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THE PHYSICAL FUNCTIONAL CAPACITY OF FRAIL ELDERLY PERSONS UNDERGOING AMBULATORY REHABILITATION IS RELATED TO THEIR NUTRITIONAL STATUS

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Abstract: *Objectives:* To estimate the prevalence of malnutrition in frail elders undergoing rehabilitation and the association between their nutritional status and physical function. *Design:* Observational study of new participants undergoing ambulatory rehabilitation. *Setting:* Two Geriatric Day Hospitals (GDH) in Montreal, Quebec. *Participants:* 121 women and 61 men. *Intervention:* Evaluation of nutritional status, body composition and physical function. *Measurements:* The nutritional status was assessed with a composite index based on anthropometric measurements and serum albumin, as well as using the Mini Nutritional Assessment (MNA) questionnaire. Patients were classified as well-nourished, having mild/at risk of malnutrition or malnourished. Body composition was estimated by bioimpedance and handgrip strength and gait speed by standard methods. *Results:* 13% of patients were found to be mildly malnourished, whereas 6% were malnourished. Malnourished patients were older and had worse cognition, lower BMI, and % body fat (all $p < 0.05$). Malnourished patients and those with mild malnutrition had lower weight, triceps skinfold thickness, muscle and fat mass (all, $p < 0.003$). Handgrip strength was different according to the nutritional status ($p = 0.034$) and correlated with muscle mass ($r = 0.65$, $p < 0.001$). MNA classified 53% of patients as being at risk whereas 3% were malnourished and it correlated with gait speed ($r = 0.26$, $p = 0.001$). *Conclusion:* There is a high prevalence of patients in GDH at risk or with mild malnutrition. Being malnourished was associated with worse physical performance, which suggests that a nutritional intervention may be of benefit in im*proving their physical function.*

Key words: Nutritional status, physical function, Mini Nutritional Assessment (MNA), Geriatric Day Hospital (GDH).

Introduction

The Frailty Syndrome (1) is linked to chronic malnutrition, of which inadequate dietary intake is a contributing factor to weight loss and physical function impairment (2). Frailty and functional decline clearly have multiple etiologies. Notably, low body weight and fat-free mass are associated with lower biceps and quadriceps strength (3), poor nutritional status with lower strength of extremity muscles (4) and weight loss with decline in activities of daily living (5). There is evidence suggesting a high prevalence of malnutrition among frail elderly persons, especially in those who are hospitalized and homebound (6-9). Several studies have also reported a high prevalence of malnutrition in patients undergoing rehabilitation in subacute care settings (6,10-12). Moreover, being a malnourished geriatric rehabilitation patient extends length of stay and impedes in function recovery (11, 12).

Many frail elderly persons participate in ambulatory rehabilitation programs in Geriatric Day Hospital (GDH) settings with the aim of regaining their autonomy. The prevalence of malnutrition in a British GDH has been found to be twice as high as in a healthy elderly population (13). However, the prevalence of malnutrition among frail elderly persons participating in ambulatory rehabilitation programs outside Great Britain and the extent to which malnutrition impacts on measures of physical function remains unknown. The objectives of this study were to determine the nutritional status and body composition of the participants undergoing rehabilitation at two GDH in Montreal and to establish the relationship with their physical performance.

Methods

Participants

A total of 192 newly admitted patients who met the inclusion criteria cited below were approached for recruitment. From these, 7 refused, two were unable to give informed consent and one passed away before completing the assessment, leaving a total of 182 (121 women and 61 men). All subjects were recruited during an 18-month period from two GDH in the Montreal metropolitan area, through their participation in rehabilitation programs at the McGill University Health Centre (MUHC) - Royal-Victoria Hospital and Notre-Dame-de-la-Merci Hospital. The Human Ethics Review Committee of the Royal Victoria Hospital approved the protocol for both hospitals and informed consent was obtained during the first

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contact with the study coordinator. Patients were seen during their first three visits to the GDH and their nutritional status and physical function were evaluated before the rehabilitation program could affect the assessments. The following variables were recorded from the patient's medical charts: age, number of prescribed medications, Mini Mental State Examination (MMSE) (14) score and serum albumin concentration.

Subjects were considered frail since they were referred to the GDH mainly for difficulties in performing their activities of daily living. Inclusion criteria comprised both genders, ability to understand the nature and requirements of the study, and having stable medical conditions. Exclusion criteria were severe cognitive deficits (MMSE < 18/30) and unstable medical conditions as assessed by a physician based on medical history and physical examination. Because of the bioimpedance electrical analysis (BIA) requirements, patients with pacemakers, metallic prostheses and edematous states were excluded.

