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Original Article

Improving aging-related frailty status among older adults: Results of a nutrition-focused program

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SUMMARY

Background: Healthcare professionals today aim to boost the years older people live in good health by reducing the impact of aging-related frailty. Toward healthier aging, our current analysis quantified frailty changes that occurred when poorly nourished, community-living, older adults received interventional nutrition care.

Methods: We recruited outpatient study participants ≥ 60 years and malnourished or at-risk on screening (Mini Nutrition Assessment-Short Form, MNA-SF). For quasi-experimental analysis, we selected those who were prefrail or frail by Fried phenotype criteria (n=524). Each followed a comprehensive nutrition-focused Quality Improvement Program (QIP)—counseling on nutrition and physical activity, daily consumption of oral nutritional supplements for 60 days (Ensure with Hydroxymethylbutyrate® and Glucerna®, Abbott, USA), with follow-up through day 90. We quantified outcomes as changes from baseline to post-intervention for (i) overall frailty status (frail, prefrail, normal) or (ii) number of positive Fried frailty criteria of five (weight loss, exhaustion, low physical activity, slow gait speed, and muscular weakness) using change categories *Worse, Same, or Better*. We also measured

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baseline and post-intervention status of nutritional state (MNA-SF), mental state/cognitive status (Mini-Mental State Exam, MMSE), depression/psychological health (Geriatric Depression Scale, GDS), and disability (Barthel Index, BI). We applied logistic regression analyses to identify factors that predicted post-intervention improvement in frailty status.

Results: At baseline, the mean age of participants was 74.2 (±8.7) years, 71% (n=372/524) of participants were prefrail, and 29% (n=152/524) were frail; 16.2% (n=85/524) were malnourished, and 83.8% (n=439/524) were at risk. By study day 90, 34.4% (180/524) of participants had a *better* frailty status, while 55% (n=288/524) met fewer frailty criteria. *Better* frailty status was also associated with significantly higher MNA-SF score (12.3 vs 9.1, $P < 0.001$), improved mental state/cognitive status as higher MMSE score (28.1 vs 27.7, $P < 0.05$), decreased depression/improved psychological health as lower GDS score (3.3 vs 4.5, $P < 0.001$), and greater independence as higher BI score (96.9 vs 96.1, $P < 0.05$). Logistic regression analyses showed that MNA-SF score improvement was predictive of frailty improvement in response to the nutrition-focused QIP intervention. Specifically, individuals who experienced improvement from prefrail or frail to normal were nearly 8-times more likely than others to have a parallel increase in MNA-SF score (Odds ratio of 7.83, 95% CI 4.3–15.2, $P < 0.01$).

Conclusion: Healthy aging can be supported by addressing poor nutritional status, a frailty risk contributor. We found that community-living older adults achieved a *better* frailty status after following a nutrition-focused QIP. Notably, improved nutritional status predicted and paralleled improvement in frailty status.

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Introduction

Frailty, an aging-related syndrome of physiological decline, is associated with marked vulnerability to adverse health outcomes [1]. Frail patients often present in healthcare with an increased burden of symptoms such as weakness and fatigue, medical complexity, and reduced tolerance of medical and surgical interventions [2]. Frail older adults also experience functional problems, e.g., decreased physical function [3], impaired cognitive function [4], and poor quality of life [5]. The presence of frailty is associated with increased use of health services (medical consulting, hospitalization, visits to nurse or physiotherapist) that is paralleled by increased costs for such services [6].

Among community-living older adults throughout the world, the prevalence of prefrailty or frailty is strikingly high, while poor nutritional status is likewise prevalent in this older population. In South America, one-in-two older adults is prefrail and one-in-five is frail [7]. Specifically in Colombia, 49% of older adults in the community were reported as prefrail, and 11–18% as frail [7,8]. Frailty prevalence rates are similarly high among older adults in Asia [9], Europe [10,11], and North America [12]. Malnutrition and its risk are likewise common among older adults. Notably, a large meta-analysis of studies around the world showed malnutrition prevalence of 3.1% among older adults in the community and 8.7% of those living at home but receiving home-health services [13]. A longitudinal study in Sweden found that nearly 25% of community-living older adults were at risk of malnutrition [14]. Of older adults (>65 years) in Spanish communities, 15% were found to be at risk of malnutrition [15]. Further, a large meta-analysis of studies in older (≥65 years), community-living European adults determined an overall prevalence of risk for malnutrition at 8.5% [16].

