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Effect of Dietary Pattern on Grip Strength in Middle Aged and Elderly People in Zhang Fang Village in Beijing

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Abstract **Objective** To investigate the effect of the dietary pattern on the grip in middle aged and elderly people in Zhang Fang village, Fang Shan District, Beijing. **Methods** Totally 134 middle aged and elderly villagers were selected randomly. We investigated the villagers about the diet intake, and the life habit, measured the parameters of anthropometry and their grip strength. According to the grip strength, the subjects were divided into grip reaching the standards group(GRS group) and grip not reaching the standards group(GNRS group). According to the median of proportion of protein intake, the subjects were divided into low proportion of protein intake group(LPPI group) and high proportion of protein intake group(HPPI group). We analyzed the differences between these groups, then used Logistic regression to analyze the indexes which can influence the grip strength. **Results** The grip strength of both hands reached the standards in 20 males (44.4%), in 55 females(61.8%). There were 75 cases in GRS group, 59 in GNRS group. There was significant difference in age, free fat mass (FFM), waist-hip ratio(WHR), arm muscle circumference (AMC), exercise conditions, intakes of carbohydrates, the intake of protein and fat between two groups. By logistic regression analysis, female, the high AMC and FFM, and high proportion of protein intake were protective factors of grip strength. In HPPI group, the intake of egg, beans, meat, fish, nut and total energy were significantly higher than the LPPI group. **Conclusion** In Zhang Fang Village, the dietary pattern is unbalanced. The low protein intake effects their grip strength. The low grip strength is associated with the low protein food, such as egg, bean, meat, fish, nut and low total energy.

Keywords: *grip strength, dietary pattern, protein intake, middle aged and elderly people*

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1. Introduction

Grip strength test is a simple, easy and repeatable method [1,2], which not only can assess of nutritional status of patients and healthy people, but also can predict the prognosis of the disease, quality of life, infection and other complications which can influence the length of life [3,4,5]. In many existing diagnostic criteria of malnutrition, grip strength is a main reference [3,6]. The grip strength can be influenced by many factors, such as age [4], gender [7], exercise [8], etc. Nutritional intervention in malnourished patients can improve the grip strength and the quality of life [9,10,11,12,13]. There was few research on the following aspects, such as which nutrient can do the greatest impact on the grip, which dietary pattern can improve the grip [14]. The aim of our research was to explore the dietary pattern and nutrient intake which can influence the grip strength in middle aged and elderly people in this village, and to provide a basis to improve the health status for the rural residents.

2. Subjects and Methods

2.1. Participants

The department of nutrition in Beijing Friendship Hospital provided a free clinics for the rural residents in Zhang Fang Village, Fang Shan District in July 2011. The village committee arranged before. 150 villagers took part in our free clinics. We measured the anthropology index (including height, weight, waist line, hip line, upper arm circumference, triceps skinfold thickness and body fat) and the bilateral grip strength, recorded the living habits (including smoking, drinking, sleeping, and exercise). Then we investigated the rural resident's nutritional intake by 24h dietary recall methods. The inclusion and exclusion criteria were as follows: age of >45 y and <90 y, had no serious liver or kidney illness, had no hemiplegia, had no osteoarticular disease, had no upper limb disability, had no cognitive impairment, the dominant hand is right. According to the inclusion criteria above, 134 villagers were selected as the research subjects. The study was

approved by the ethical committee of Beijing Friendship Hospital of Capital Medical University. And the participants had all written the informed consent.

2.2. The Standard of Grip Strength Test

The method of grip strength test: using electronic dynamometer (Model:EH101, produced by Shuqi group limited company by Xiangshan, Guangdong) to measure the grip strength of the subjects. Subject stand, feet separate, and the pointer of dynamometer point to the outside. According to the palm size, we regulate the second joint of the index finger to approximate right angle and then measure the grip strength. Dynamometer try not to touch the body or clothes. Try to remain motionless state to determine. Record the left and right hand grip strength. Require the subjects to use their own greatest strength. The grip strength unit is calculated by kilogram. The grip strength standards is related to age and gender, and the standards refer to instrument.(Data comes from the research report from technology center of Xiangshan Hengqi in Zhongshan City). The standard detail is shown in Table 1. According to grip strength, the subjects were divided into two groups, grip reaching the standards group(GRS group) and grip not reaching the standards group(GNRS group). The subjects who both two hands all reach the standard were classified into the GRS group, and the subjects who only one hand reach the standard or both two hands all not reach the standard were classified into the GNRS group.

