JAMDA xxx (2021) 1–7

JAMDA

journal homepage: www.jamda.com

Original Study

Response and Adherence of Nursing Home Residents to a Nutrition/Exercise Intervention

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Keywords:
Functional leg strength
nutrition
physical exercise
responsiveness
older adults
intervention

A B S T R A C T

Objectives: Interindividual response variability to nutrition and exercise interventions is extensive in older adults. A group of nursing home (NH) residents participated in a combined intervention. The objective of this post-hoc analysis was to identify factors associated with intervention response measured by change in physical function and body composition.

Design: Post-hoc analyses in the Older Person's Exercise and Nutrition study, a 2-arm randomized trial. The primary outcomes were 30-second Chair Stand Test and composite scores combining physical function and fat-free mass. A secondary outcome was intervention adherence. A 12-week intervention of sit-to-stand exercises and protein-rich nutritional supplements did not improve chair-stand capacity vs control on intention-to-treat basis.

Setting and Participants: Residents ≥75 years of age from dementia and somatic units in eight NHs in Sweden.

Methods: Logistic regressions were performed to define factors associated with response (maintenance/improvement) or nonresponse (deterioration) in 30-second Chair Stand Test, and with intervention adherence. Linear regressions were performed to explore factors associated with response in composite scores.

Results: Mean age of participants (n = 52 intervention, n = 49 control) was 85.8 years. Sarcopenia was occurring in 74%. Sarcopenia at baseline ($P = .005$) and high adherence to nutritional supplements ($P = .002$) increased the odds of response. Higher independence in daily activities increased the odds of adherence to sit-to-stand exercises ($P = .027$) and the combined intervention ($P = .020$). Allocation to the intervention group and higher self-perceived health were associated with higher composite scores.

Conclusions and Implications: NH residents with baseline sarcopenia, better self-perceived health, and high adherence to nutritional supplements benefitted most from a combined nutrition and exercise

This work was financially supported by Danone Nutricia Research, Utrecht, the Netherlands, who also provided the study product, and by Gamla Tjänarinnor.
The authors declare no conflicts of interest.
E.K., H.G., S.V., E.F., Å.S., A.W., G.F-I., and A-M.B. declare no conflicts of interest. T.C has previously received unconditional research funding as well as honoraria for lectures from the sponsoring agent (Nutricia). Y.C.L is an employee of Danone Nutricia Research.

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https://doi.org/10.1016/j.jamda.2021.04.001

intervention regarding chair-stand capacity and composite scores of function and fat-free mass. Adherence was related to higher grade of independence. Understanding factors associated with response and adherence to an intervention will help target susceptible residents in most need of support and to optimize the outcome.

Adequate physical function and nutritional status are crucial aspects of healthy aging[1] that directly transfer to independence in daily life and well-being in older adults. However, muscle function and muscle mass deteriorate with age[2,3] (ie, primary sarcopenia).[4] There is an expected average decline of about 40% in physical performance from 60 to 90 years of age.[5] Nursing home (NH) residents display an array of geriatric syndromes such as frailty,[6,7] sarcopenia,[4,8] and malnutrition,[9,10] which contribute both separately and combined to functional disability and increased care needs.[11] For this reason, delaying functional decline is of great importance in the NH context.

It is recognized that optimization of physical function and nutritional status is beneficial for older adults.[11–14] Still, the interindividual variability in health trajectories and intervention response is extensive. The variability in intervention response is multifactorial and influenced by person-related factors such as heterogeneity in health and functional status in older populations,[15,16] provider-related factors such as staff attitudes, knowledge and resources,[17] and organization-related factors such as NH leadership and resources.[18,19] Another determinant of response is adherence to an intervention. In older adults, adherence to exercise interventions is influenced by medical conditions, self-perceived health, physical function, and cognitive health.[20–22] When it comes to nutritional interventions, presence of malnutrition and chewing difficulties are associated with higher adherence and immobility, depression, and gastrointestinal problems with lower adherence.[23] Beyond person-related factors, adherence to interventions in NHs is also influenced by provider- and organization-related factors such as the staff's understanding of the intervention and leadership engagement.[24,25]

Previously, the effects of daily sit-to-stand exercises and oral nutritional supplementation during 12 weeks in NH residents [the Older Person's Exercise and Nutrition (OPEN) Study] have been reported.[26] Intention-to-treat analyses did not show any statistically significant differences between the intervention and the control group regarding physical function. Nevertheless, participants with a high adherence to the intervention were more likely to improve nutritional status and physical function.[26]

The overall objective of this post-hoc analysis was to deepen the understanding of the residents for whom the intervention was most beneficial and which individual factors facilitated a beneficial response. One specific objective was to separately analyze the intervention group to identify factors associated with response in the primary outcome of 30-second Chair Stand Test and in various composite scores. Another specific objective was to analyze relevant factors for adherence to the 2 intervention components (ie, exercise and nutritional supplementation). Finally, the total study population was combined to investigate if the intervention or factors beyond the intervention were associated with improvement, maintenance, or decline in the outcomes over the 12-week study period.

