>Increased malnutrition (risk) in (pre-) frail (p&lt;0.001)</td>
<td>I</td>
</tr>
<tr>
<td>Ferrer, 2015 (25)</td>
<td>Prospective population-based</td>
<td>Spain</td>
<td>All subjects were Spanish Caucasians born in 1924, registered in primary healthcare centers</td>
<td>290 (60.0% female)</td>
<td>85</td>
<td>MNA-LF Mean (SD): 24.88 (3.56)</td>
<td>Fried 16.7% F 55.0% PF</td>
<td>Not disclosed in article</td>
<td>E3</td>
</tr>
<tr>
<td>Gillain, 2015 (26) (Abstract only)</td>
<td>Prospective cohort</td>
<td>Country: no specified</td>
<td>Healthy old people</td>
<td>131 (57.3% female)</td>
<td>71.3</td>
<td>Mini Nutritional Status Mean: 12.8</td>
<td>Edmonton 14.5% mild/moderate F</td>
<td>Not disclosed in abstract</td>
<td>E2</td>
</tr>
<tr>
<td>Hamza, 2012 (27)</td>
<td>Cross-sectional</td>
<td>Egypt</td>
<td>Older outpatients recruited at geriatric clinic</td>
<td>80 (60.0% female)</td>
<td>67.6 (6.3)</td>
<td>DETERMINE 57.5% moderate/high risk of M</td>
<td>Fried 25.0% F 45.0% PF</td>
<td>Not disclosed in article</td>
<td>E2</td>
</tr>
<tr>
<td>Jung, 2016 (28)</td>
<td>Prospective cohort (ASPRA)</td>
<td>Korea</td>
<td>Potentially eligible residents were identified through the National Healthcare Service</td>
<td>382 (56% female)</td>
<td>74.4 (6.5)</td>
<td>MNA-5F 37.9% RM</td>
<td>Fried (n=380) 17.4% F 52.6% PF</td>
<td>Odds ratio (95% CI) for risk of malnutrition for frail vs. non-frail 4.2 (2.0-8.8)</td>
<td>E3</td>
</tr>
<tr>
<td>Jürschick, 2014 (29)</td>
<td>Prospective cohort (Fralle)</td>
<td>Spain</td>
<td>Random selection from of older people living independently in community</td>
<td>640 (62.1% female)</td>
<td>81.2 (5.0)</td>
<td>MNA-LF 2.3% M 19.6% RM</td>
<td>Fried 9.6% F 47% PF</td>
<td>Results show a clear association between MNA and Fried phenotype (p&lt;0.001)</td>
<td>I</td>
</tr>
<tr>
<td>Source</td>
<td>Study design</td>
<td>Country</td>
<td>Selection</td>
<td>Sample Size</td>
<td>Age (mean ± SD)</td>
<td>Malnutrition tool and status</td>
<td>Frailty tool and status</td>
<td>Result on association regarding (RM* &amp; PF)</td>
<td>Code in flowchart (figure 1)</td>
</tr>
<tr>
<td>------------------------------</td>
<td>-------------------------------</td>
<td>-----------</td>
<td>---------------------------------------------------------------------------</td>
<td>-------------</td>
<td>-----------------</td>
<td>------------------------------</td>
<td>-------------------------------</td>
<td>---------------------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>Kamo, 2014 (30)</td>
<td>Cross-sectional</td>
<td>Japan</td>
<td>Patients receiving home care recruited through the Health Care Service Foundation for Older People</td>
<td>90 community-dwelling 72.2% female</td>
<td>84.3 (± 8.2)</td>
<td>MNA-SF Prevalence not specified for community-dwelling</td>
<td>Rockwood Mean (SD): 4.7 (± 1.5) (community-dwelling)</td>
<td>No significant direct effect of nutritional status on frailty (B = −0.115, NS)</td>
<td>E2</td>
</tr>
<tr>
<td>Lilamand, 2015 (31)</td>
<td>Prospective cohort (Toulouse Frailty Clinic)</td>
<td>France</td>
<td>All out-patients admitted to the Toulouse Frailty Clinic (pre-screened for frailty by GP) in 2013</td>
<td>267 community (female)</td>
<td>(67.0% female)</td>
<td>MNA-SF 1.9% M 22.8% RM</td>
<td>Fried 36.8% F 51.9% PF</td>
<td>Not disclosed in article</td>
<td>E1</td>
</tr>
<tr>
<td>Liu, 2015 (32)</td>
<td>Community-based aging cohort (ILAS)</td>
<td>Taiwan</td>
<td>People aged 50 years and older</td>