While poor nutritional status and frailty commonly overlap in older populations, cause-and effect roles are not yet understood. Recent study results pointed to poor nutritional status as a risk factor or predictor of physical frailty in older adults [17–19], Frail individuals were in fact five times more likely to have malnutrition risk, while frailty is also predicted by older age and lower skeletal muscle [17]. Muscle loss, recognized as sarcopenia, is likewise frequently coincident in the conditions of malnutrition and frailty [20] and represents yet another link between these conditions [21]. Clearly, there remain gaps in understanding relationships between malnutrition, frailty, muscle loss, and limited physical function. There are also evidence gaps regarding how to predict risk for frailty, how to recognize early signs of frailty, what interventions are clinically effective, and how to implement and ensure such care. Improved understanding of the overlap between malnutrition and frailty is expected to provide insights into the use of nutritional support as a treatment for frailty or its risk.

For older people who want to maintain independent living, it is particularly important to pinpoint strategies that can prevent or delay transition from prefrailty to frailty and to promote recovery when frailty signs and symptoms are present. In the present study, we examined the outcomes of implementing a comprehensive nutrition-focused Quality Improvement Program (QIP) for treating malnutrition or its risk among community-living prefrail/frail older people. With participants enrolled from an outpatient clinic in Colombia, we sought to quantify improvements in frailty status and its defining criteria following nutritional intervention, i.e., frailty responses to a nutritionally focused QIP.

Methods

Study participants, sample size, and intervention protocol

Study participants were patients receiving care at a Bogotá-based outpatient clinic post discharge from the hospital or for chronic condition management, were ≥60 years, and were malnourished or at risk for malnutrition based on Mini Nutrition Assessment-Short Form (MNA-SF) screening (Figure 1); nutritional findings from this study have been reported previously [22]. For our current quasi-experimental analysis, we studied a subgroup of subjects (n=524) who were prefrail or frail according to Fried phenotypic criteria.

Participants followed a nutrition-focused QIP, which provided education and counseling on diet and physical exercise along with oral nutritional supplements (Ensure with Hydroxymethylbutyrate (HMB)® for patients with no diabetes or Glucerna® for patients with diabetes, Abbott, USA) to consume daily (60 days) [22]. Participants were followed up to 90 days with follow-up visits and/or phone calls conducted at 4-, 8-, 10-, and 12-weeks post baseline visit to reinforce education and compliance with the recommended nutrition regimen and specifically oral nutrition supplements.

Pre- and post-QIP outcome measures

For pre-post nutritional-status comparisons, we used the MNA-SF score to identify malnutrition or its risk (MNA-SF score 0–7 *malnourished*, 8–11 *at risk for malnutrition,* >11 *adequately nourished*) [23].

To identify frailty status, we used Fried phenotyping based on five specific criteria (unintentional weight loss, self-reported exhaustion, low physical activity, slow speed for a 15-foot walk, and muscular weakness as low grip) [1]. Colombia-appropriate cut-offs were used [24]: (i) *Weight loss*: >4.5 kg or >5% lost unintentionally in the last year; (ii) Self-reported *exhaustion* with categorical responses, feeling I could not get going *at all*, *most of the time*, or *some of the time*; (iii) *Physical activity* (Minnesota Leisure Time Activity Questionnaire; *Energy expenditure* <383 kcal per week for men or <270 kcal per week for women [25]; (iv) *Walk time* (15-ft walk): ≥7 sec for women or ≥6 sec for men; (v) *Grip strength* by dynamometer (average of three trials): ≤29–32 kg for men and ≤17–21 kg for women. For overall assignments to frail, prefrail, and not-frail categories, the 5 Fried criteria were used together. *Frail* participants scored below the cut-offs for three or more criteria, *pre-frail* participants scored below the cut-offs for one or two criteria, and non-frail participants did not score below the cut-offs for any criteria. For binary analyses, each participant was classified as *positive (if they met the criterion)* or *negative* for each criterion.