Table 1. The grip level progression table about male and female in different ages

Age	Male			Female		
	weak	medium	strong	weak	medium	strong
40-44	<35.5	35.5-55.3	>55.3	<18.9	18.9-32.7	>32.7
45-49	<34.7	34.7-54.5	>54.5	<18.6	18.6-32.4	>32.4
50-54	<32.9	32.9-50.7	>50.7	<18.1	18.1-31.9	>31.9
55-59	<30.7	30.7-48.5	>48.5	<17.7	17.7-31.5	>31.5
60-64	<30.2	30.2-48.0	>48.0	<17.2	17.2-31.0	>31.0
65-69	<28.2	28.2-44.0	>44.0	<15.4	15.4-27.2	>27.2
70-99	<21.3	21.3-35.1	>35.1	<14.7	14.7-24.5	>24.5

Note: The grip level of medium and strong record reached the standard.

2.3. Measurement

Body weight was measured while the subjects were wearing light clothing and no shoes. Height without shoes was measured by using a stadiometer. And body mass index (BMI) was calculated as weight divided by the square of height. We used a tape to measure the waist girth as the narrowest circumference between the bottom of the rib cage and the iliac crest, the hip girth as the widest circumference, and the biceps circumference as the fullest upper arm circumference. The waistline hipline rate (WHR) was calculated as waistline divided by the hipline. We used skinfold instrument to measure triceps skinfold thickness. The arm muscle circumference was calculated as upper arm circumference minus 3.14 times the triceps skinfold. We used portable bioelectrical impedance analyzer (Jas technology trade co., LTD, Japan) to measure the body fat. The subjects, with arms straight and body axis was 90 degrees, hold the two sides of the electrode with both hands forefinger and thumb force, then read and recorded the data after 15 seconds. The free fat mass (FFM) was calculated as weight divided by the 1 minus body fat. The FFM represents the actual body weight removal of body fat, include muscle, bone and other lean body weight.

2.4. Living Habits

(1) Activity: record the daily activity time in hour. Daily activity time more than 2 hours was recorded as more activity, and the time less than 2 hours was recorded as less activity.

(2) Sleeping: record the daily sleeping time in hour. Daily sleeping time more than 6 hours was recorded as good, and the time less than 6 hours was recorded as bad.

(3) Smoking: record smoking or not, and the smoking number per day.

(4) Drinking: record drinking or not, and the capacity for liquor.

2.4. Dietary Survey Method

Using 24-hour dietary retrospective method. 24-hour generally refer to 24 hours from the last meal to eat began to push forward for 24 hours. Select continuous 3 days, record the food variety and intake.

2.5. Statistical Analysis

Data with normal distribution was presented as means ± SDs, and data not meet normal distribution was presented as M(QR). The data with normal distribution was analyzed by using Student's t test, and date not meet normal distribution was analyzed by rank test. A chi-square test was used to compare discrete variables. Using a univariate analysis to study the factors difference between GRS group and GNRS group. Then Multiple backward step-wise regression analysis was used to study the independent variables which can predict grip strength including body measurement, living habit, various nutrients and food intake in our study. The results of the latter were shown as β coefficients. The 2-tailed significance threshold was set as $P<0.05$. All statistics were calculated with the use of the STATISTICAL PACKAGE FOR SOCIAL SCIECES (SPSS for Windows, version 17.0; SPSS, Chicago, IL).