Methods

Study Design, Participants, and Recruiting Units

This was an explorative post-hoc analysis of data from a 2-arm randomized clinical trial (OPEN Study). A power analysis based on the original objective and study details are described elsewhere.[26,27] Data include 102 older adults living in 8 NHs in Stockholm County, Sweden. Five of 8 NHs recruited from both dementia and somatic units. They were all small-scale units with approximately 10 residents and 10–12 staff/unit that applied a 2-shift work schedule for daytime/evening staff. Each NH, except for one, recruited approximately the same amount of participants in relation to their total amount of residents (Supplementary Table 1). One outlier in the control group was excluded due to an unprecedented improvement in the sit-to-stand test, probably because of an infection at baseline. Thus, the sample included 101 participants (52 from the intervention and 49 from the control group). The inclusion criteria were ≥75 years of age and ability to stand up from a seated position. The exclusion criteria were body mass index >30 kg/m^2, a prescription of protein-rich oral nutritional supplements, and conditions prohibiting nutritional or physical interventions or testing. Verbal informed consent was obtained before study inclusion, and in a few cases, strengthened by a legal representative. Patients unable to give informed consent themselves or by a legal representative were excluded from the study. The Regional Ethical Board in Stockholm approved the study (Dno: 2013/1659-31/2, 2015/1994-32, 2016/1223-32). The original trial was registered at ClinicalTrials.gov, registration no. NCT02702037.

Procedure

Baseline demographic and clinical data were retrieved from the medical records. Assessments of physical function and nutritional status, and data on health-related quality of life and health care resources were collected and performed at baseline and follow-up by 2 clinically experienced study physical therapists in all recruiting sites. The OPEN Study was a 12-week intervention, which consisted of a combination of sit-to-stand exercises 4 times/day and protein-rich oral nutritional supplements 2 bottles/day corresponding to 600 kcal and 36 g protein (Fortimel Compact Protein, Nutricia N.V., Zoetermeer, the Netherlands). In brief, the daily physical intervention was delivered and/or supported by nursing staff in all intervention sites and integrated in the regular activities of daily living. The staff also offered the nutritional supplements. Detailed information about the intervention and intervention delivery has been published previously.[27] The control group received standard care.

Primary Outcome Measures — 30-Second Chair Stand Test and Composite Scores

The primary outcome of the overall OPEN project was change in the 30 second Chair Stand Test (ie, number of chair-risings in 30 seconds, from baseline to follow-up).[26] The test was conducted according to Le Berre et al,[28] which allows arm-use and includes a definition of a counted stand from halfway up to a fully erect position.

For this post-hoc analysis, one primary outcome was the binary response in 30s Chair Stand Test defined as maintained or improved vs decreased number of sit to stands. Beyond the Chair Stand test, the OPEN intervention aimed for improvements also in other physical functions as well as in nutritional status. Thus, walking speed (assessed over a 10-m distance[29]), and the 13 motor items of self-care,

transfer, and locomotion from the 18-item functional independence measure (FIM) were used to assess function in activities of daily living.[30] For potential changes in nutritional status, body composition was assessed by bioelectrical impedance analysis. Fat free mass was estimated as a proxy for muscle mass. Next, components from the 2 areas of physical function and nutritional status were merged into composite scores. An improvement from baseline to follow-up gave a score of 2 points, a maintenance 1 point and a decrease a score of 0 point.

Secondary Outcome Measure—Adherence

Adherence was defined as number of occasions each participant performed the sit-to-stand exercises, and the amount of oral nutritional supplements they consumed.[26] Based on previous literature, an adherence to the combined intervention of 40% (120 sit-to-stand occasions and 60 nutritional supplements over 12 weeks) was set as a cut-off value.[31] In a subgroup analysis, we divided the intervention group into individuals with an adherence of ≤40%, from 40% to 60% and ≥60%.

Explanatory Variables

Independent variables that may have had an impact on the response to the intervention were chosen as sex, number of diagnoses, cognitive capacity categorized in 4 levels from normal to severe impairment based on results from the Mini-Mental State Examination. Furthermore, sarcopenia was assessed and defined according to the steps of the pathway Find-Assess-Confirm-Severity (F-A-C-S) from the European Working Group on Sarcopenia in Older People, and then

Table 1
Demographic and Clinical Baseline Characteristics of the Total Sample, Intervention Group (Divided into Responder or Nonresponder to the Primary Outcome; ie, 30-Second Chair Stand Test), and Control Group (Divided into Stable/Improved or Decreased in the Primary Outcome)

