A Comparative Study of Well-Nourished and Malnutrition-Risk Older People Living in Nursing Home: Vitamin D Status and Physical Function Parameters

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Article

A Comparative Study of Well-Nourished and Malnutrition-Risk Older People Living in Nursing Home: Vitamin D Status and Physical Function Parameters

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Abstract: This study aims to investigate the Vit D status, physical function parameters and analyze their correlation in older nursing home residents with malnutrition risk and malnutrition. Methods: This study was a cross-sectional study and recruited 152 older residents from multiple nursing homes and divided into well-nourished (n=34), malnutrition risk (n=102) and malnutrition (n=16) groups. The nutrition status was evaluated by mini nutritional assessment short form (MNA-SF), then anthropometric data, biochemical blood test and physical function parameters were evaluated and compared among groups. Compared with well-nourished group, BW (body weight), BMI (body mass index), ASMI (appendicular skeletal muscle index) and calf circumference were significantly lower in the malnutrition risk and malnutrition groups. The malnutrition risk and malnutrition groups also represented the significantly higher SOF (study of osteoporotic fractures) score than that of well-nourished group. Three groups showed the Vit D insufficiency that means blood 25(OH)D level is less than 30ng/dL, although there is no difference among three groups. In addition, The MNA-SF was negatively correlated with BMI, ASMI and calf circumference, whereas positively correlated with SOF score. Regarding the odd ratios, when the score of MNA-SF was low, the odds ratios of low ASMI, low calf circumference, and high SOF score were significantly increased. The institutionalized older adults with malnutrition risk or malnutrition had lower ASMI and calf circumference. However, regardless of nutritional status, occurrence of Vit D insufficiency was observed, and Vit D showed no significant correlation with physical function parameters among the older adults in the nursing home.

Keywords: vitamin D status; physical function; malnutrition risk; nursing home; older people

1. Introduction

Older adults tend to have the problems of nutrient deficiencies, because aging may contribute to the eating issue, decreased ability of digestion and absorption, chronic diseases and physical impairments [1]. According to the data announced by World Health Organization (WHO), the prevalence of malnutrition in older people ranges from 1.3% to 47.8% [2]. A systematic review also

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showed that the prevalence of malnutrition and at risk of malnutrition were 11.7-60% and 21-60% in older people, respectively [3] In the US, the prevalence of malnutrition was 1~15% in older persons who lived in the community, but that increased to 25~85% among those in nursing homes and hospitals [4]. Nevertheless, the Nutrition and Health Survey in Taiwan in 2013-2016 reported that approximately 40% of older adults had insufficient intake of energy, while 18.2% of older adults did not reach 75% of the recommended protein intake [5]. A study in Taiwan also showed that about 3.6% of community-living older adults were malnutrition, and 20.7% of nursing home residents were malnourished [6]. Those studies showed that residents in nursing homes had a higher rate of malnutrition than community-dwelling older adults.

Malnutrition is related with hypovitaminosis D which is also highly prevalent among older adults [7]. A systemic review reported that about 74% of participants over 65 years old had serum 25(OH)D level less than 30ng/mL which defined as the Vit D insufficiency [7]. Nutrition And Health Survey in Taiwan (NAHSIT) 2013-2016 reported that about 3.7% of males and 15.8% of women had serum Vit D deficiency (25(OH)D level less than 20ng/mL) and about 22.3% of males and 36.8% of women had serum Vit D insufficiency in the older people [8]. The prevalence of Vit D insufficiency in Thailand nursing home were 61.3% [9]. Vit D deficiency can be related to older age, malnutrition, obesity, sun exposure, living conditions, and illnesses [10].

It has been confirmed that Vit D status was positively correlated with muscle strength and physical performance not only in animal studies but also in clinical trials [11]. An Ireland study represented that Vit D deficiency was associated with the impaired muscle strength and physical performance including low hand grip strength and poor short physical performance battery (SPPB) (≤ 6 points) in community-dwelling older people [12]. A study finished in China also demonstrated that hand grip strength was positively related to serum 25(OH)D concentration in male adults who aged over 50 years old [13]. However, not all studies have confirmed this correlation. For example, a community-based prospective cohort study found that Vit D deficiency did not reduce muscular strength or mobility among participants [14]. Similarly, a study of elderly German individuals discovered that low serum levels of 25(OH)D were associated with adverse changes in muscle mass and physical performance but not with the incidence of sarcopenia [15]. The reasons for the inconsistent results might be due to the different dietary pattern screening tools and measurement method. To fully understand the correlation between nutrition status, Vit D status, and physical function parameters, there is a need for more local data which has the integrated evaluation.