Data collection

Anthropometric Measurements

Research dietitians at both sites conducted measurements, after having received the same training. Patients were weighed on a beam scale (Detecto Scales, Webb City, Missouri) to the nearest 100 g in light clothing after voiding. Height was measured without shoes, in the erect position when possible, to the nearest 0.1cm. Height was estimated from knee height (15) in two patients with severe kyphosis. Body Mass Index (BMI) in kg/m^2 was calculated from weight and height; body circumferences were measured with a measuring tape at the chest, mid-arm, smallest waist, umbilical waist, hip, right thigh and calf. Skinfold thickness measurements were taken, using a Lange skinfold caliper, at biceps, triceps (TST), subscapular and suprailiac sites according to standard techniques (16). The bone free or corrected arm muscle area (CAMA) was calculated (17,18). Results of anthropometric measurements were compared to the percentiles obtained from elderly American males and females (17,19,20).

Body Composition Assessment

The sum of four skinfold thickness measurements was used to estimate the % body fat according to equations developed by Durnin and Wormersley (21). From this result, fat mass and free fat mass (FFM) were calculated, based on body weight. FFM was also estimated using bioelectrical impedance analysis (BIA) with the tetra polar RJL-101A Systems instrument (RJL Systems Inc, Detroit) at fixed frequency. Resistance and reactance were measured on the dominant side in overnight fasted patients after voiding. FFM was calculated using an equation validated in healthy elderly persons (22). Skeletal muscle mass was estimated based on BIA results (23) and the muscle mass index was calculated as skeletal muscle mass /height in meters to correct for differences in stature.

Handgrip Strength

The GDH therapists measured the handgrip strength with the Jamar ® dynamometer (Model PC5030J1-Therapeutic Equipment Corporation, Clifton, NJ). Subjects were seated on a straight-backed chair without armrests. Shoulders were adducted, elbow flexed at 90 degrees, forearm in neutral position and wrist slightly extended. Three measures were taken from the dominant hand and the highest measure was recorded in kg of force.

Gait Speed

The GDH therapists measured the gait speed. Subjects were requested to walk at their usual walking speed on a flat surface for a distance of 15 meters. Time was measured with a stopwatch and speed was calculated in m/s. In order to relate nutritional status with functional capacity, the individuals who had the following conditions were not considered in the correlation analysis: patients with severe mobility impairment from neurodegenerative disease (documented stroke with hemiplegia, Parkinson's disease, and myopathy) osteoarthritis, cardio-respiratory diseases and acute rehabilitation following a limb fracture.

Composite Index of Malnutrition

Any single criterion of malnutrition is known to have low specificity and sensitivity in the elderly (8,24). For this reason, we defined our own screening tool based on criteria with cut-off values available in the literature. According to four criteria using BMI, serum albumin, TST and CAMA, three groups of subjects were defined: those without malnutrition, those with mild malnutrition and those malnourished. Cut-offs of mild malnutrition or for being malnourished are listed in Table 1. Subjects had to meet three of the four criteria (in 19 cases, it was based on 2 out of 3, because of missing data) and categories of nutrition status were mutually exclusive.

The Mini Nutritional Assessment (MNA) questionnaire

The MNA is a validated tool to assess the risk of malnutrition in the elderly (25). It includes 18 items grouped in 4 domains: 1) the anthropometric measurements, 2) the global assessment of lifestyle, medication and mobility, 3) the dietary assessment and 4) the subjective assessment of self-health and nutritional status. A score below 17 is considered as malnourished, 17-23.5, as at risk for malnutrition and ≥ 24, as well-nourished. A dietitian completed the MNA during one of the first three visits.

Statistical Analysis

Results are presented as means ± standard error of the mean (SEM). One way ANOVA was used to seek differences among the three groups, with sex and/or age as a covariate when found to have a significant relationship with the independent variable. The post-hoc multiple comparisons LSD test was used to identify pairwise differences. Pearson's correlation was

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performed to relate two variables, controlling for a third variable when needed. A statistical significance level of $p< 0.05$ was used for comparisons and correlations. Data were analyzed with SPSS version 14.0 for window (SPSS Inc, Chicago).