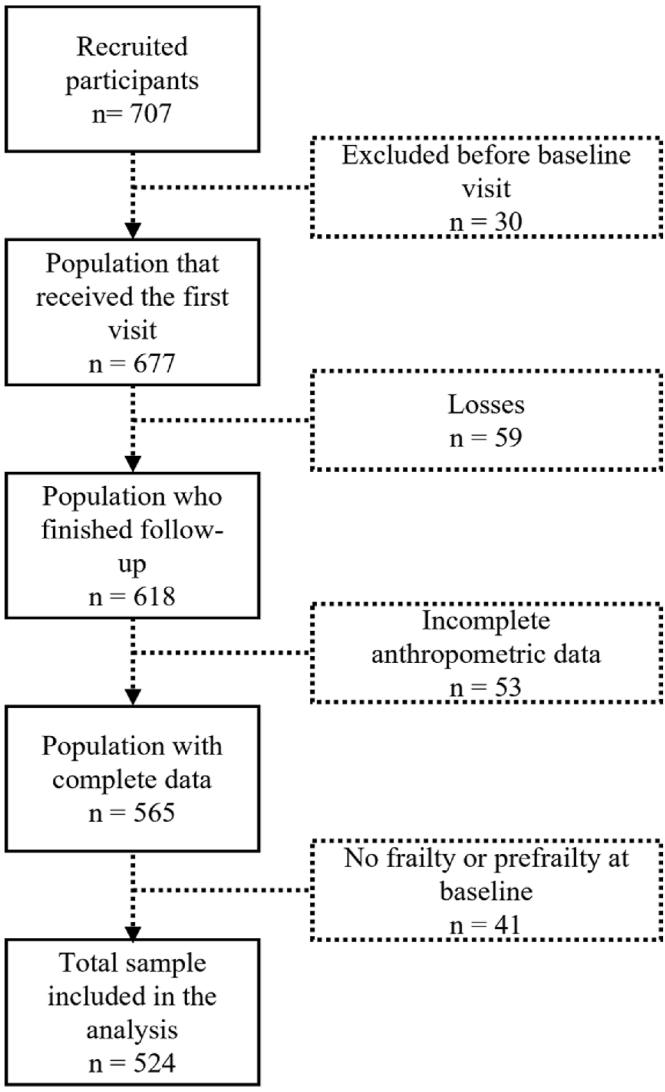


Figure 1. Flowchart for sample selection.

We also analyzed disabilities through assessment of Activities of Daily Living (ADL) through the Barthel Index (BI) [26], the mental state/cognitive status through Mini-Mental State Exam (MMSE) [27], and the depression status/psychological health through the Geriatric Depression Scale (GDS) [28] as outcome measures.

Primary and secondary outcomes

The primary outcome was *change in frailty phenotype* at the end of the follow-up period (90 days) compared to the baseline value. Such change was measured by two different strategies: (i) frailty category *improvement* was identified by category change from frail to prefrail, frail to non-frail, or prefrail to non-frail, or (ii) frailty score *improvement* was identified by a reduction in the number of

frailty-positive criteria, while *worsening* was identified by an increase in the number of frailty criteria met.

The secondary outcome was *change in nutritional status* considering (i) improvement in overall nutritional status as change from category of malnutrition to risk of malnutrition or to adequate nutrition, or (ii) difference between post- versus pre-intervention MNA-SF score with *improvement* as score increase of 1 or more points and *worsening* as a score decrease of 1 or more points.