In 2018, Taiwan officially entered an aging society, and it is predicted to become a super-aged society by 2025. However, research data related to health problems of older adults, such as malnutrition, remains limited. Thus, the purpose of this study is to investigate the vitamin D status and physical function parameters and analyze their correlation in older nursing home residents at risk of malnutrition and those experiencing malnutrition in Taiwan.

2. Materials and Methods

2.1. Study Design and Population

This study was a clustered, cross-sectional, and multicenter clinical trial that was approved by the Taipei Medical University (TMU)-Joint Institutional Review Board (ID: N202011065, 27 January 2021) and ClinicalTrials.gov Protocol Registration and Results System (NCT04857463, 20 April 2021) and conducted from November 2021 to April 2023. The older dwellers aged over 65 years were recruited from the nursing homes located in the northern area of Taiwan. The older residents were divided into three groups based on the Mini-Nutritional Assessment Short Form (MNA-SF), including well-nourished (MNA-SF=12-14), malnutrition risk (MNA-SF=8-11) and malnutrition (MNA-SF=0-7) groups [16]. The exclusion criteria were older people who has acute or chronic diseases such as hyperlipidemia, diabetes, heart disease, cancer, and chronic kidney disease etc. All subjects were informed about the aims of the study and signed a consent form based on their own wiliness.

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2.2. Anthropometric Data and Body Composition

Anthropometric measurement was performed to evaluate the participants' physical characteristics, including height, body weight (BW), body mass index (BMI) and calf circumference. Calf circumference was measured using a non-elastic tape with triple repeat. Body composition was evaluated using the Karada Scan 371 (Omron Kabushiki-Gaisha, Kyoto, Japan), including body fat mass and muscle mass in percentage of body weight. Appendicular skeletal muscle mass index (ASMI) was obtained based on the body weight, muscle mass (%) and height. The calculation formula was BW (kg) × muscle mass (%) ÷ height2 (m2).

2.3. Daily Calorie Intake

The daily calorie intake was assessed by a dietitian. Since the nursing home served identical meals to all residents, calorie intake was calculated based on the cycle menu and approximated by assessing the remaining portion of each participant's meal.

2.4. Physical Function Parameters and the SOF Index

Following the Asian Working Group for Sarcopenia (AWGS) consensus guideline, muscle strength was defined by measuring hand grip strength (HGS) with cutoffs <28kg for men and <18kg for women, determined as low HGS, and physical performance was assessed by recording the time spent of walking in a 6-meter distance, <1m/s considered as slow walking speed [17]. Thus, the muscle strength and walking speed were examined as the physical functional parameters. Using the Camry Digital hand dynamometer EH101 (Camry Scale, South El Monte, CA, USA) to measure the hand grip strength by the dominant hand.

Frailty was also assessed using the Study of Osteoporotic Fractures (SOF) Index Scoring system, which examines weight loss, inability to rise from a chair 5 times without the arms and poor energy. The risk categories are ≥2/3 criteria met indicates frailty; 1/3 indicates pre-or-intermediate frailty; 0/3 indicates non-frail [18,19].

2.5. Blood Biochemical Analysis

Fasting blood samples were collected to evaluate the participants' lipid profile, liver, and kidney function after. The ADVIA 1800® Clinical Chemistry System (Siemens Healthcare GmbH, Erlangen, Germany) was used to analyze total cholesterol (TC), triglyceride (TG), uric acid, creatinine (CRE), aspartate aminotransferase (AST), alanine aminotransferase (ALT), and albumin.

Abbott Alinity I device (Abbott Park, Illinois, USA) was used to assess the amount of 25(OH)D, a vital marker of Vit D level, utilizing the chemiluminescence immunoassay technique. In categorical analysis, Vit D status was divided into three categories: deficiency (<20 ng/mL), insufficiency (20-29 ng/mL), and sufficiency (≥30 ng/mL) group [20–22].