3. Result

3.1. The Baseline of the Subjects

From 150 participants screened by inclusion criteria, 134 participants met the criteria and enrolled in the study. Table 2 describes the general condition, living habit, anthropometric and nutrient intake of the research subjects.

Table 2. The baseline of the subjects

Item		Data
Number of participant (n)		134
Male person[n(%)]		45 (33.6)
Female person[n(%)]		89 (66.4)
Age (mean±SD, years old)		61.4±10.8
Smoking[n(%)]		31 (23.1)
Drinking[n(%)]		26 (19.4)
Exercise	Less[n(%)]	70 (52.2)
	More[n(%)]	64 (47.8)
Sleeping	Bad[n(%)]	15 (11.2)
	Good[n(%)]	119 (88.8)
BMI (mean±SD, kg/m^2)		25.3±3.8
BF (mean±SD, %)		25.9±11.1
FFM (mean±SD, kg)		33.6±17.6
WHR (mean±SD)		0.91±0.06
TSF (mean±SD, mm)		19.3±8.3
UAC (mean±SD, cm)		24.0±2.4
Energy intake (mean±SD, KJ)		8 207.8±2 640.9
Carbohydrate intake (mean±SD, g)		339.4±119.3
Protein intake (mean±SD, g)		54.4±22.6
Fat intake (mean±SD, g)		39.6±21.7
Dietary fiber intake (mean±SD, g)		11.0±6.0

Note: BMI: Body mass index, BF: Body fat, FFM: Free fat mass, WHR: Waist hip ratio, TSF: Triceps skinfold thickness, UAC: Upper arm circumference

3.2. Grip Strength and the Condition of Reached the Standard

There were 20 cases in male who both two hands reached the standard(44.4%), and 55 cases in female(61.8%). The subjects classified into grip reach standard group (GRS group) were 75 cases, and those classified into grip not reach standard group (GNRS group) were 59 cases. The data is shown in Table 3 in detail.

Table 3. The grip strength and the condition of reached the standards [n(%)]

Gender	N	Left hand	Right hand	Both two hands
Male	45	24 (53.3)	24 (53.3)	20 (44.4)
Female	89	62 (69.7)	64 (71.9)	55 (61.8)
Total	134	86 (64.2)	88 (65.7)	75 (56.0)

3.3. A Univariate Analysis between GRS Group and GNRS Group

A univariate analysis was performed on the general condition, living habit, parameters of anthropometry and dietary intake between GRS group and GNRS group. There were significant differences in age, FFM, WHR, arm muscle circumference (AMC), exercise time, the intake of carbohydrate, protein and fat (P<0.05). The data is shown in Table 4 in detail.

Table 4. The univariate analysis between GRS group and GNRS group

Group	N	Age	BMI(kg/m2)	BF(%)	FFM(kg)	WHR	TSF(mm)	AMC(cm)	Energy(kcal)
GRS group	75	59.4±10.2	25.2±3.6	25.6±7.5	25.2±8.0	0.9±0.1	20.1±8.5	27.11±4.6	1984.7±648.4
GNRS group	59	65.03±9.05	25.5±4.1	26.4±14.5	43.7±21.2	0.9±0.0	18.3±8.0	24.3±2.8	1936.8±614.5
t		-3.314	-0.411	-0.396	-6.931	-2.745	1.26	4.114	0.434
P		0.001	0.682	0.692	<0.001	0.007	0.210	<0.001	0.665

Group	Gender		Drinking		Smoking		Exercise		Sleeping		Carbohydrate intake*		Protein intake△		Fat intake▲	
	Male	Female	Yes	No	Yes	No	Less	More	Bad	Good	Low	High	Low	High	Low	High
GRS group	20	55	18 (24.0)	57 (76.0)	20 (26.7)	55 (73.3)	20 (26.7)	55 (73.3)	6 (8.0)	69 (92.0)	58 (77.3)	17 (22.7)	17 (22.7)	58 (77.3)	25 (33.3)	50 (66.7)
GNRS group	25	34	8 (13.6)	51 (86.4)	11 (18.6)	48 (81.4)	50 (84.7)	9 (15.3)	9(15.3)	50 (84.7)	11 (14.7)	48 (81.3)	57 (96.6)	2(3.4)	46 (78.0)	13 (22.0)
χ^2	3.652		2.302		0.727		44.650		1.748		45.540		73.020		26.410	
P	0.056		0.129		0.394		<0.001		0.270		<0.001		<0.001		<0.001	