Results

Prevalence of Malnutrition

All results from the two GDH were comparable and therefore, they were analyzed together. Table 1 shows the proportion of patients meeting each individual criterion for defining mild malnutrition and malnourished categories. Based on the criteria, 6% of the frail elderly persons undergoing rehabilitation were malnourished and another 13% had mild malnutrition.

Table 1

Criteria and prevalence of mild and established malnutrition

		Mild malnutrition			Malnutrition		
Criteria	**N**	**Cut-off**	**N**	**%**	**Cut-off**	**N**	**%**
BMI	181	22-24 kg/m^2	29	16.0	< 22 kg/m^2	27	14.9
Albumin	162	35-38 g/L	24	14.8	< 35 g/L	18	11.1
TST	182	10-25 th perc.[1]	26	14.3	< 10thperc.[1]	28	15.4
CAMA	180	10-25th perc.[1]	43	23.9	< 10thperc.[1]	35	19.4
3 out of 4 criteria	182		24	13.2		11	6.0

BMI: body mass index; TST: triceps skinfold thickness; CAMA: corrected arm muscle area; 1. Percentile ranking according to reference (19) and (20); 2. In case of missing data, 2 out of 3 criteria were taken.

Subjects Characteristics

All subjects' characteristics are summarized in Table 2. According to the nutritional status, groups were different in age, height, weight, BMI, TST, CAMA and MMSE score (all, $p < 0.05$). Post-hoc analysis revealed that patients were older and their BMI and CAMA were lower with increasing degree of malnutrition. Malnourished patients and those with mild malnutrition had significantly lower body weight and TST than well-nourished patients and MMSE score was lower in malnourished than in well-nourished patients.

Body Composition Assessment

Results of body composition estimated by BIA and by anthropometry are presented in Table 3. All indices obtained from either method were significantly lower in malnourished patients and in those with mild malnutrition compared with the well-nourished patients. Regardless of the method, % body fat was different among the 3 groups and was lowest in malnourished patients ($p < 0.001$).

Level of Physical Function according to Nutritional Status

Table 4 presents results of physical function tests according to nutritional status. Using the composite index, handgrip strength was reduced with the severity of malnutrition ($p = 0.034$) whereas gait speed did not differ among groups ($p = 0.803$). When patients were categorized according to the MNA score, handgrip strength was no longer significantly different among the 3 groups. In contrast, the gait speed of malnourished patients and those with mild malnutrition was lower than that of well-nourished patients ($p = 0.031$).

Table 2

Subjects' characteristics according to nutritional status

	Well-nourished	**Mild malnutrition**	**Malnutrition**	**p-value**
n	147	24	11	-
Gender ratio(W/M)	97/50	17/7	7/4	-
Age (yr)	78.1 ± 0.6	82.2 ± 1.6*	85.9 ± 1.5**	< 0.001
Height (m)	1.60 ± 0.01	1.56 ± 0.02*	1.61 ± 0.03	0.023
Weight (kg)	72.2 ± 1.1	52.7 ± 1.8*	46.4 ± 2.1*	< 0.001
BMI (kg/m^2)	28.2 ± 0.4	21.6 ± 0.5*	17.9 ± 0.6**	< 0.001
TST (cm)	23.6 ± 0.7	13.0 ± 1.0*	11.0 ± 1.4*	< 0.001
CAMA (cm^2)	35.8 ± 0.9	26.6 ± 1.0*	17.1 ± 1.2**	< 0.001
Serum albumin (g/L)	39.6 ± 0.3	38.2 ± 0.8	37.8 ± 1.6	0.102
Medications[1]	6.6 ± 0.3	5.4 ± 0.5	5.3 ± 0.8	0.124
MMSE score	26.0 ± 0.3	24.8 ± 1.0	22.8 ± 2.6*	0.049

Data are presented as mean ± SEM. P-value from One way ANOVA with sex as covariate for height, weight and TST; BMI: body mass index; TST: triceps skinfold thickness; CAMA: corrected arm muscle area; MMSE: Mini-Mental State Exam; 1. Number of different prescribed medications, not including vitamins and minerals; * Different from well-nourished patients; ** different from well-nourished and patients at risk of malnutrition, $p < 0.05$ by LSD post-hoc test