2.6. Statistical Analysis

Data were presented as mean and standard deviation (SD) or frequencies and percentages. Categorical variables were summarized as percentage and compared using the Fisher's exact test or Chi-Square test. Shapiro Wilk test was used to examine the normality of variables distribution. The parametric data was compared by Student's t-test, while the non-parametric data was compared by Mann-Whitney U test. Spearman's rank correlation test and multiple linear regression were employed to assess the relationships and associations among the different factors in the study. Logistic regression was used to analysis the odds ratio of parameters. The results were shown as odds ratios (ORs) with 95% confidence interval (CI). All the statistical analysis was carried out with IBM SPSS version 22.0 (IBM, Armonk, NY, USA), with a significance level established as $p<0.05$. The power value of this study was 0.99 analyzed by G*Power software version 3.1 (Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany) by setting alpha=0.05 based on the 25-(OH)D level.

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3. Results

3.1. Groups and Demographic Characteristic

A study flowchart is presented in Supplementary Figure S1. One hundred fifty-two participants were recruited in this study. Thirty-four participants were assigned to the well-nourished group, 102 participants were classified as the malnutrition risk group, and 16 participants were identified as having malnutrition based on the MNA-SF. The demographic characteristics were shown in Table 1. Most participants were categorized as malnutrition risk (67.1%) with an average age of 78.35 years. Regarding age and sex, three groups showed a similar distribution ratio.

Table 1. Baseline demographic, anthropometric assessment, dietary intakes, and blood biochemical parameters of study participants.

	all (n=152)	well-nourished (n=34)	malnutrition risk (n=102)	malnutrition (n=16)	*p* value
Age (yr)	77.81 ± 8.57	75.85 ± 8.92	78.35 ± 8.68	78.50 ± 6.80	0.218
≦75, n, %	71, 46.7	21, 61.8	44, 43.1	6, 37.5	0.125
>75, n, %	81, 53.5	13, 38.2	58, 56.9	10, 62.5	
Sex					
Male, n, %	106, 69.7	27, 79.4	71, 69.6	8, 50.0	0.107
Female, n, %	46, 30.3	7, 20.6	31, 30.4	8, 50.0	
MNA-SF	9.93 ± 1.85	12.32 ± 0.64	9.67 ± 1.07	6.56 ± 0.73	<0.001
Daily calorie intake (kcal)	1222.30 ± 68.86	1245.59 ± 48.25	1222.75 ± 71.88	1170.00 ± 60.66	0.001
Height (cm)*	162.44 ± 7.61	162.06 ± 8.79	163.00 ± 7.20	159.66 ± 7.33	
BW (kg)*	59.70 ± 11.04	67.96 ± 10.01 [a]	58.82 ± 9.73 [b]	47.79 ± 7.58 [c]	
BMI (kg/m²)	22.58 ± 3.65	25.77 ± 2.88	22.12 ± 3.19	18.73 ± 2.56	<0.001
Fat mass (%)*	27.00 ± 5.17	28.52 ± 4.97	26.59 ± 5.12	26.46 ± 5.61	
Muscle mass (%)	25.86 ± 3.19	26.64 ± 2.76	25.69 ± 3.38	25.32 ± 2.65	0.302
Low, n, %	136, 89.5	31, 91.2	91, 89.2	14, 87.5	0.915
Normal or high, n, %	16, 10.5	3, 8.8	11, 10.8	2, 12.5	
ASMI (kg/m²)*	5.84 ± 1.18	6.88 ± 1.10 [a]	5.66 ± 1.02 [b]	4.72 ± 0.68 [c]	
Low, n, %	112, 73.7	13, 38.2	84, 82.4	15, 93.8	<0.001
Normal or high, n, %	40, 26.3	21, 61.8	18, 17.6	1, 6.3	
Calf circumference (cm)*	32.73 ± 3.36	34.91 ± 2.92 [a]	32.55 ± 3.00 [b]	29.29 ± 3.31 [c]	
Low, n, %	71, 46.7	10, 29.4	57, 55.9	14, 87.5	<0.001
Normal, n, %	81, 53.3	24, 70.6	45, 44.1	2, 12.5	
Grip strength (kg)*	21.29 ± 6.47	22.27 ± 7.16	21.36 ± 6.30	18.79 ± 5.69	
Low, n, %	110, 72.4	25, 73.5	72, 70.6	13, 81.3	0.665
Normal or high, n, %	42, 27.6	9, 26.5	30, 29.4	3, 18.8	
Walking speed (m/s)*	0.79 ± 0.25	0.85 ± 0.24	0.78 ± 0.26	0.73 ± 0.19	
Low, n, %	120, 78.9	25, 73.5	79, 77.5	16, 100.0	0.082
Normal or high, n, %	32, 21.1	9, 26.5	23, 22.5	0, 0.0	
SOF	0.81 ± 0.64	0.47 ± 0.56	0.90 ± 0.64	0.94 ± 0.57	0.002