Note1:
GRS group: grip strength reach the standard group; GNRS group: grip strength not reach the standard group.
Note2:
BMI: Body mass index, BF: Body fat, FFM: Free fat mass, WHR: Waist hip ratio, TSF: Triceps skinfold thickness, AMC: the upper arm muscle circumference.
Note3:
*The proportion of carbohydrate intake was （69.5±8.2）%. Classify the carbohydrate intake into high proportion of carbohydrate intake group and low proportion of carbohydrate intake group according the mean of proportion of carbohydrate intake 69.5%.
△The proportion of protein intake was (10.9±2.0）%. Classify the protein intake into high proportion of protein intake group and low proportion of protein intake group according the mean of proportion of protein intake 10.9%.
▲The proportion of fat intake was (18.2±6.9）%. Classify the fat intake into high proportion of fat intake group and low proportion of fat intake group according the mean of proportion of fat intake 18.2%.

3.4. The Multivariate Logistic Regression Analysis on the Influence Factors of Grip Strength

By univariate analysis, eight factors which had significant difference between GRS group and GNRS group were introduced into the Logistic regression analysis, including age, exercise(the more exercise set to 1, and the less exercise set to 2), FFM, WHR, AMC, the intake of carbohydrate(the high proportion of carbohydrate intake set to 1, and the low proportion of carbohydrate intake set to 2), the intake of protein(the high proportion of protein intake set to 1, and the low proportion of protein intake set to 2)and the intake of fat(the high proportion of fat intake set to 1, and low proportion of fat intake set to 2). The P of the gender was 0.056 by univariate analysis, approximate to 0.05. Analyzed the data, female in rural do a lot of labor, so the grip strength is stronger. And the grip standard of female is lower than that of male. So we think that the factor of gender has to be introduced into the

Logistic regression analysis(male set to 1 and female set to 2). Reach or not reach the grip strength standard was dependent variable(reach the standard set to 1 and not reach the standard set to 2). In the end, gender, FFM, AMC and the proportion of protein intake were introduced into the regression equation. The rate of reached the standard in female was higher than that in male. The FFM and AMC were positively correlated with grip strength. The proportion of protein was positively correlated with grip strength. Increased with the proportion of protein intake, the rate of reached the standard was improving. The data is shown in Table 5 in detail.

Table 5. The logistic regression analysis of influence factors about grip strength

	β	*P*	Exp(β)	95%CI
Gender	-6.107	0.015	0.002	(0.000, 0.308)
Age	0.052	0.280	1.053	(0.959, 1.157)
Exercise	-0.934	0.341	0.393	(0.057, 2.693)
FFM	0.122	0.006	1.130	(1.036, 1.233)
WHR	19.095	0.082	2.0×10^{-8}	(0.090, 4.030)
AMC	0.913	0.008	0.402	(0.205, 0.787)
The proportion of carbohydrate intake	0.316	0.780	1.372	(0.149, 12.594)
The proportion of protein intake	-7.552	0.002	0.901	(0.000, 0.959)
The proportion of fat intake	-1.296	0.248	0.274	(0.030, 2.473)
Constant	24.867	0.035	6.31	-

Note: - represent no data.

3.5. The Difference of Food Intake between HPPI Group and LPPI Group

According to the proportion of protein intake, the subjects were classified into high proportion of protein intake group (HPPI group) and low proportion of protein intake group (LPPI group). Then we analyzed the difference between two groups about food intake. The data showed that, there was significant difference between two groups on the intake of egg, bean, meat, fish, nut and total energy, and the intake of those in HPPI group were significantly more than those intake in LPPI group($P<0.05$). The data is shown in Table 6 in detail.