Table 3

Body composition according to the degree of malnutrition

	Well-nourished	**Mild malnutrition**	**Malnutrition**	**p-value**
From BIA				
Lean body mass (kg)[1]	43.2 ± 0.7	36.9 ± 1.6*	35.5 ± 2.2*	< 0.001
Fat mass (kg)	29.0 ± 0.7	16.1 ± 0.9*	11.0 ± 0.6*	< 0.001
% body fat	39.8 ± 0.7	30.5 ± 1.6*	23.9 ± 1.4**	< 0.001
Muscle mass (kg)[2]	20.9 ± 0.5	17.3 ± 1.2*	16.5 ± 1.7*	0.005
Muscle mass index (kg/m)	12.9 ± 0.3	11.0 ± 0.7*	10.2 ± 0.9*	0.003
From anthropometry				
Lean body mass (kg)[3]	45.3 ± 0.7	38.6 ± 1.9*	36.1 ± 1.9*	< 0.001
Fat mass (kg)	26.9 ± 0.7	14.1 ± 0.7*	10.3 ± 0.6*	< 0.001
% body fat	36.9 ± 0.5	27.2 ± 1.4*	22.5 ± 1.3**	< 0.001
Waist circumference (cm)	93.1 ± 1.0	76.9 ± 1.6*	69.6 ± 2.0*	< 0.001

Data are presented as mean ± SEM. P-value from One way ANOVA with sex as covariate; 1. Estimated using equation from reference (22); 2. Estimated using equation from reference (23); 3. Estimated from the sum of 4 skinfold thickness according to reference (21); Different from well-nourished patients; ** different from well-nourished and patients at risk of malnutrition, $p < 0.05$ by LSD post-hoc test

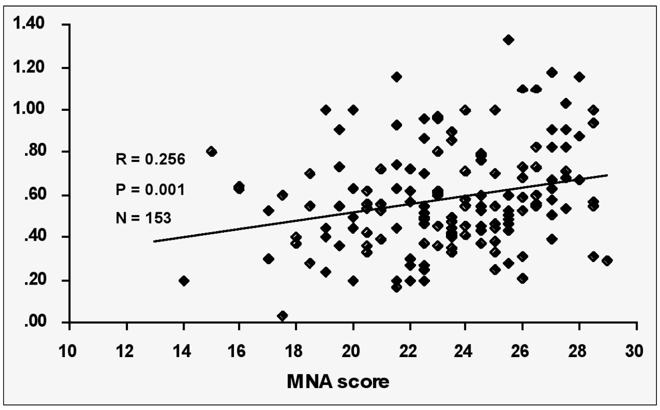
Several significant correlations between measures of physical function and body composition indices were found. Including data from all individuals, handgrip strength correlated with lean body mass (LBM; $r = 0.65$, $p< 0.001$), but less so when controlling for gender ($r = 0.34$, $p < 0.001$), indicating that gender has an important effect. It was negatively correlated with age ($r = - 0.35$, $p < 0.001$). It correlated with muscle mass (r = 0.65, p < 0.001), muscle mass index (r = 0.62, p < 0.001) and with gait speed after excluding individuals with impeding conditions mentioned in the methods (r = 0.39, p < 0.001). Gait speed was negatively correlated with adiposity, as % body fat (r = - 0.23, p = 0.005) and BMI (r = - 0.21, p = 0.008), and with the number of prescribed medications (r = - 0.26, p = 0. 008). In addition, as shown in Figure 1, MNA score correlated positively with gait speed (r = 0.26, p = 0.001), even after controlling for gender (r = 0.24, p = 0.02).

Table 4
Functional tests according to nutritional status by the composite index and MNA

	Composite Index			
	Well-nourished	Mild malnutrition	Malnutrition	p-value
Handgrip strength (kg)[1]	18.6±0.8	16.4±1.9	13.5±1.8	0.034
n	105	18	10	
Gait speed (m/s)	0.59±0.02	0.56±0.06	0.55±0.07	0.803
n	126	20	10	
	MNA			
	Well-nourished	**At risk of malnutrition**	**Malnutrition**	**p-value**
n (%)	78 (44.1)	93 (52.5)	6 (3.4)	
Handgrip strength (kg)[1]	18.6±1.0	17.1±1.0	15.1±4.2	0.190
n	62	65	3	
Gait speed (m/s)	0.64±0.03	0.53±0.03*	0.56±0.13	0.031
n	71	78	4	

Data are presented as mean ±SEM. P-value from One way ANOVA; 1. Highest of 3 measurements taken from the dominant side; * Different from well-nourished patients, p < 0.05 by LSD post-hoc test