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0, n, %	48, 31.6	19, 55.9	26, 25.5	3, 18.8	0.008
1, n, %	85, 55.9	14, 41.2	60, 58.8	11, 68.8	
≧2, n, %	19, 12.5	1, 2.9	16, 15.7	2, 12.5	
TC (mg/dL)	171.37 ± 39.00	170.52 ± 36.84	172.98 ± 41.65	162.88 ± 23.49	0.805
TG (mg/dL)	120.95 ± 85.30	114.15 ± 43.82	127.87 ± 99.09	91.31 ± 39.36	0.182
Uric acid (mg/dL)	6.03 ± 1.68	6.03 ± 1.60	6.05 ± 1.63	5.85 ± 2.24	0.844
CRE (mg/dL)	1.19 ± 0.87	1.07 ± 0.39	1.11 ± 0.42	1.90 ± 2.35	0.678
AST (U/L)	27.35 ± 13.06	27.59 ± 8.62	25.92 ± 7.39	35.94 ± 33.08	0.364
ALT (U/L)	21.08 ± 18.67	22.24 ± 13.14	18.97 ± 11.33	32.13 ± 45.82	0.213
ALB (g/dL)	4.22 ± 0.32	4.32 ± 0.32	4.20 ± 0.32	4.18 ± 0.32	0.203
25(OH)D (ng/mL)*	25.52 ± 10.01	24.05 ± 9.41	25.85 ± 10.03	26.52 ± 11.42	
Sufficiency (n, %)	48, 31.6	8, 23.5	35, 34.3	5, 31.3	0.843
insufficiency (n, %)	55, 36.2	14, 41.2	35, 34.3	6, 37.5	
deficiency (n, %)	49, 32.2	12, 35.3	32, 31.4	5, 31.3	

Data were expressed as the mean ± SD. Shapiro–Wilk test was used to test determine the normality of population. Data were compared by one-way ANOVA with LSD post hoc test (*) or Kruskal-Wallis test. Different alphabets showed significant differences. The frequency between groups were compared by fisher's exact test or Chi-square test. Normal percentage of muscle mass was 32.9-35.7% in male, 25.9-27.9% in female; normal ASMI in male≧7.0 kg/m^2, female≧5.7 kg/m^2; MNA-SF 12-14 was considered as well-nourished; SOF 1 was considered as pre-frailty, ≧2 was considered as frailty; normal grip strength in male≧28 kg, female≧18 kg; normal walking speed≧1.0m/s; calf circumference >34cm in male >33cm in female was considered normal. BW, body weight; BMI, body mass index; ASMI, appendicular skeletal muscle index; SOF, study of osteoporotic fractures; MNA-SF, mini nutritional assessment short form; ALT, alanine aminotransferase; ALT, aspartate aminotransferase; TC, total cholesterol; TG, triglyceride, CRE, creatinine; ALB, albumin; 25(OH)D level, sufficiency (≧30 ng/mL), insufficiency (20.1-29.9 ng/mL), deficiency (≦20 ng/mL).

3.2. Nutritional Status and Daily Calorie Intake

The average score of MNA-SF was 9.93 which meant this population was under malnutrition risk (Table 1). When compared with well-nourished group, the MNA-SF score and daily calorie intake was significantly lower in malnutrition risk and malnutrition groups (Table 1).

3.3. Anthropometric Data and Body Composition

Malnutrition risk and malnutrition groups showed significantly lower BW, BMI, ASMI and calf circumference when compared with well-nourished group (Table 1).

3.4. Physical Functional Parameters and SOF Score

Not only hand grip strength but also 6-meter walking speed represented no difference among three groups (Table 1). However, the malnutrition risk and malnutrition groups had significantly higher SOF scores than the well-nourished group, and also a higher percentage of participants were classified as pre-frailty or frailty (Table 1).

3.5. Blood Biochemical Analysis

There is no difference among three group in all blood biochemical analysis (Table 1). However, the average level of blood 25(OH)D was 25.52 which represented the Vit D insufficiency in this population (Table 1).