Statistical analyses

All analyses were performed with the statistical software RStudio [29] and a p value of < 0.05 was deemed as statistically significant. An exploratory analysis of the data in search of missing data and extreme values was conducted; proceeded afterwards with a descriptive analysis of the population. The difference between pre- and pot-intervention total frailty phenotype score was assessed, and the effect size was calculated through Cohen's d statistic defining as small, medium, and large effect size as 0.2, 0.5, and 0.8, respectively. We determined difference of proportions for each of the Fried frailty criteria. Pre- and post-intervention differences for each group were assessed using a paired T-test for continuous variables or McNemar's test for categorical variables.

To assess the association between the change in nutritional status and the change in frailty state, we used six logistic regression models for different combinations between independent and dependent variables. The models were built through a backward strategy starting with a complete model (with all variables) and excluding variables considering the Akaike information criterion (AIC). The goodness of fit was assessed by the likelihood ratio test, comparing both the complete and final models. Finally, a model considering only participants who passed from frail or prefrail in baseline to normal state at follow-up as the dependent variable, and the improvement in the MNA-SF status as the independent variable was constructed.

Ethical standards and informed consent

The original study protocol was approved by the Ethics and Research Committee of the Hospital Universitario San Ignacio, in Bogota, Colombia. Each participant (or caregiver) signed an informed consent form. Study is registered online with ClinicalTrials.gov Identifier: NCT04042987.

Results

Our current quasi-experimental analysis included older adults (n=524) who were prefrail or frail according to Fried phenotypic criteria and were malnourished or at risk according to MNA-SF scores. At baseline, 71% of participants were prefrail and 29% were frail; 16.2% were malnourished, and 83.8% were at risk (Table 1).

At 90-days, almost 1 in 3 participants had a *Better* frailty status (n=180/524; 34.4%), 59.5% (n=312/524) of the participants maintained their status and were categorized as *Same*, while only 6.1% (n=32/524) experienced a decline in their frailty status and were categorized as *Worse* (Table 2). The greatest part of this improvement was observed between categories pre-frail to normal and between frail to prefrail. Few participants showed improvements from frail to normal (Figure 2). When subjects were grouped by changes in frailty category from pre- to post-intervention, those with *Worse* status were nearly a decade older than those in *Same* or *Better* categories. However, we found significant improvement of nutritional status (MNA-SF scores) in all change categories (*Worse, Same, or Better*). Among subjects who had improved or unchanged frailty status, we also observed significant post-intervention improvement, i.e., reduction in the proportion who were malnourished or at nutritional risk (Table 2). Similarly, we found improvement in mental state/cognitive status (MMSE) and less depression/improved psychological health (GDS) in these groups. Only those subjects with *Better* frailty status experienced small but significant improvement in BI functional activities.

In a related analysis, subjects were grouped by changes in frailty category from pre- to post-intervention based on the number of frailty phenotype component criteria met (unintentional

Table 1
Study population characteristics at baseline (n=524)

Variable	
Age, mean (SD)	74.19 (8.7)
Female, n (%)	361 (68.9)
Charlson Comorbidity Index, mean (SD)	6.03 (1.8)
Medication number, mean (SD)	3.39 (2.3)
BMI, mean (SD)	24.77 (3.7)
MNA-SF, mean (SD)	9.22 (1.7)
Nutritional Status, n (%)	
Risk	439 (83.8)
Malnutrition	85 (16.2)
MMSE, mean (SD)	27.15 (3.7)
GDS, mean (SD)	4.34 (2.8)
Barthel Index, mean (SD)	95.86 (6.8)
Frailty phenotype status, n (%)	
Prefrail	372 (71)
Frail	152 (29)

BMI, body mass index; Barthel index: Barthel Index for Activities of Daily Living (ADL); GDS, Geriatric Depression Scale; MMSE, Mini Mental State Examination; MNA-SF, Mini Nutritional Assessment-Short Form; SD, standard deviation.