Figure
Correlation of gait speed after excluding individuals with conditions mentioned in the methods with MNA score



Discussion

The main objectives of this study were to assess the nutritional status of frail elders participating in GDH and to determine to what extent their nutritional status would impact on their physical performance. The nutritional status was evaluated by a composite index of common nutritional parameters because none alone is sensitive and specific enough (8,24) and by the MNA (25). According to the composite index, 6% of subjects were malnourished and 13.2 % had mild degree of malnutrition, whereas using the MNA, 3.4 and 53%, were malnourished or at risks of malnutrition, respectively. Using the composite index, these percentages were lower than those reported in homebound elderly (9) and from those in some (6,10,11) but not all of the subacute in-patient geriatric rehabilitation units (6,10-12). The prevalence of established malnutrition or risk of is also lower than in the only published study involving GDH patients (13). This discrepancy is likely due to difference in the health state and functional capacity of the individuals attending these rehabilitation programs and the variable criteria used. We retained cut-offs for the criteria used to determine the nutritional status, based on published data. However, uncertainty remains regarding the limit of detection of these criteria that could affect ascertainment of malnutrition. Nonetheless, in the study conducted on homebound elderly persons in a nearby area of our province, 33% were considered malnourished based on a single criterion of a BMI < 24 kg/m^2 (9), whereas we would have identified 30.9% in the present study (Table 1) with this criterion. In subacute rehabilitation settings, Neumann et al. found that 17% of the patients had a BMI < 22 kg/m^2 and 20% a CAMA below their reference values (12), remarkably close to those of our ambulatory population of 14.9% and 19.4%, respectively. Using a composite index, comprising MNA score, BMI and CAMA, these authors found a prevalence of malnutrition of 10%, which is only slightly above our prevalence of 6.7%. However, in another subacute rehabilitation study, Thomas et al reported that 36% of the patients had a BMI < 22 kg/m^2 and 67% had a serum albumin < 35 g/L (11), whereas in our ambulatory population the proportion of patients below these cut-offs was 14.9 and 11.1%, respectively. In assessing the type of population admitted to these two subacute rehabilitation hospitals, it emerges that there was more patients convalescing from infectious episodes in the study by Thomas et al, a condition known to promote rapid weight loss and decrease serum albumin elicited by the inflammatory state (26). Therefore, the closer percentage of malnutrition found in our study with that in Newman et al (12) might be related to the fact that none of our patients had recent infections or surgical interventions.

In the study involving GDH patients (13), 15-50% of the elderly were below the 5th percentile (determined from a healthy elderly population) for weight, TST, arm muscle circumference, serum albumin (<37 g/L) and pre-albumin. In our nutritional assessment (Table 1), 15% of patients were below the 10th percentile for TST, whereas Morgan et al found 50% of patients (13). However, when using the albumin cut-off of < 38 g/L, 26% of our patients were hypoalbuminemic,

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which is similar to their 20% when using albumin < 37 g/L (13). Therefore, the general prevalence of malnutrition in our population was on average less compared with the study by Morgan et al. The cause of this difference is not obvious, as both study populations were of comparable age but other demographic data, such as number of medications, cognitive and physical function are missing to allow a full comprehensive comparison between the two studies.

We also employed the MNA to evaluate the nutritional status of our patients. When comparing both assessment methods, MNA tends to under diagnose malnutrition compared with the composite index: 3.4 vs. 6%. It classifies patients at risk of malnutrition significantly more than our composite index would for mild malnutrition: 52.5 vs. 13.2%. The obvious reason for this is that milder cases of malnutrition were not ascertained by our more stringent criteria of malnutrition using measurable parameters. MNA has been reported to have an excellent positive predictive value for malnutrition of 97% (27) and can identify those at risk for malnutrition compared with a comprehensive nutritional assessment (28). In subacute rehabilitation, prevalence of malnutrition and risk of malnutrition using the MNA were found to be 29% and 63%, respectively in (11) and 32% and 55% in (6). The prevalence of malnutrition defined by the authors as a MNA score < 24 was found to be 53% in another subacute rehabilitation study (12). Again, as with the individual parameters discussed above, the MNA results of our study were similar to this latter study (12), whose population is likely to be also more comparable to ours. This implies that, as the timing of acute illness becomes more remote, the higher are the chances of improved nutritional status, but the risk of developing malnutrition remains present in this category of frail patients.