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3.6. Correlation of the Parameters

As shown in Table 2, MNA-SF was positively correlated with sex (male), daily calorie intake, BW, BMI, fat mass, ASMI, calf circumference. In addition, SOF score was negatively correlated with MNA-SF, implied that better nutritional status had less risk of frailty. On the other hand, male and young age had higher ASMI, whereas higher daily calorie intake, BW, BMI, muscle mass, calf circumference, grip strength, walking speed and blood albumin level were correlated with higher AMSI.

Regrading to the correlation with grip strength, it was found that higher grip strength was correlated with sex (male), age (younger), more daily calorie intake, BW (heavier), higher muscle mass, higher calf circumference, higher walking speed, and higher blood albumin level (Table 2). Moreover, walking speed was positively correlated with daily calorie intake, BW, grip strength, muscle mass, calf circumference, and blood albumin level, whereas negatively correlated with age and SOF score (Table 2).

On the other hand, blood 25(OH)D level was positively correlated with body fat mass (%), while negatively correlated with muscle mass (%).

Table 2. The results of linear regression analysis.

	MNA-SF		ASMI		grip strength		walking speed		25(OH)D	
	r	*p* value	r	*p* value	r	*p* value	r	*p* value	r	*p* value
Sex	0.194	0.017	0.210	0.009	0.475	<0.001	0.134	0.099	-0.142	0.081
Age	-0.123	0.132	-0.254	0.002	-0.177	0.029	-0.377	<0.001	0.041	0.612
MNA-SF	-	-	0.628	<0.001	0.157	0.054	0.099	0.225	-0.032	0.696
Daily calorie intake	0.297	<0.001	0.371	<0.001	0.182	0.025	0.217	0.007	-0.057	0.482
BW	0.620	<0.001	0.719	<0.001	0.246	0.002	0.249	0.002	-0.037	0.648
BMI	0.680	<0.001	0.746	<0.001	0.086	0.293	0.102	0.210	0.011	0.893
Fat mass (%)	0.258	0.001	0.017	0.833	-0.126	0.123	-0.020	0.807	0.161	0.047
Muscle mass (%)	0.087	0.288	0.541	<0.001	0.301	<0.001	0.204	0.012	-0.267	0.001
ASMI	0.628	<0.001	-	-	0.229	0.005	0.190	0.019	-0.122	0.135
Calf circumference	0.532	<0.001	0.519	<0.001	0.322	<0.001	0.190	0.019	-0.042	0.610
Grip strength	0.157	0.054	0.229	0.005	-	-	0.308	<0.001	-0.065	0.428
walking speed	0.099	0.225	0.190	0.019	0.308	<0.001	-	-	-0.055	0.500
SOF	-0.267	0.001	-0.303	0.001	-0.048	0.559	-0.185	0.023	0.104	0.202
ALB	0.147	0.071	0.229	0.005	0.261	0.001	0.342	<0.001	-0.150	0.066

Data was analyzed by Spearman's rank correlation (n=152). MNA-SF, mini nutritional assessment short form; ASMI, appendicular skeletal muscle index; SOF, study of osteoporotic fractures; ALB, albumin.

3.7. Regression Analysis of the Parameters

As shown in Table 3, after adjusting for age and sex, it was found that participants with malnutrition risk and malnutrition had lower BMI, fat mass, ASMI, calf circumference. However, higher MNA-SF seemed to have lower SOF score, which indicated low risk of frailty.

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Table 3. Comparing different parameters with MNA-SF by multiple linear regression.

	β	*p* value	R^2
BMI	0.642	<0.001	0.442
Fat mass (%)	0.227	0.006	0.052
Muscle mass (%)	0.038	0.631	0.087
ASMI	0.544	<0.001	0.408
Calf circumference	0.455	<0.001	0.432
Grip strength	0.086	0.226	0.289
Walking speed	0.051	0.505	0.182
SOF	-0.220	0.008	0.046
ALB	0.114	0.148	0.126
25(OH)D	-0.017	0.843	0.000

Data was analyzed by multiple linear regression and was adjusted for age and sex (n=152). BMI, body mass index; ASMI, appendicular skeletal muscle index; SOF, study of osteoporotic fractures; MNA-SF, mini nutritional assessment short form; ALB, albumin.

3.8. Odds Ratio

3.8.1. MNA-SF

As shown in Table 4, the older age, low ASMI and calf circumference represented the higher risk of malnutrition. Based on the category of the SOF score, participants with malnutrition risk and malnutrition had high risk for pre-frailty and frailty. After adjusting sex and age, the similar results were obtained.