Variables, n Total (Intervention-Control)	Value						
	Total Sample (n = 101)*	Intervention Group (n = 52)		P	Control Group (n = 49)		P
		Responders (n = 33)	Nonresponders (n = 19)		Stable/Improved (n = 23)	Decreased (n = 26)	
Demographics							
Age in y, n = 101 (52–49), mean (SD)	85.8 (5.2)	85.9 (5.0)	85.8 (5.2)	.95†	85.2 (5.8)	86.3 (5.2)	.48†
Sex, male, n = 101 (52–49), n (%),	38 (38)	13	5	.38‡	9	11	.82‡
Unit, n = 101 (52–49), n (%)				.22‡			.62‡
Somatic	40 (40)	10	9		9	12	
Dementia	61 (60)	23	10		14	14	
N of diagnoses, median (IQR), n = 100 (52–48)	4 (3–5)	4 (3–4)	4 (2–5)	.90§	3 (3–5)	4 (3–5)	.16§
Cognition, n = 77 (41–36), n (%)‖				.23‡			.62‡
Normal function, 24–30 on MMSE	15 (20)	6	4		4	1	
Mild impairment, 20–23 on MMSE	20 (26)	6	1		6	7	
Moderate impairment, 10–19 on MMSE	37 (48)	14	8		8	7	
Severe impairment, 0–9 on MMSE	5 (6)	0	2		1	2	
Sarcopenia (EWGSOP), n = 101 (52–49), n (%)				.049§			.40§
No sarcopenia	26 (26)	4	8		6	8	
Probable sarcopenia	53 (52)	21	8		10	14	
Confirmed sarcopenia	3 (3)	1	0		2	0	
Severe sarcopenia	19 (19)	7	3		5	4	
Frailty, n = 101 (52–49), n (%) 0–5				.95§			.17§
Robust (0 p)	46 (50)	16	9		11	10	
Prefrailty (1–2 p)	36 (39)	10	6		7	13	
Frailty (3–5 p)	10 (11)	4	3		1	2	
Physical function, mean (SD)							
30sCST, n = 101 (52–49), n	6.3 (3.1)	5.5 (2.8)	7.2 (3.7)	.07†	6.3 (3.0)	6.7 (3.2)	.63†
FIM motor items, n = 101 (52–49), sum score 13–91	68.1 (19.5)	69.8 (19.0)	63.1 (24.6)	.44§	76.8 (10.2)	62.1 (19.8)	.011§
Walking speed, n = 92 (46–46), m/s	0.72 (0.31)	0.70 (0.33)	0.75 (0.30)	.66†	0.73 (0.30)	0.72 (0.30)	.88†
Nutritional status and body composition, mean (SD)							
Body weight, n = 101 (52–49), kg	68.0 (12.9)	68.7 (12.3)	66.3 (13.4)	.50†	66.4 (13.4)	69.7 (13.4)	.39†
Fat mass, n = 88 (46–42), kg	23.8 (7.3)	23.7 (6.1)	24.7 (8.2)	.62†	21.9 (7.3)	25.2 (8.0)	.17†
Fat free mass, n = 88 (46–42), kg	43.6 (9.6)	44.0 (9.1)	40.8 (7.4)	.46§	43.4 (11.4)	45.5 (10.1)	.35§
Vitamin D, n = 93 (47–42), mmol/L	62.9 (26.6)	57.7 (17.6)	67.3 (29.1)	.26§	68.6 (31.5)	60.7 (29.0)	.30§
Nutritional status GLIM, n = 101 (52–49), n (%)				.46‡			.27‡
Not malnourished	83 (82)	26	17		17	23	
Malnourished	18 (18)	7	2		6	3	
Laboratory markers, n = 95 (49–46)							
C-reactive protein, mg/L, median (IQR)	3 (0–6)	3 (0–7)	3 (0–5)	.94§	2 (1–6)	3 (1–4.5)	.76§
Insulin-like growth factor, μg/L, median (IQR)	88.5 (72–114)	98 (77–115)	90 (76–111)	.51§	85.5 (73–124)	79 (59.5–97)	.11§
Health and resources, median (IQR)							
EQ5D-5L VAS, n = 89 (46–43), 0–100	65 (50–90)	70 (50–90)	50 (50–75)	.13§	80 (55–92.5)	55 (50–100)	.30§
EQ5D-5L index, n = 95 (49–46), 0–1	0.82 (0.69–1.0)	0.82 (0.69–1.0)	0.81 (0.48–0.86)	.40§	0.82 (0.77–1.0)	0.86 (0.69–1.0)	.85§
Caregiver time, n = 91 (47–44), min	60 (30–120)	70 (45–120)	60 (30–90)	.39§	40 (20–120)	60 (45–180)	.09§

30sCST, 30s Chair Stand Test; EWGSOP, European Working Group on Sarcopenia in Older People; GLIM, Global Leadership Initiative on Malnutrition; IQR, interquartile range; MMSE, Mini Mental State Examination; MNA-SF, Mini Nutritional Assessment Short Form; VAS, visual analogue scale.

*Exclusion of one outlier in the control group.

†Independent *t*-test.

‡$\chi 2$ or Fisher exact test if the cell count was less than 5.

§Mann Whitney.

‖The Short Portable Mental Status Questionnaire was used for n = 7.