Table 2
Pre- and post-intervention health characteristics of subjects grouped by categories of change in frailty status (*Worse*, *Same*, or *Better;* n=524 analyzed) as determined by change in overall Fried frailty phenotype (frail, prefrail, normal). For each variable and category, p-values represent statistical differences between baseline and 90 day follow-up

	Change in frailty status					
	Worse n=32 (6.1%)		Same n=312 (59.5%)		Better n=180 (34.4%)	
	Baseline	Follow-up	Baseline	Follow-up	Baseline	Follow-up
Age, mean (SD)	81.3 (8.6)	-	74.1 (8.6)	-	73.0 (8.5)	-
Female, n (%)	24 (75.0)	-	218 (69.9)	-	119 (66.1)	-
Charlson Index, mean (SD)	6.2 (1.9)	-	6.0 (1.7)	-	6.0 (2.0)	-
Medication number, mean (SD)	3.8 (2.3)	-	3.4 (2.3)	-	3.3 (2.5)	-
BMI, mean (SD)	24.7 (3.0)	24.5 (3.2)	25.1 (3.9)	25.4 (4.0) (***)	24.2 (3.4)	24.7 (3.6) (***)
MNA-SF, mean (SD)	9.2 (1.5)	10.9 (2.0) (***)	9.3 (1.6)	11.2 (2.1) (***)	9.1 (1.8)	12.3 (2.0) (***)
Nutritional status, n (%)						
Normal	-	11 (34.4)	-	127 (40.7)	-	122 (67.8)
Risk	26 (81.2)	21 (65.6)	264 (84.6)	181 (58.0) (***)	149 (82.8)	56 (31.1) (***)
Malnutrition	6 (8.8)	0 (0) (*)	48 (15.4)	9 (2.9) (***)	31 (17.2)	2 (1.1) (***)
MMSE, mean (SD)	25.1 (4.9)	25.3 (4.7)	27.0 (3.9)	27.5 (3.6) (***)	27.7 (2.8)	28.1 (2.5) (*)
GDS, mean (SD)	4.3 (3.3)	3.8 (2.3)	4.2 (2.8)	3.5 (2.4) (***)	4.5 (2.7)	3.3 (2.3) (***)
Barthel index, mean (SD)	95.6 (6.7)	95.9 (5.9)	95.7 (6.4)	96.2 (6.9)	96.1 (7.6)	96.9 (6.3) (*)

BMI: body mass index; Barthel index: Barthel Index for Activities of Daily Living (ADL); MNA-SF: Mini Nutritional Assessment-Short Form; MMSE: Mini Mental State Examination; GDS: Geriatric Depression Scale; SD: standard deviation.
* p-value <0.05.
** p-value < 0.01.
*** p-value < 0.001.

weight loss, self-reported exhaustion, low physical activity, slow speed for a 15-foot walk, and muscular weakness as low grip). At 90-days, 55% of the participants (n=288/524) met fewer frailty phenotype criteria and were categorized as *Better*, 31.9% (167/524) met the same number of frailty criteria and were categorized as *Same*, while 13.2% (69/524) met more frailty criteria and were categorized as *Worse* (Table 3). The Fried criteria with the greatest post-intervention improvements were unintentional weight loss, exhaustion, and low physical activity. On average, those with *Worse*