Table 4. Crude and adjusted odd ratios (ORs) (95% confidence intervals (CIs)) of variables related to MNA-SF in old nursing home residents.

	Crude			Adjusted		
	OR	CI	*p* value	OR	CI	*p* value
Sex						
Female	1			-		
Male	0.525	0.210-1.312	0.168	-		
Age						
≦75	1					
>75	2.197	1.005-4.803	0.049			
ASMI						
Normal	1			1		
Low	8.417	3.604-19.657	<0.001	12.248	4.542-33.026	<0.001
Calf circumference						
Normal	1			1		
Low	3.626	1.589-8.270	0.002	3.035	1.261-7.306	0.013
Grip strength						
Normal	1			1		
Low	0.927	0.392-2.194	0.927	0.783	0.304-2.014	0.612
Walking speed						
Normal	1			1		
Slow	1.487	0.612-3.612	0.381	1.169	0.465-2.942	0.740
SOF score						
0	1			1		
1	3.323	1.472-7.501	0.004	3.187	1.382-7.347	0.007
≧2	11.793	1.451-95.835	0.021	10.934	1.324-90.318	0.026
25(OH)D						
Sufficiency	1			1		

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Insufficiency	0.586	0.222-1.548	0.586	0.555	0.206-1.491	0.243
Deficiency	0.343	0.227-1.676	0.343	0.706	0.254-1.960	0.504

Data was analyzed by logistic regression, and was adjusted for age and sex (n=152). ASMI, appendicular skeletal muscle index; SOF, study of osteoporotic fractures; MNA-SF, mini nutritional assessment short form. Normal ASMI in male≧7.0 kg/m², female≧5.7 kg/m²; MNA-SF 12-14 was considered as well-nourished; SOF 1 was considered as pre-frailty, ≧2 was considered as frailty; normal grip strength in male≧28 kg, female≧18 kg; normal walking speed≧1.0m/s; calf circumference >34cm in male >33cm in female was considered normal. BW, body weight; BMI, body mass index; ASMI, appendicular skeletal muscle index; SOF, study of osteoporotic fractures; MNA-SF, mini nutritional assessment short form.

3.8.2. Grip Strength

Male and the older people aged more than 75 years old had higher risk of low hand grip strength (Supplementary Table S1). After adjusting sex and age, no significant odd ratio was observed.

3.8.3. Vit D Status

The Vit D status didn't show any significant change in the odd ratios of malnutrition, low ASMI, low calf circumference, low grip strength, slow walking speed and frailty (Table 5).

Table 5. Crude and adjusted odd ratios (ORs) (95% confidence intervals (CIs)) of variables related to Vit D status in old nursing home residents.

	Crude			Adjusted		
	OR	CI	*p* value	OR	CI	*p* value
Sex						
Female	1					
Male	1.148	0.683-2.944	0.348			
Age						
≦75	1					
>75	0.742	0.372-1.481	0.398			
MNA-SF						
Normal	1			1		
Low	0.600	0.249-1.446	0.255	0.613	0.251-1.499	0.284
ASMI						
Normal	1			1		
Low	0.543	0.235-1.256	0.154	0.469	0.195-1.131	0.092
Calf circumference						
Normal	1			1		
Low	1.073	0.541-2.129	0.840	1.211	0.573-2.562	0.616
Grip strength						
Normal	1			1		
Low	0.822	0.377-1.792	0.622	0.717	0.308-1.670	0.441
Walking speed						
Normal	1			1		
Slow	1.175	0.514-2.684	0.702	1.245	0.529-2.932	0.616
SOF						
0	1			1		
1	0.468	0.210-1.045	0.064	0.486	0.216-1.092	0.081
≧2	1.115	0.306-4.059	0.869	1.154	0.313-4.255	0.830

Data was analyzed by logistic regression, and was adjusted for age and sex (n=152). The vitamin D status was grouped by sufficiency (≧30 ng/mL) and insufficiency or deficiency (≦29.9 ng/mL). ASMI, appendicular skeletal muscle index; SOF, study of osteoporotic fractures; MNA-SF, mini nutritional assessment short form. Normal ASMI in male≧7.0 kg/m², female≧5.7 kg/m²; MNA-SF 12-14 was considered as well-nourished; SOF 1 was

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considered as pre-frailty, ≧2 was considered as frailty; normal grip strength in male≧28 kg, female≧18 kg; normal walking speed≧1.0m/s; calf circumference >34cm in male >33cm in female was considered normal. BW, body weight; BMI, body mass index; ASMI, appendicular skeletal muscle index; SOF, study of osteoporotic fractures; MNA-SF, mini nutritional assessment short form.