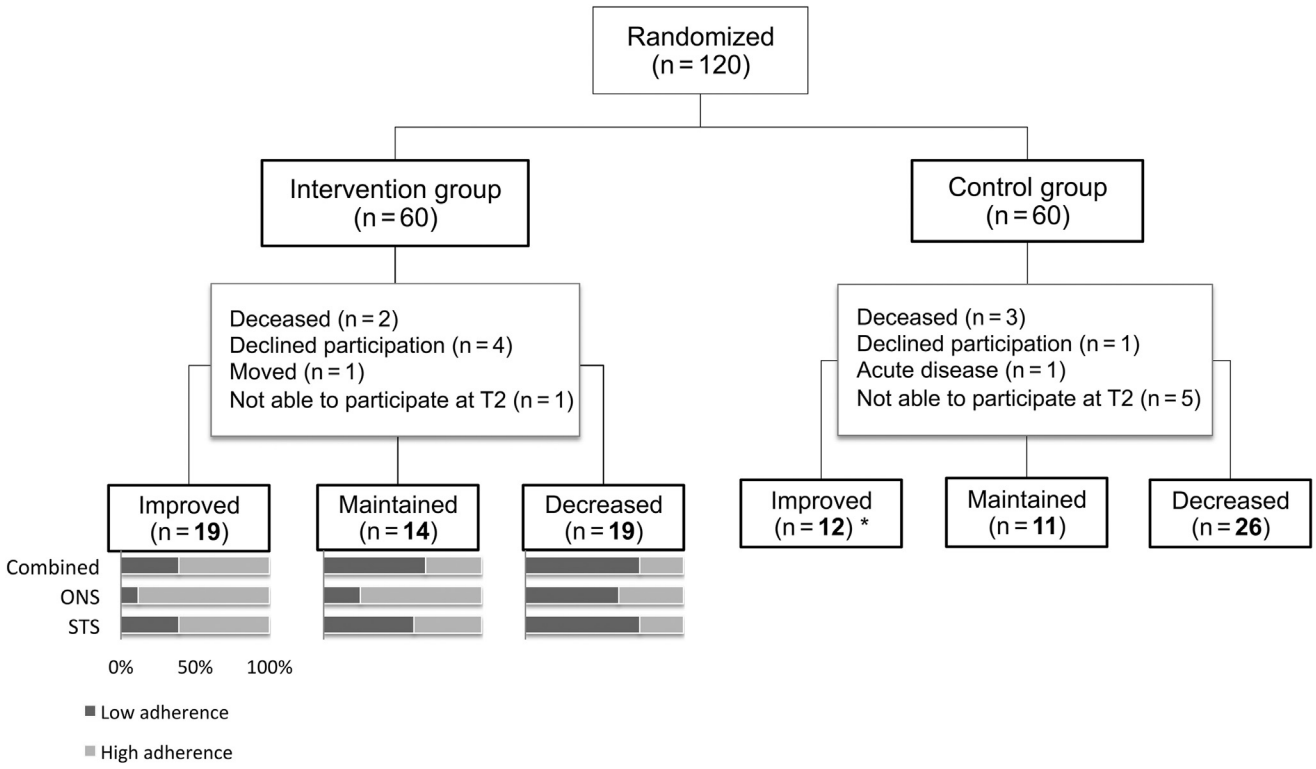

Fig. 1. Flow diagram of included participants assigned to the intervention and control group, divided into improved/maintained/decreased in the primary outcome (30-second Chair Stand Test). For the intervention group each response group is divided into low or high adherence to the combined [ie, oral nutritional supplement (*ONS*) and sit-to-stand (*STS*), intervention] *One outlier was excluded from analysis.

dichotomized into nonsarcopenic and sarcopenic (probable/confirmed/severe).[4] Assessment of frailty grade was based on the FRAIL questionnaire, and categorized into robust (0 points), prefrail (1–2 points), and frail (3–5 points).[32] Baseline physical function was measured with 30-second Chair Stand Test, walking speed, and FIM motor items. Nutritional status was assessed according to the Global Leadership Initiative on Malnutrition format.[33] Fat-free mass (kg) by bioelectrical impendence was used as a proxy for muscle mass. The biochemical markers C-reactive protein, serum vitamin D (25(OH)D) and insulin-like growth factor-1 were analyzed.[34–36] Health-related quality of life was estimated by the EuroQoL Group 5 Dimensions (EQ5D-5L), which includes a descriptive part converted into an index value between 0 and 1, and the visual analogue scale reporting perceived overall health from 0 (worst health) to 100 (best health).[37] Adherence to the sit-to-stand and nutritional supplement interventions were dichotomized into high or low adherence as previously described.[31] The resource utilization in dementia instrument was used to collect caregiver time in minutes/day at baseline.[38] Group allocation (control = 0, intervention = 1) was added in calculations including the total sample.

Statistical Analyses

Demographic and clinical data were reported as mean and standard deviations for continuous variables, median and interquartile range for skewed data, and numbers and percentage for categorical data. Between-group analyses were performed with the independent *t*-test, Mann Whitney U test, or the χ^2 (or Fisher exact test if cell count $\leq$5) as appropriate. In comparisons with more than 2 groups a 1-way analysis of variance followed by Tukey test were used. Participants of the intervention group were divided into responders, who maintained or improved, and nonresponders, who decreased their value from baseline to follow-up on the primary outcome. Logistic regressions were performed to explore factors associated with positive response in 30-second Chair Stand Test in the intervention group, and linear regressions to explore factors associated with positive response in composite scores. Factors associated with high or low adherence in the intervention group were investigated by logistic regressions. Two receiver operating curve analyses were performed to find a possible cut-off for the minimal number of sit-to-stand occasions and oral nutritional supplements needed to get positive response in the intervention group. Cut point selection was made according to Liu.[39]

Univariate regressions were performed with each independent variable and the dependent variable. Variables with a *P* value of $\leq$.2 in the univariate regressions were tested in a multivariable model. At each step the variable with the largest *P* value was removed until the final model only contained variables with a *P* value of $\leq$.2.[40] The significance level was set at $P \leq .05$. Collinearity occurred between adherence to the sit-to-stand and the combined intervention, whereas the variable of least interest was omitted. Missing data were apparent mainly in the EQ5D-5L visual analogue scale, cognition and fat-free mass. Full information maximum likelihood analyses and multiple imputations were conducted in sensitivity analyses, which overall indicated the same patterns as the main analysis.[41,42] Statistical analyses were performed using STATA SE (v 14.2; College Station, TX).