Table 6. The difference of food intake between HPPI group and LPPI group

	Staple food*	Egg&	Mile&	Bean&	Meat&	Fish&	Vegetable*	Fruit&	Nut&	Total energy*
LPPI group	8.06±3.00	0(0,1)	0(0,0)	0(0,0)	0(0,0)	0(0,0)	6.31±4.47	2(0,5)	0(0,0)	1827.94±549.67
HPPI group	7.93±2.62	0.5(0,1)	0(0,0)	0(0,1)	1(0.5,2)	0(0,0)	7.43±4.35	2(0,5)	0(0,0)	2136.05±689.82
T/Z	0.259	-3.530	-0.709	-4.574	-7.339	-2.559	-1.465	-0.658	-2.851	-2.878
P	0.796	<0.001	0.478	<0.001	<0.001	0.010	0.145	0.511	0.004	0.005

* The data with normal distribution is presented as means ± SDs, and is analyzed by using Student's t test.
& The data not meet normal distribution is presented as M(QR), and is analyzed by rank test.

4. Discussion

4.1. The Clinical Value of Grip Strength Measurement

Grip strength is a sensitive marker to evaluate the nutritional status. According to the different phases of causing malnutrition, the evaluation of malnutrition is classified into three aspects, the nutritive evaluation of metabolism, the nutritive evaluation of function change, and the nutritive evaluation of body composition [15]. Using metabolism evaluation can detect the nutritional status change in the early stage. This early stage is always the early phase of the illness. The change of metabolism, such as some influence on the creatine synthesis, the activity of mitochondrial compound, the increase of intracellular calcium influx. This metabolism changes all cause the reduction of the grip strength. Using the function change evaluation can detect malnutrition a few days to a few weeks after disease. In this phase, the synthesis of protein decreases and the degradation of protein increases [2]. Then muscle fiber atrophy and muscle function decline can appear. These changes cause the reduction of grip strength. In this phase, the decline of muscle tissue is not obvious. Kristina [2] also showed that the decline of muscle function preceded the reduction of muscle tissue. In the two phases above, the quality of muscle tissue has not decrease, but the function of muscle has decreased. And the grip strength has declined in a certain degree. When using body composition nutritive evaluation, the malnutrition has occurred in some weeks later, and the disease develop further in this phase of disease. Not only the influence on the muscle function, but also the quality of muscle can obviously decline. At this time, the body weight, BMI, FFM all decline. The grip strength decreases obviously. In clinic, it performance on frailty or sarcopenia. In different phrases of malnutrition, grip strength all can evaluate the nutrition status sensitively. In 2009, the Academy of Nutrition and Dietetics (Academy) and the American Society for Parenteral and Enteral Nutrition (ASPEN) recommended that a standardized set of diagnostic characteristics must be used to identify and document adult malnutrition in routine clinical practice [6]. There were six indexes, and the person with more than two indexes can be diagnosed malnutrition. The indexes include: (1) insufficient energy intake, (2) loss of weight, (3) loss of muscle tissue, (4) loss of subcutaneous fat, (5) local or systemic fluid retention, (6) the declination of function detected by the measurement of grip strength. In this standard, grip strength not only reflect the nutritional status of body in three levels, but also be one criteria for

the diagnosis of malnutrition. At the same time, the grip strength can also predict the outcome of disease, quality of life, infection, other complications and the length of life [3,4,5]. The measurement of grip strength is simple, repeatable, noninvasive and cost lowly [1,2]. By nutrition intervention, the grip strength can increase. And it can improve the prognosis of patients with disease, and improve the patient quality of life [9,10,11,12,13]. The measurement of grip strength has a large of clinical value. Through nutritional support and therapy, the grip strength can increase. And it can improve the prognosis of patients with the disease. But which nutrient or which dietary pattern can influence the grip strength has few study in current.