4. Discussion

4.1. Malnutrition and Reduced Physical Function

Based on MNA-SF, the participants recruited in this study exhibited the risk of malnutrition. This result demonstrated the issue of nutritional care in nursing home (Table 1). In this population, over fifty percent exhibit characteristics such as low muscle mass (89.5%), weak grip strength (72.4%), slow walking speed (78.9%) and high risk of frailty (SOF≧1, 68.4%) (Table 1). The primary nutritional issues among nursing home residents are weight loss and associated protein-energy malnutrition, which lead to malnutrition and reduced physical function [23]. On the other hand, research indicated that older adults residing in assisted living facilities participated in minimal physical activity, with exercise being particularly scarce [24]. The similar occurrences were observed in Taiwanese nursing homes, despite this study being based on a small sample size. Therefore, a large-scale epidemiological survey on nutritional status among elderly residents in nursing homes is necessary in Taiwan.

4.2. The Correlation of Malnutrition, Anthropometric Data, and Physical Function Parameters

Regrading to the correlation analysis, MNA-SF was correlated to daily calorie intake, BW, BMI, fat mass, calf circumference, ASMI and frailty (Table 2). The similar results were obtained based on the multiple liner regression (Table 3). Previous research has shown that malnutrition leads to reduced body weight, calf circumference, fat mass, and appendicular skeletal muscle mass index (ASMI), while also increasing the risk of frailty [25–27]. In addition, ASMI was positively correlated to daily calorie intake muscle mass, calf circumference, grip strength, walking speed, while negatively correlated with SOF index (Table 2). A study of residents in Turkish nursing home had reported that malnutrition, defined by MNA-SF, was associated with lower appendicular muscle mass and sarcopenia [28]. Another study in China nursing home also had showed that normal nutritional status residents had higher skeletal muscle index than residents with malnutrition risk or malnourished [29]. Declines in muscle mass and strength were expected with aging, while adequate calorie intake might be the reason for maintaining the well status of muscle mass and physical function [30,31]. Nevertheless, we only recorded the total calories intake from the menu provided by nursing home, the intake of protein, carbohydrate and fat should be calculated in future study. Furthermore, it is important to analyze dietary intake to investigate the relationship between nutrients and physical function.

4.3. Malnutrition, Vit D Status and Physical Function Parameters

The average blood 25(OH)D level was 25.52 (ng/mL) which illustrated Vit D insufficient status in this population, although Vit D status had no correlation with nutritional status and physical function parameters (Table 1-3). In the Nutrition and Health Survey in Taiwan (NAHSIT) 2017-2020 had reported the prevalence of Vit D deficiency in the older people was 19.8%, and the insufficient prevalence was 55.8% [32]. Another study reported the prevalence of Vit D deficiency 33.6%, and 50.5% for insufficiency about community-dwelling older adults living in northern Taiwan [13]. It might be due to the lifestyle, sun exposure time, living environment [32]. Regular exercise could be incorporated into the nursing home activities, and dietary plans designed by dietitians could contribute to maintaining adequate vitamin D levels.

Previous studies conducted that Vit D deficiency or Vit D receptor (VDR) knockout animal had abnormalities in skeletal muscle and secondary metabolic changes [33–36]. although animal studies have clearly defined roles and plausible mechanisms regarding the influence of vitamin D on muscle

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health, its effects in humans are still a matter of debate due to inconsistent clinical findings [37,38]. Chuang et al. indicated that the factors linked with vitamin D insufficiency in Taiwan included higher education, higher BMI, and lower consumption of fish and milk [39]. However, there was no dose-effect relationship observed between vitamin D levels and physical performance in Chuang's study [39]. Previous research also has indicated comparable inconsistencies regarding the correlation between serum vitamin D levels and muscle strength [14,40]. It has been proposed that variations between studies could stem from a failure to consider confounding variables. Thus, vitamin D alone cannot be a reliable predictor of low muscle strength in the older population, other parameters such as nutritional status, and physical performance should be added into consideration. This study also highlights the importance of considering vitamin D and functional parameters when evaluating the nutritional status of elderly individuals in nursing homes.