Results

Altogether 101 participants (mean age 85.8 years) having follow-up data at 12 weeks were included. Eighteen participants were lost at follow-up (Figure 1). They had significantly worse performance on 30-second Chair Stand Test at baseline (median = 4) compared with those who completed the study (median = 6, $P = .015$), but did not

Table 2
Multivariable Logistic Regression; Associations Between Baseline Factors/Adherence and Positive Response in 30-Second Chair Stand Test in the Intervention Group (n = 52)

Independent Variables	Positive Response in 30sCST	
	Intervention Group*	
	OR (95% CI)	*P*
Sarcopenia, (if probable/confirmed/severe)	14.99 (2.28–98.36)	**.005**
Adherence to ONS (if high)	16.55 (2.76–99.37)	**.002**

30sCST, 30s Chair Stand Test; ONS, oral nutritional supplement.
Bold numbers indicate $P \leq .05$.
*n = 47 because of missing data in multiple variables.

differ significantly regarding age, sex, or nutritional status (previously described in detail).[26,27]

Any grade of sarcopenia was occurring in 74% (n = 75) of the total study sample (Table 1). In the intervention group (n = 52), 2 of 3 improved or maintained their 30-second Chair Stand Test. In the control group (n = 49) more than one-half deteriorated in their 30-second Chair Stand Test. Change from baseline to follow-up for each group is displayed in Figure 2.

Factors Associated with Positive Response to the Intervention

Responders to the primary outcome in the intervention group were more likely to have some grade of sarcopenia compared to nonresponders (Table 1, $P = .049$). A tendency was observed for lower baseline 30-second Chair Stand Test performance in the responders vs nonresponders ($P = .07$).

In univariate regression analyses, increases in the odds of response in 30-second Chair Stand Test were observed for any level of sarcopenia at baseline [odds ratio (OR) 5.27; 95% confidence interval (CI) 1.32–21.09; $P = .019$] or a higher adherence to the nutritional intervention (OR 7.14; 95% CI 1.83–27.88; $P = .005$). Baseline Vitamin D status, baseline 30-second Chair Stand Test, EQ5D-5L visual analogue scale, and adherence to the sit-to-stand intervention all had a *P* value of ≤.2 in univariate tests (Supplementary Table 2). When keeping variables with a *P* value of ≤.2 in the multivariable model, only level of sarcopenia and adherence to the nutritional supplements remained linked to improved response in the primary outcome (Table 2). Also, higher perceived overall health at baseline was significantly associated with positive responses in any of the composite scores (Table 3).

In an additional analysis including the total sample, allocation to the intervention group, sarcopenia, FIM motor items, and perceived overall health were related to stable/improved results in 30-second Chair Stand Test (Supplementary Table 3). Any level of sarcopenia and higher independency increased the odds of a stable/improved result in 30-second Chair Stand Test during the observation period (OR 9.82; 95% CI 2.75–35.04; $P < .001$ and OR 1.06; 95% CI 1.03-1.10; $P < .001$ respectively). Higher perceived overall health and allocation to the intervention group were also associated ($P < .01$) with higher composite scores (Supplementary Table 4).

Factors Related to Adherence to the Intervention

More than one-half of the responders in 30-second Chair Stand Test adhered to the sit-to-stand intervention for more than 120 occasions, and 4 out of 5 responders adhered to the nutritional intervention by consuming more than 60 bottles during 12 weeks. Corresponding adherence in nonresponders were one-fourth and two-fifths (Supplementary Table 5). A higher score on FIM motor items, meaning more independence in self-care, transfers, and walking tasks, significantly increased the odds of high adherence to the sit-to-stand (OR 1.04; 95% CI 1.00–1.08; $P = .027$) and combined intervention (OR 1.04; 95% CI 1.01–1.08; $P = .020$) (Table 4). In receiver operating curve analyses the minimal number of sit-to-stand occasions performed in order to get a likely positive response in the primary outcome was 111 of a maximum of 336 sit-to-stand occasions during 12 weeks (sensitivity 0.62, specificity 0.72, area under the curve 0.67), and the minimal number of oral nutritional supplements consumed was 58 of a maximum of 168 bottles during 12 weeks (sensitivity 0.83, specificity 0.59, area under the curve 0.71).

Discussion

This post-hoc analysis of the OPEN Study including a combined intervention in NH residents revealed that any level of sarcopenia at baseline and high adherence to the oral nutritional supplements increased the odds of response in 30-second Chair Stand Test when the intervention group was analyzed separately. Furthermore, independence in daily activities significantly increased the odds of high adherence to the sit-to-stand and the combined intervention. Eventually, when the total sample was analyzed, we noticed that allocation to the intervention group and a higher perceived overall health were significantly associated with positive responses in composite scores combining 2 to 3 physical and nutritional outcomes.