<td>1839 female</td>
<td>81.5 (± 5.8)</td>
<td>MNA-LF Mean (SD): 27.2 (± 1.8)</td>
<td>Fried 6.8% F 40.5% PF</td>
<td>Lower MNA score was independent risk factor for pre-fraility and frailty (PF: OR 0.928 (CI: 0.865, 0.997); F: OR: 0.662 (CI: 0.582, 0.754))</td>
<td>E3</td>
</tr>
<tr>
<td>Martinez-Regl, 2014 (33)</td>
<td>Concurrent cohort (Fradea, second wave)</td>
<td>Spain</td>
<td>were randomly selected from the database</td>
<td>678 female</td>
<td>63.9 (± 9.3)</td>
<td>MNA-SF 2.9% M 23.9% RM</td>
<td>Fried 18.4% F 55.6% PF</td>
<td>Significant association between frailty status and MNA (p&lt;0.001)</td>
<td>I</td>
</tr>
<tr>
<td>Maseda, 2016 (34)</td>
<td>Longitudinal (Veritaside) study</td>
<td>Spain</td>
<td>Adults aged 70 years or more randomly selected from the census of health</td>
<td>749 female</td>
<td>78.0 (± 5.7)</td>
<td>MNA-SF 0.8% M 13.5% RM</td>
<td>Fried 3.7% F 71.8% PF</td>
<td>Increased (pre-) frailty risk with low MNA-SF scores (≤11) (p&lt;0.001)</td>
<td>I</td>
</tr>
<tr>
<td>Nykänen, 2012 (35)</td>
<td>Population based intervention study (GeMS)</td>
<td>Finland</td>
<td>Baseline data of subpopulation with malnutrition risk in the GeMS intervention study</td>
<td>159 female</td>
<td>75.8 (± 7.2)</td>
<td>MNA-LF 100% RM</td>
<td>Fried Intervention: 24.7% F 61.0% PF Control: 25.6% F 61.0% PF</td>
<td>Not disclosed in article</td>
<td>E1</td>
</tr>
<tr>
<td>Source</td>
<td>Study design</td>
<td>Country</td>
<td>Selection</td>
<td>Sample Size</td>
<td>Age (mean ± SD)</td>
<td>Malnutrition tool and status</td>
<td>Frailty tool and status</td>
<td>Result on association regarding (R)M &amp; (P)F</td>
<td>Code in flowchart (figure 1)</td>
</tr>
<tr>
<td>------------------------</td>
<td>------------------------------</td>
<td>--------------------</td>
<td>----------------------------------------------</td>
<td>-------------</td>
<td>-----------------</td>
<td>-------------------------------</td>
<td>------------------------</td>
<td>---------------------------------------------</td>
<td>------------------------------</td>
</tr>
<tr>
<td>Papiol, 2015 (36)</td>
<td>Population-based cross-sectional study between January and June 2014</td>
<td>Spain</td>
<td>Random sample from the database, from 3 primary care centers</td>
<td>126 47% female</td>
<td>80.3 (3.5)</td>
<td>MNA-LF 7.3% (R)M</td>
<td>Fried 29.4% F 35.7% PF</td>
<td>Not disclosed in article</td>
<td>I</td>
</tr>
<tr>
<td>Rolf, 2013 (37)</td>
<td>Cross-sectional</td>
<td>Poland</td>
<td>Not specified</td>
<td>77 66.2% female</td>
<td>Range: 59-96</td>
<td>Dietary Screening Tool 66% at nutritional risk</td>
<td>Fried 88% (P)F</td>
<td>No statistically significant relationship between frailty and nutritional risk</td>
<td>E2</td>
</tr>
<tr>
<td>Ruiz-Aregui, 2013 (38)</td>
<td>Longitudinal observational study (Coyocan)</td>
<td>Mexico</td>
<td>Random selection from government database among community-dwelling elderly</td>
<td>1124 55.9% female</td>
<td>79.5 (7.1)</td>
<td>MNA-LF 3.4% M 23.9% RM</td>
<td>Fried 14.1% F 37.4% PF</td>
<td>Not disclosed in article</td>
<td>I</td>
</tr>
<tr>
<td>Satake, 2015 (39)</td>
<td>Cross-sectional</td>
<td>Japan</td>
<td>Non-dependent outpatients &gt; 65 years, with chronic conditions were recruited</td>
<td>164 33.5% female</td>
<td>76.4 (6.2)</td>
<td>MNA-LF 0.6% M 24.4% RM</td>
<td>Fried 11.6% F 60.4% PF</td>
<td>Not disclosed in article</td>
<td>I</td>
</tr>
<tr>
<td>Serra-Prat, 2013 (40)</td>
<td>Intervention</td>