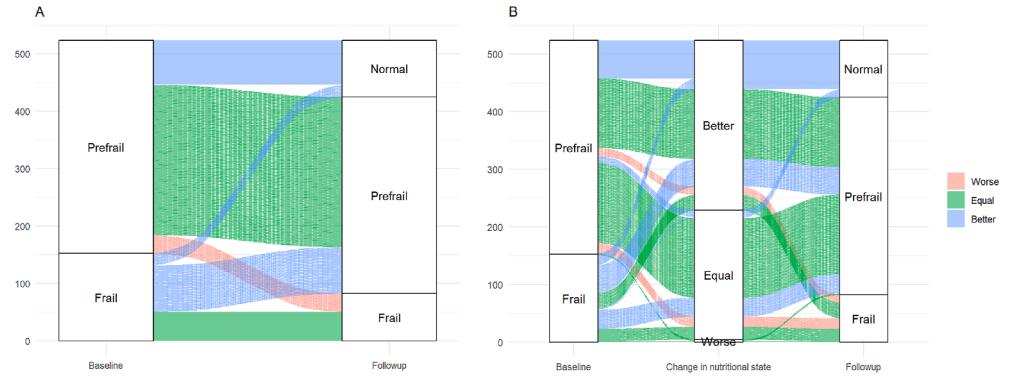


Figure 2. Changes in the frailty status during follow-up and its distribution regarding changes in the nutritional status, grouped by *Better* (improved in the frailty status), *Equal/Same* (no change), or *Worse* (deterioration in the frailty status) (A), and association with the change in the nutritional status (B).

status were older than those in *Same* or *Better* categories. Further, we found significant improvement of nutritional status (MNA-SF scores) in change categories (*Worse, Same, or Better*). Among subjects who had improved or unchanged frailty status, we also observed significant post-intervention improvement, i.e., reduction, in the proportion who were malnourished or at nutritional risk (Table 3). Similarly, we found improvement in mental state/cognitive status (MMSE) and less depression/

Table 3
Pre- and post-intervention health characteristics for patients grouped by change in frailty status (*Worse*, *Same*, *Better;* n=524), as determined by changes in number of frailty phenotype components present

	Change in number/components of frailty phenotype criteria					
	Worse n=69 (13.2%)		Same n=167 (31.9%)		Better n=288 (55%)	
	Baseline	Follow-up	Baseline	Follow-up	Baseline	Follow-up
Age, mean (SD)	78.8 (8.6)	-	74.1 (8.6)	-	73.1 (8.6)	-
Female, n (%)	49 (71.0)	-	120 (71.9)	-	192 (66.7)	-
Charlson Index, mean (SD)	6.1 (1.7)	-	5.9 (1.4)	-	6.4 (2.0)	-
Medication number, mean (SD)	3.1 (2.1)	-	3.7 (2.3)	-	3.3 (2.4)	-
BMI, mean (SD)	24.8 (3.4)	24.6 (3.4)	25.4 (3.9)	25.7 (4.0) (***)	24.4 (3.6)	24.9 (3.8) (***)
MNA-SF, mean (SD)	9.2 (1.6)	10.9 (1.8) (***)	9.5 (1.5)	11.2 (2.1) (***)	9.1 (1.8)	11.9 (2.1) (***)
Nutritional status, n (%)						
Normal	-	23 (33.3)	-	62 (37.1)	-	144 (60.0)
Risk	56 (81.2)	46 (66.7)	146 (87.4)	101 (60.5) (***)	237 (82.3)	111 (38.5) (***)
Malnutrition	13 (18.8)	0 (0) (***)	21 (12.6)	4 (2.4) (***)	51 (17.7)	7 (2.4) (***)
MMSE, mean (SD)	25.7 (4.7)	26.0 (4.7)	27.2 (3.7)	27.7 (3.1) (**)	27.4 (3.3)	27.9 (3.1) (**)
GDS, mean (SD)	3.9 (2.8)	3.6 (2.1)	4.5 (2.8)	3.6 (2.4) (***)	4.4 (2.7)	3.3 (2.4) (***)
Barthel index, mean (SD)	95.6 (6.9)	95.9 (8.6)	96.3 (5.9)	96.7 (5.6)	95.7 (7.4)	96.4 (6.7) (*)

BMI: body mass index; Barthel index: Barthel Index for Activities of Daily Living (ADL); MNA-SF: Mini Nutritional Assessment-Short Form; MMSE: Mini Mental State Examination; GDS: Geriatric Depression Scale; SD: standard deviation.
* p-value <0.05.
** p-value < 0.01.
*** p-value < 0.001.

improved psychological health (GDS) in these groups. Only those subjects with *Better* frailty status experienced small but significant improvement in BI functional activities.