Responders in the intervention group were significantly more likely to have some degree of sarcopenia compared to nonresponders, and fewer chair-risings at baseline. Notably, because of a broad CI, the magnitude of the absolute estimates in the logistic regression should be interpreted with caution; instead, we would like to emphasize the direction of the findings. The results indicate that those most likely to respond to an exercise and nutritional intervention are those with the

Table 3
Multivariable Linear Regression; Associations Between Baseline Factors and Positive Response in Composite Scores in the Intervention Group (n = 52)

Independent Variables	Positive Response in Composite Scores		
	Coefficient (95% CI)	*P*	R^2
	Composite score A*: 30sCST (0–2p) + FFM kg (0–2 p) (score range 0–4, n = 33)		
Adherence to STS (if high)	0.52 (−0.35, 1.40)	.231	32%
EQ5D-5L VAS (overall health 0–100)	0.03 (0.01, 0.05)	**.002**	
	Composite score B*: 30sCST + FIM motor items + FFM kg (score range 0–6, n = 35)		
Sex (if female)	−0.89 (−1.97, 0.18)	.099	29%
EQ5D-5L VAS (overall health 0–100)	0.04 (0.02, 0.06)	**.002**	
	Composite score C*: 30sCST + walking speed + FFM kg (score range 0–6, n = 31)		
Sex (if female)	−0.68 (−1.68, 0.33)	.178	26%
EQ5D-5L VAS (overall health 0–100)	0.03 (0.007, 0.05)	**.012**	

30sCST, 30s Chair Stand Test, FFM, fat free mass; STS, sit-to-stand; VAS, visual analogue scale
Bold numbers indicate $P \leq .05$.
*An improvement from baseline to follow-up in any variable relented 2 points, a maintenance 1 point, and a decrease 0 point. The points from each assessment were then summarized into a total score from 0–4 or 0–6 points.

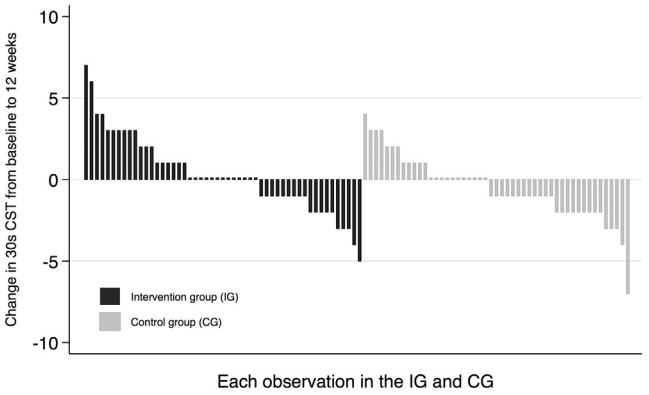

Fig. 2. Change in 30-second Chair Stand Test (number of sit-to-stands in 30 seconds) from baseline to follow-up for each participant in the intervention (*IG*) and control group (*CG*), respectively, n = 101.

Table 4
Multivariable Logistic Regressions; Associations Between Baseline Factors and Adherence to Sit-to-Stand, Oral Nutritional Supplement, and the Combined Intervention in the Intervention Group (n = 52)

Independent Variables	Adherence (Low/High) – Dependent Variable	
	OR (95% CI)	*P*
	Sit-to-Stand Exercises (n = 50)	
Age in y	1.10 (0.97–1.3)	.150
FIM motor items (if higher score)*	1.04 (1.00–1.08)	**.027**
GLIM (if malnourished)	5.03 (0.83–30.63)	.080
	Oral Nutritional Supplement (n = 36)	
Level of cognition (from normal to severe impairment)	0.41 (0.14–1.23)	.113
FIM motor items (if higher score)*	1.04 (1.00–1.08)	.054
	Combined Intervention (n = 50)	
Age in y	1.10 (0.97–1.25)	.140
FIM motor items (if higher score)*	1.04 (1.01–1.08)	**.020**

GLIM, Global Leadership Initiative on Malnutrition.
Bold numbers indicate $P \leq .05$.
*A higher FIM score means higher independence in activities of daily living.

lowest physical function and muscle strength to begin with and, thus, likely greater room to improve. This corroborates a previous study of a nutritional and physical intervention, showing higher improvement in participants who were frailer, had lower functional level, and poorer nutritional status.[43] In addition, this might be the most important group to optimize regarding physical function and nutrition from an overall health perspective. Similar observations were made in other contexts such as preoperative care,[44] balance training in Parkinson disease,[45] and postmenopausal women.[46] It also suggests that people with a higher level of physical activity might need exercise with higher intensity and workload to achieve a positive response.[47]

High compliance to oral nutritional supplements is an important factor to improve nutritional status.[23] This assumption seemed to be corroborated as an essential factor for a positive response to physical function in this study. An additional aspect of potential importance could be that the nursing staff generally is more familiar with providing nutritional supplements than supervising sit-to-stand exercises.[25]

A higher perceived overall health at baseline increased the odds of a positive response in the composite scores of combined physical and nutritional outcomes. High psychological well-being has been shown to be associated with less decline in physical function over time in participants ≥60 years of age living in NH or at home.[48] In future investigations, subjective measures, such as motivation, should be considered as covariates.