4.2. The Main Influence Factors of Grip Strength in Middle Aged and Elderly Villagers in Zhang Fang Village

There were all 24 cases reached the standard in male of left hand or right hand separately, and the rate was 53.3%. There were 20 cases reached the standard in male of both two hands, and the rate was 44.4%. There were 62 and 64 cases reached the standard in female of left or right hand separately, and the rate were 69.7% and 71.9% separately. There were 55 cases reached the standard in female of both two hands, and the rate was 61.8%.

The data showed that the grip strength was closely related to the gender, FFM, AMC and the proportion of protein intake in middle aged and elderly people in Zhang Fang Village in Beijing. The standard-reaching rate of grip in female was higher than that in male. It may be due to the more physical labor that the rural women to do than the city women to do. But the standard criteria is applied to all women. So the rural women can easily reach the standard. But in male, there was no advantage. So the standard-reaching rate in female was higher than that in male. FFM and AMC are not only related to the activity or labor, but also closely related to the nutrient intake.

In our research, the dietary pattern was staple food and pickles in this village. This dietary pattern caused the unbalance of the nutrients. The proportion of carbohydrate is too high. At the same time, the intake of protein and fat are too low. Although, in the end, the proportion of carbohydrate and fat intake were not be introduced into the regression equation, the data also showed that the proportion of carbohydrate was negative correlated to the standard-reaching of grip strength in a trend, and the proportion of fat was positive correlated to the standard-reaching of grip strength in a trend. Decrease the carbohydrate intake or increase the fat intake can also enhance the standard-reaching rate of grip strength. This unbalanced dietary pattern obviously influenced the standard-reaching rate of grip strength and caused malnutrition. Previous study found that malnutrition can lead to inflammation [3,5,7]. As the presence of inflammation, the energy consumption is increased, the protein catabolism is hyperthyroidism, and negative nitrogen balance can be shown [7]. Even in healthy older people with mild inflammation, muscle function will reduce, resulting in reduction of grip strength.

In our research, the unbalanced nutrient intake can directly influence the standard-reaching rate. And the proportion of protein intake played an important role for the standard-reaching of grip strength. Appropriately increased proportion of protein intake can significantly increase the standard-reaching rate of grip strength. Possible reasons: (1) with the increased proportion of protein intake, the number and the volume of muscle fiber can increase, and it can lead to the increased muscle tissue quality, with FFM and AMC increased. (2) protein-rich food such as meat has a lot of taurine, arginine, glutamic acid. With the decrease of protein intake, these free amino acid decreased also. These free amino acid can significantly influence the function of muscle. The study found that two factors can affect the function of muscle, the synthesis of creatine and the intake of taurine. The raw material for the synthesis of creatine phosphate is free amino acid and methionine. With the decreased intake of protein, the concentration of the free amino acid in blood is declined, and the activity of creatine phosphate synthetase will decrease. This can influence the synthesis of creatine phosphate, and lead to lack of energy when muscle contraction. The final result is dysfunction and decrease of grip strength.

In our research, we also study which food the villagers intake can influence the proportion of protein intake. We found that there were some significantly differences on the intake of high-quality protein rich foods between HPPI group and LPPI group, such as egg, meat, fish and nut. The intake of these foods in HPPI group were significantly more than those in LPPI group. At the same time, the energy intake in HPPI group was also more than that in LPPI group. The appropriate increase in energy can not affect the body weight and body fat, but it has the effect on saving the protein. When the energy is sufficient, the protein intake will not be used to produce energy, but it can be transferred into the body muscle. Therefore, we suggest to ensure the sufficient energy intake, appropriately increase the high quality protein rich foods. This can increase the grip strength and improve the nutritional status.

In conclusion, the measurement of grip strength is not only a tool to evaluate the nutritional status, but also to predict the prognosis and life of patients. The low proportion of protein intake, lack of high quality protein intake and unbalanced dietary pattern are significantly influence the standard-reaching rate of grip strength in middle aged and elderly villagers. Improving the dietary pattern, increasing the proportion of protein intake, increasing the intake of high quality protein food, can enhance the grip strength and improve the nutritional status.

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