Unintentionally, blood 25(OH)D level was positively correlated with fat mass and negatively correlated with muscle mass (Table 2). Jonasson et al. confirmed that lower level of 25(OH)D was associated with higher BMI and waist circumference, as well as increased fat accumulation in body compartments [41]. A cross-sectional analysis involving 271 healthy elderly individuals living in the community has found that lower vitamin D levels correlate with higher fat mass and increased visceral adipose tissue [42]. Several observational studies, including both cross-sectional and longitudinal analyses, have shown an association between lower vitamin D status and higher body weight and fat mass [43,44]. Some hypotheses suggest that Vit D may play a role in regulating body weight through its effects on calcium metabolism, appetite regulation, and adipogenesis [45]. However, studies examining blood 25(OH)D level and body composition have primarily focused on overweight and obese individuals, with limited data available for nonobese individuals, including those who are underweight. It's essential to note that correlation does not necessarily imply causation, and further research is needed to understand the precise mechanisms in the case of low BMI or underweight.

4.4. Blood Albumin Level, ASMI, and Physical Function Parameters

Blood albumin levels remained within the normal range in three groups (Table 1). In addition, it was found that ASMI, grip strength and walking speed were positively correlated with blood albumin level (Table 2). The previous research has indicated that albumin levels decline with age, with older adults experiencing more significant decreases in albumin levels [46,47]. In addition, a meta-analysis conducted by Cabrerizo et al. and a cohort study led by Kitamura et al. revealed correlations between albumin levels and physical activity, activities of daily living (ADLs), and muscle mass [46,48]. Therefore, nutrient intake, particularly protein, and physical activity levels should be closely monitored in elderly individuals residing in nursing homes.

4.5. Strengths and Limitations

The study highlighted the prevalence of malnutrition, impaired physical function, and vitamin D inadequacy among elderly residents in nursing homes. The findings also underscore the strong correlation between nutritional status, body composition, and measures of physical function. This study also concluded that vitamin D alone does not solely determine functional performance in older adults.

There are still some limitations in this study. First, the sample size is small even multiple centers were included. Second, there might be accuracy issues with the portable equipment used for anthropometric measurements. Third, this study lacks the data on sun exposure and parathyroid hormone levels.

5. Conclusions

In this study, it was found that malnutrition risk and malnutrition defined by MNA-SF were correlated with low BW, BMI, calf circumference, and frailty. However, this study did not establish

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a clear association between blood 25(OH)D levels and functional parameters, including grip strength and walking speed. Thus, these findings suggest that besides Vit D insufficiency or deficiency, other factors may also contribute to the reduced physical function resulting from malnutrition in older nursing home residents.

Supplementary Materials: The following supporting information can be downloaded at the website of this paper posted on Preprints.org, Figure S1: Study flow chart; Table S1: Crude and adjusted odd ratios (ORs) (95% confidence intervals (CIs)) of variables related to grip strength in old nursing home residents.

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Institutional Review Board Statement: In this section, you should add the Institutional Review Board Statement and approval number, if relevant to your study. You might choose to exclude this statement if the study did not require ethical approval. Please note that the Editorial Office might ask you for further information. Please add "The study was conducted in accordance with the Declaration of Helsinki, and approved by the Institutional Review Board (or Ethics Committee) of NAME OF INSTITUTE (protocol code XXX and date of approval)." for studies involving humans. OR "The animal study protocol was approved by the Institutional Review Board (or Ethics Committee) of NAME OF INSTITUTE (protocol code XXX and date of approval)." for studies involving animals. OR "Ethical review and approval were waived for this study due to REASON (please provide a detailed justification)." OR "Not applicable" for studies not involving humans or animals.

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Abbreviations

The following abbreviations are used in this manuscript:

ALT	Alanine aminotransferase
ASMI	Appendicular skeletal muscle index
AWGS	Asian Working Group for Sarcopenia
AST	Aspartate aminotransferase
BMI	Body mass index
BW	Body weight
CI	Confidence interval
MNA-SF	Mini nutritional assessment short form
NAHSIT	Nutrition and Health Survey in Taiwan
ORs	Odds ratios
SPPB	Short physical performance battery
SOF	Study of osteoporotic fractures
TC	Total cholesterol

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TG	Triglyceride
CRE	Uric acid, creatinine
WHO	World Health Organization

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