Using an adjusted regression model, we found that improvement in nutritional status total score and positive change in MNA-SF status were highly correlated with improvement of the frailty condition (Table 4). Simply stated, those with frailty improvement were nearly 3-fold more likely to have parallel improvement in nutritional status based on MNA-SF score (Table 5). These findings are also shown in Figure 2.

Discussion

Our study results showed that community-living older adults could achieve a *better* frailty status when they followed a nutrition-focused QIP—counseling on good diet and nutritional practices, daily consumption of oral nutritional supplements, physical activity, and follow-up. Notably, we reported that improved nutritional status predicted and paralleled improvement in frailty status. Post-intervention improvement of frailty status was also associated with significantly higher MMSE score, decreased depression/improved psychological wellness (lower GDS score), and greater independence (higher BI score). Our findings therefore showed that nutrition could be used effectively to improve prefrailty and frailty, i.e., to support healthier aging.

Perspective for our findings

Human life expectancy around the world has risen substantially over recent decades. In the entire world, life expectancy increased by more than 14 years over the last 50 years' time; in Colombia, life expectancy is now nearly 78 years [30]. With such success in longevity, an updated goal is now to lengthen the interval older people live in good health.

Table 4
Adjusted regression model for improvements in MNA-SF total score and status, and differences between post-intervention and baseline MNA-SF scores

Model of improvement in MNA-SF score				
Variable	Coefficient (SE)	p-value	Odds ratio	CI 95%
Improvement in MNA-SF total score	0.96 (0.23)	<0.01	2.62	1.67–4.22
Age	-0.02 (0.01)	0.04	0.98	1.96–1.00
Model of improvement in MNA-SF status				
Variable	Coefficient (SE)	p-value	Odds ratio	CI 95%
Improvement in MNA-SF status	1.17 (0.20)	<0.01	3.23	2.19–4.85
Age	-0.02 (0.01)	0.02	0.97	0.95–1.00
Model of difference in MNA-SF pre- and post-intervention				
Variable	Coefficient (SE)	p-value	Odds ratio	CI 95%
Δ MNA-SF	0.22 (0.04)	<0.01	1.26	1.16–1.37
Age	-0.02 (0.01)	0.03	0.98	0.96–1.00

MNA-SF: Mini Nutritional Assessment-Short Form; CI: Confidence Interval; SE: Standard Error.

Table 5
Adjusted regression model for change from frail or prefrail (pre-intervention) to normal state (post-intervention)

Variable	Coefficient (SE)	p-value	Odds ratio	CI 95%
Improvement by MNA-SF status	2.85 (1.14)	<0.01	7.83	4.32–15.16
Age	-0.07 (0.01)	<0.01	0.93	0.90–0.96
Medication number	-0.13 (0.05)	0.02	0.88	0.78–0.98
Δ MMSE	0.11 (0.05)	0.04	1.12	1.01–1.24

MNA-SF: Mini Nutritional Assessment-Short Form; CI: Confidence Interval; SE: Standard Error.

Malnutrition and frailty are conditions that impede healthy aging and independent living [11]. To promote healthy aging in older adults, it is now essential to develop public health strategies that delay frailty onset, prevent its worsening, and help reverse its adverse consequences [31], as highlighted in the World Health Organizations' Decade of Healthy Ageing 2020–2030 proposal [32]. To recognize and treat frailty risk factors—especially malnutrition—is thus central to quality geriatric healthcare [33].

Evidence for overlap of poor nutritional status and frailty

Our present findings confirm and extend prior observations that poor nutritional status and frailty are conditions that adversely affect physical health outcomes for older adults. Notably, Faxen-Irving reported a high prevalence of (pre)frailty (51%), sarcopenia (29%) or malnourishment (17%) in nursing home residents; there was considerable overlap of the three conditions [34]. A systematic review established the importance of nutrition quantity (energy intake) and quality (complete and balanced nutrient intake) in the development of frailty syndrome in older adults [35]. A pan-European study (SPRINTT) sought to improve quality of life in vulnerable older people, thus paving the way for treatment of frailty [36]. Early SPRINTT results showed that a combination of personalized dietary advice and exercise could be used to preserve mobility in adults with physical frailty and sarcopenia [36]. In another study of community-living older adults in Spain, Rodríguez-Mañas *et al.* found that being at risk for malnutrition predicted risk of becoming frail, while being malnourished predicted mortality [18]. Beyond physical health, poor nutrition and frailty can negatively impact aspects of mental health and quality of life, as we have previously shown for this older cohort in Colombia [37].