In this study, greater independence increased the odds of adherence to the sit-to-stand and the combined intervention. This is in line with interviews with the staff involved in the study where some residents were described as independent in performing the intervention, whereas others needed constant support from staff.[25] In addition, some participants described an extra drive to support fellow residents, whereas others experienced an increased need of support themselves.[49] Such findings indicate that participants with high adherence took greater responsibility and ownership to complete the intervention.[26] Thus, those who were more dependent might need further support by staff during this type of intervention to increase adherence to especially sit-to-stands. As some residents had to rely on staff assistance to conduct the intervention, staff engagement and resources could also be influential factors with regard to intervention success. Interviews with the staff showed that they had varying understandings and attitudes towards the intervention. Some staff also brought up the importance of involvement from front-line leaders to create conditions for continuity.[25]

Increased feedback and monitoring might improve exercise adherence in older adults.[20] In our study, a cut-off of 111 sit-to-stand occasions (approximately 9 occasions/week) and 58 nutritional supplement bottles (5 bottles/week) were necessary to get a likely positive response in the primary outcome. This confirms that 120 sit-to-stand occasions is an adequate cut-off level for adherence, as previously indicated.[31]

Finally, in the total sample, allocation to the intervention group was significantly associated with higher scores in the various composite scores, indicating that the combined intervention was a factor associated with positive responses in primary and secondary outcomes when combined. The use of composite scores is justified by the fact that a positive outcome by a complex intervention cannot easily be captured by 1 single outcome variable.

Among study limitations, it should be acknowledged that selection bias cannot be avoided in a NH context, which is reflected by the fact that one-third of the eligible residents declined participation in the original study sample, and that another 18 participants were lost at follow-up.[26] Multiple testing was conducted in this study, which increase the risk for type I error. The findings should be interpreted with this in mind. Accordingly, the results should be regarded as hypothesis generating rather than conclusive. Moreover, the fairly small study sample generated insufficient power especially for some subgroup analyses. Further, data on the amount of support each participant required to conduct the intervention would have been of use to understand how support from the staff may affect adherence. In this study, detailed contextual factors were not monitored. Nevertheless, more detailed information should be collected and considered in future studies to enable process evaluation and implementation.[50]

Conclusions and Implications

The results suggest that responders (ie, those with improved or maintained chair stand capacity) to the combined nutrition and exercise intervention were characterized by any degree of sarcopenia and had a high adherence to specifically the oral nutritional supplement. Level of independence was important for adherence to the sit-to-stand and combined intervention. In the total sample, allocation to the combined intervention, eventually, appeared as a factor associated with positive response in composite scores of physical function and body composition. These results may help to target NH residents in most need of support, as well as to recognize NH residents that are most likely to benefit from this type of intervention.

Acknowledgments

We thank all participating residents and staff in the 8 NHs. We are grateful to our Canadian colleagues, Dr Susan E. Slaughter and her research group at University of Alberta, Edmonton, Canada, for advice in developing the study protocol. We are also grateful to Ms Elin Linde for support regarding data collection, and Ms Frida Eriksson for data management. Representatives from Nutricia have been involved in the study design and advised on data analysis and interpretation. The company was not involved in data collection and analyses. The final interpretation of the study results and decision to submit were performed by independent researchers with no affiliation to the funding source.

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Supplementary Table 1
NH Characteristics

NH (n = 8)	No. of Included Units	Total No. of Beds	Somatic/Dementia	No. of Participants Who Completed the Study (n = 102)*
A	9	81	Yes/Yes	17
B	8	72	Yes/Yes	16
C	2	16	Yes/Yes	5
D	5	58	Yes/No	12
E	3	24	No/Yes	5
F	7	68	Yes/No	13
G	9	81	Yes/Yes	7
H	14	130	Yes/Yes	27

*Exclusion of 1 outlier in the control group.

Supplementary Table 2
Univariate Logistic Regressions; Associations Between Baseline Factors/Adherence and Positive Response in 30-Second Chair Stand Test in Intervention Group (n = 52) and Total Sample (n = 101) Separately