Using the composite index, we found that malnutrition was associated with increased age and poorer cognitive performance ($p < 0.05$), confirming the findings of others (7,8). Low serum albumin is a classical criterion for diagnosing malnutrition that we used, but there were no significant differences in albumin among the groups, although a decreasing trend was seen from the well-nourished to the malnourished category. This finding is consistent with the non-specificity of albumin as a single independent predictor of malnutrition, which can at times show discordant results with the nutritional status in older patients (29), supporting a screening tool including multiple measurable parameters to ascertain the nutritional status. Not surprisingly, being malnourished or at risk of malnutrition was associated with lower LBM, muscle mass and muscle mass index ($p \leq 0.003$). Among the factors contributing to reduced muscle mass with aging, undernutrition is recognized as being an important one (30,31). However, in frail elders, hormones, growth factors and pro-inflammatory cytokines could also play a role (32-34), as well the level of physical activity (35,36). We did not assess any of these factors but there is a reason to infer that both the well-nourished as well as the malnourished patients had similar limited levels of physical activity and were otherwise in stable medical condition, poor nutrition is likely responsible for lower LBM and muscle mass in the malnourished ones.

It is well recognized that LBM, of which 40-50% is skeletal muscle (37), is linked to muscle strength (3,4,31,38). LBM correlated with handgrip strength but not with gait speed in our population of frail elders. Similar findings were noted in the study of Payette et al (3) since handgrip strength assessed with the Jamar dynamometer correlated with FFM but not with the Timed up and Go test in their group of frail elderly women. At least two reasons are responsible for the discrepancy between the two tests: adiposity and a "floor effect" of the gait speed test. At high BMI (>29 kg/m2), the gait performance is reduced due to the excess of weight (39,40). Our results are consistent with this finding, as gait speed correlated negatively with % body fat ($r = -0.23$, $p = 0.005$) and BMI ($r = -0.21$, $p = 0.008$). Furthermore, 25% of our well-nourished subjects had a BMI >29 kg/m2 perhaps masking the differences of the impact of lower LBM in gait speed between the different nutritional states. Moreover, gait speed requires more than muscle power, since neuromuscular control is also essential for balance (41). Normal gait speed in elderly persons is approximately 1 - 1.2 m/s (42) and values of 0.4 m/s are associated with significant disability (41). In our population and after excluding those subjects in who gait would be impaired by other causes than lower extremity strength, an average gait speed of 0.55 and 0.60 m/s were found for women and men, respectively. It is likely that at gait speed values of 0.5 – 0.6 m/s, we observed a "floor effect", where it becomes very difficult to discriminate between the different factors contributing to a reduced gait speed, including the effects of nutrition. Nonetheless, the MNA showed a significant correlation of $r = 0.26$ with gait speed. The most likely explanation for this it that the MNA includes questions about functional status, such as mobility and number of medications (25) that were not considered in our index of malnutrition.

There was a significant effect of the nutritional status on handgrip strength ($p = 0.034$) but when age and sex were considered as covariates, this effect was no longer significant, suggesting a dominant effect of reduced LBM and muscle mass. Indeed, our own results showed that handgrip strength was closely related to lean tissue ($r = 0.65$, $p < 0.001$) and is reduced with age ($r = -0.35$, $p < 0.001$). The relationship between handgrip strength and LBM is still significant but is weakened when corrected for sex, meaning that gender differences other than LBM also have important effects on handgrip strength. However, caution is required when interpreting the effect of the covariates on handgrip strength as the number of patients considered malnourished was low (11, 7 women), which could affect the weight of the correction and possibly, masking the effect of malnutrition on handgrip strength. Based on the above, we felt justified to present the results of Table 4 on handgrip strength without further corrections for these two covariates.

Conclusions

This study provided evidence that 1) despite a low degree of established malnutrition, there is a high prevalence of patients at risk or with mild malnutrition among frail elderly persons participating in GDH rehabilitation programs that are similar to those of subacute rehabilitation setting, 2) compared to those who are well-nourished, malnourished patients and those at risk of malnutrition have lower LBM and muscle mass, and 3) based on the correlation between the nutritional status with handgrip strength and the MNA score with gait speed, it appears that there is a significant effect of the nutritional status on physical performance. Thus, emphasis should be made in screening for malnutrition in this setting, as an effective nutritional intervention is likely to be of benefit in improving their physical function and help in attaining the rehabilitation goals.

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