A new look at treatment strategies for malnutrition and frailty

Malnutrition and frailty have customarily been treated independently even though these conditions share some common pathophysiological pathways—weight loss, decreased functional capacity, and weakness (handgrip strength) [38]. While associated with malnutrition, frailty can also result from other causes, such as physical inactivity, chronic diseases, polypharmacy, and metabolic imbalances [39]. Although considerable research has focused on identifying treatments specific to frailty, this limited approach could lead to missed opportunities to recognize benefits of complementary interventions such as for malnutrition. An important observation is that 2 of 3 malnourished older adults were reported to be physically frail [11]. It is therefore not surprising that our research results on use of a multi-component/comprehensive QIP (counseling on healthy diet and physical activity along with daily consumption of oral nutritional supplements) effectively improved both nutritional status and the severity of frailty.

Study strengths

This study is the first of its kind to examine the association between nutritional risk and frailty in community-living older adults of Latin America. Our present report extends results of our related reports for this Colombian population, which showed significant improvements in indicators of nutritional status (calf circumference) along with maintenance or improvement of nutrition-related anthropometric measures (body weight and BMI) following the nutritional QIP intervention [22]. As well, we showed significant improvements in physical functions (ADL and SPPB), depression status/psychological health (GDS), and both health-related and self-reported quality of life [37]. Economic modeling has shown that total cost savings equated to nearly twice the initial investment for this nutritional QIP intervention, i.e., the return on a $1 nutrition investment was $1.82 for savings in healthcare costs [40].

Study limitations

Our observational real-world QIP had inherent limitations associated with non-randomized study designs. Definitive studies on strategies for prevention and delay of frailty onset will require

prospective randomized study designs and longer-term treatment protocols and follow-up. Our current study was limited to a 60-day treatment with follow-up to 90 days; sustained nutritional intervention and longer follow-up may better reveal benefits for treating and offsetting frailty risks. Although the participants reported high compliance with the treatment regimen and oral nutritional supplementation consumption, use of self-reported methods for assessing compliance or adherence to nutritional interventions are prone to recall bias and other limitations. Future studies can benefit from the combination of self-reported data with objective measures when possible. Given the importance of exercise/physical activity for frailty prevention and treatment, we call for future studies to include nutritional intervention plus individualized prescription of physical activity, rather than just *exercise counseling* in the present protocol.

Conclusion and clinical implications

Healthy aging can be supported by addressing frailty risks. Results of our present analysis showed that community-living older adults achieved an improved frailty status when they followed a comprehensive nutrition-focused QIP. Specifically, we found that improved nutritional status predicts and parallels improvement in frailty status.

Based on these findings, we recommend the following for community-living older adults who attend outpatient clinics for post-acute care and for management of chronic diseases: (i) routine nutritional screening on outpatient visits, (ii) patient-directed counseling with nutrition and physical exercise advice, and (iii) treatment with disease-specific oral nutritional supplements when nutritional screening identifies malnutrition or its risk. Our study results showed that such focus on nutritional care was key to lessening frailty and its impact on older people.

Disclosures

Cano-Gutierrez and L Rodríguez-Mañas have received honoraria from Abbott Nutrition. G Gomez is a retired employee of Abbott. D Gracia, JD Misas, and S Sulo are employees of Abbott.

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Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Cano-Gutierrez and L Rodríguez-Mañas have received honoraria from Abbott Nutrition for this study and/or manuscript. G Gomez is a retired employee of Abbott. D Gracia, JD Misas, and S Sulo are employees of Abbott. The other authors have no conflicts of interest to report.

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