Independent Variables	N	Positive Response in CST – Dependent Variable				
		Intervention Group		Total Sample		
		OR (95% CI)	*P*	n	OR (95% CI)	*P*
Group allocation, (if control)		–	–	101	0.51 (0.23–1.13)	*.097*
Sex, (if female)	52	0.55 (0.16–1.89)	.34	101	0.85 (0.38–1.92)	.70
Number of diagnoses, n	52	1.00 (0.72–1.38)	.99	100	0.90 (0.72–1.12)	.33
Level of cognition	41	0.75 (0.37–1.56)	.45	77	0.71 (0.42–1.22)	.217
Frailty, robust to frail	48	1.06 (0.64–1.76)	.82	92	0.89 (0.60–1.30)	.53
Sarcopenia according to EWGSOP, (no or probable/confirmed/severe)	52	5.27 (1.32–21.09)	*.019*	101	2.54 (1.01–6.35)	*.046*
CST at baseline, n	52	0.85 (0.70–1.02)	*.086*	101	0.90 (0.79–1.02)	*.096*
Walking speed, m/s	46	0.63 (0.09–4.58)	.65	92	0.84 (0.22–3.27)	.80
FIM motor scale	52	1.02 (0.99–1.04)	.27	101	1.03 (1.01–1.05)	*.011*
GLIM (if malnourished)	52	2.29 (0.42–12.36)	.34	101	2.42 (0.79–7.40)	*.121*
Fat free mass, kg	46	1.05 (0.97–1.13)	.23	88	1.00 (0.96–1.05)	.85
Insulin-like growth factor, μg/L	49	1.00 (0.99–1.02)	.60	95	1.01 (1.00–1.02)	*.118*
Vitamin D, mmol/L	47	0.98 (0.96–1.01)	*.169*	93	1.00 (0.98–1.01)	.84
C-reactive protein, mg/L	49	1.02 (0.89–1.17)	.77	95	0.98 (0.93–1.03)	.40
Overall health, EQ5D-5L VAS	46	1.02 (0.99–1.05)	*.143*	89	1.02 (1.00–1.04)	*.098*
Health state utility, EQ5D-5L index	49	5.9 (0.52–67.54)	*.152*	95	2.38 (0.43–13.13)	.32
Caregiver time, min	47	1.00 (0.99–1.01)	.74	91	1.00 (0.99–1.00)	.40
Adherence to STS (low/high)	50	2.95 (0.85–10.22)	*.088*		–	–
Adherence to ONS (low/high)	47	7.14 (1.83–27.88)	*.005*		–	–

EWGSOP, European Working Group on Sarcopenia in Older People; GLIM, Global Leadership Initiative on Malnutrition; ONS, oral nutritional supplement; STS, sit-to-stand; VAS, visual analogue scale.
Italic numbers indicates $P \leq .2$ (cut-off for inclusion in multivariable analyses).

Supplementary Table 3
Multivariable Logistic Regressions; Associations Between Baseline Factors and 30-Second Chair Stand Test in the Total Sample (n = 101)

Independent Variables	Maintained/Improved Result in 30sCST	
	Total sample*	
	OR (95% CI)	*P*
Group allocation (if intervention group)	2.52 (0.91–6.95)	.075
Sarcopenia (if probable/confirmed/severe)	9.82 (2.75–35.04)	**<.001**
FIM motor items (if higher score)†	1.06 (1.03–1.10)	**<.001**
EQ5D-5L VAS (Overall health 0–100)	1.02 (0.99–1.05)	.101

30sCST, 30-second Chair Stand Test; VAS, visual analogue scale.
Bold numbers indicate $P \leq .05$.
*n = 89 because of missing data in multiple variables.
†A higher FIM score means higher independence in activities of daily living.

Supplementary Table 4
Multivariable Linear Regressions; Associations Between Baseline Factors and Change in Composite Scores in the Total Sample (n = 101)

Independent Variables	Maintained/Improved Result in Composite Scores		
	Coefficient (95% CI)	*P*	R^2
	Composite score A* 30sCST (0–2 p) + FFM kg (0–2 p) (score range 0–4, n = 69)		
Group allocation (if intervention group)	0.96 (0.34, 1.58)	**.003**	24%
EQ5D-5L VAS (overall health 0–100)	0.03 (0.01, 0.04)	**.002**	
	Composite score B* 30sCST + FIM motor items + FFM kg (score range 0–6, n = 68)		
Group allocation (if intervention group)	1.08 (0.33, 1.83)	**.005**	21%
EQ5D-5L VAS (overall health 0–100)	0.03 (0.01, 0.05)	**.001**	
	Composite score C* 30sCST + walking speed + FFM kg (score range 0–6, n = 63)		
Group allocation (if intervention group)	0.97 (0.31, 1.62)	**.005**	19%
EQ5D-5L VAS (overall health 0–100)	0.02 (0.007, 0.04)	**.006**	

30sCST, 30-second Chair Stand Test; FFM, fat free mass; VAS, visual analogue scale.
Bold numbers indicate $P \leq .05$.
*An improvement from baseline to follow-up in any variable relented 2 points, a maintenance 1 point, and a decrease 0 point. The points from each assessment were then summarized into a total score from 0–4 or 0–6 points.

Supplementary Table 5
Number of Participants in the Intervention Group with Low vs High Adherence to the Sit-to-Stand, Oral Nutritional Supplement, and the Combined Intervention

Variables	Value		
	Total Intervention Group N = 50*	Responders n = 32	Nonresponders n = 18
Adherence, n (%)			
STS			
High adherence >120 occasions	22 (44%)	17 (53%)	5 (28%)
Low adherence <120 occasions	28 (56%)	15 (47%)	13 (72%)
ONS†			
High adherence >60 bottles	32 (68%)	25 (83%)	7 (41%)
Low adherence <60 bottles	15 (32%)	5 (17%)	10 (59%)
Combined (STS + ONS)			
High adherence	21 (42%)	16 (50%)	5 (28%)
Low adherence	29 (58%)	16 (50%)	13 (72%)

ONS, oral nutritional supplement; STS, sit-to-stand.
*2 missing because of missing data.
†3 missing because of missing data.