<td>Spain</td>
<td>Recruited at health consortium medical centers, preselected frail and non-frail (NF) groups</td>
<td>34 older people F: 78.6% female NF: 35.0% female</td>
<td>F: 84.5 (5.0) NF: 80.7 (8.4)</td>
<td>MNA-LF F: 100% RM NF: 15% RM</td>
<td>Fried 41.2% F 58.8% NF</td>
<td>Not disclosed in article</td>
<td>E1</td>
</tr>
<tr>
<td>Source</td>
<td>Study design</td>
<td>Country</td>
<td>Selection</td>
<td>Sample Size</td>
<td>Age (mean ± SD)</td>
<td>Malnutrition tool and status</td>
<td>Frailty tool and status</td>
<td>Result on association regarding (RIM* &amp; (PF))</td>
<td>Code in flowchart (figure 1)</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>-------------------------------------</td>
<td>-----------</td>
<td>---------------------------------------------------------------------------</td>
<td>-------------</td>
<td>-----------------</td>
<td>-----------------------------</td>
<td>------------------------</td>
<td>-----------------------------------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>Sewo Sampiao, 2015 (41)</td>
<td>Cross-sectional</td>
<td>Brazil</td>
<td>Recruited at community centers for older adults</td>
<td>109</td>
<td>70.8 (6.9)</td>
<td>MNA-SF When frail/non frail: 12.5% / 2.4% M 45.8% / 20% RM</td>
<td>Fried 54.5% F</td>
<td>Those who were either at risk of malnutrition or malnourished were more likely to be frail (OR 0.206 (0.079-0.536, p=0.001)</td>
<td>E2</td>
</tr>
<tr>
<td>Tavasoli, 2014 (42)</td>
<td>Prospective cohort (Toulouse Frailty Clinic)</td>
<td>France</td>
<td>All out-patients (pre-screened for frailty by GP) admitted to the Toulouse Frailty Clinic in 2011</td>
<td>1108</td>
<td>82.9 (6.1)</td>
<td>MNA-LF 8.0% M 39.5% RM</td>
<td>Fried 59.1% PF</td>
<td>Not disclosed in article</td>
<td>E1</td>
</tr>
<tr>
<td>Turusheva, 2016 (43)</td>
<td>Population-based prospective cohort (Crystal study)</td>
<td>Russia</td>
<td>A representative random sample of 462 in age group 65-74 group and 452 in age group ≥75</td>
<td>611: 65-74 y: 305, 67.2% female &amp; ≥75 y: 305, 76.1% female</td>
<td>Median (IQR) 65-74 y: 70 (58-72) ≥75 y: 79 (77-83)</td>
<td>MNA-LF 1.8% M 17.3% RM</td>
<td>Fried 65-74 y: 16.6% F 65.1% PF ≥75 y: 28.7% F 59.1% PF</td>
<td>Not disclosed in article</td>
<td>I</td>
</tr>
<tr>
<td>Van Asselt, 2013 (44)</td>
<td>Prospective observational</td>
<td>Country: not specified</td>
<td>Elderly receiving home-delivered dinners</td>
<td>90% female not specified</td>
<td>Median: 84.0</td>
<td>MNA 2% M 43% RM</td>
<td>TFI§ 64% F</td>
<td>Not disclosed in abstract</td>
<td>E2</td>
</tr>
<tr>
<td>Woo, 2015 (45)</td>
<td>Two-phase cross-sectional study: screening &amp; assessment</td>
<td>Honk Kong SAR China</td>
<td>Invited via elderly community centers</td>
<td>816</td>
<td>Age group: 65-69: 21.9% 70-74: 19.1% ≥75: 58.9%</td>
<td>MNA-SF When F: 28.9% M When PF: 22.9% M</td>
<td>Frail scale 12.5% F 52.4% PF</td>
<td>No association between MNA-SF score and frailty in (pre-) frail subgroup</td>
<td>E1</td>
</tr>
</tbody>
</table>

* RIM: risk of malnutrition; M: malnourished; (RIM): (risk of) malnutrition | † PF: pre-frail; F: frail; (PF): (pre-) frail | ‡ SOF: Study of Osteoporotic Fractures index | § TFI: Tilburg Frailty Index | || Supplemental data provided by the authors
High prevalence of physical frailty among community-dwelling malnourished older adults

REFERENCES chapter 2


High prevalence of physical frailty among community-dwelling malnourished older adults


