

Obesity combined with low grip strength is correlated with cardiac autonomic nervous function in the Chinese elderly-an observational study

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Abstract

Background: Heart rate variability (HRV) provides indices related to all types of risks for death, increased risk of cardiovascular disease and diabetes, especially in elderly. Obesity and grip are related to diseases, thus decrease elderly healthy life. However, there is no definitive link between HRV and muscle strength and obesity. We conducted a cross-sectional study to determine whether grip strength and obesity are associated with HRV in elderly, community-dwelling Chinese individuals.

Method: Our study population consisted of residents of Township Central Hospital of Chadian, Tianjin, China. We measured short term HRV, grip strength, and body mass index (BMI). The HRV measures were transformed to the natural log to normalize the distribution and we used logistic regression to explore the relationship.

Results: A total of 534 participants over the age of 60 (200 men, mean age 69.2 ± 6.0) had complete data at the baseline and were included in the analysis. Compared with the isolated-obesity group and isolated-low-grip-strength group, the group with concurrent obesity and low grip strength has a stronger relation with LF $n.u.[0.94(0.90-0.98)]$, $\ln(LF)$ $[0.50(0.29-0.95)]$, and $\ln(LF/HF)$ $[0.41(0.20-0.83)]$.

Conclusion: Our results demonstrate that low HRV is associated with concurrent low grip strength and obesity in older adults, rather than isolated low grip strength or isolated obesity. These results may provide a reference for early screening of cardiac autonomic function disorders in patients with potential heart disease in clinic, thus contributing indirectly to the prevention or rehabilitation of cardiovascular disease. It also provides a new idea for further mechanism research. Clinical trial registry Our research was registered on Research Registry website (URL: <http://www.chictr.org.cn/index.aspx>), the registry number was ChiCTR1800016308.

Background

In today's increasingly aging society, the elderly are more susceptible to chronic diseases, especially heart disease and related chronic disease. These diseases are at least partly linked to increasing cardiac electrophysiological and autonomic dysfunction(1, 2). Heart rate variability (HRV), which provides an indicator of healthier responses relating to cardiac electrophysiology and autonomic regulation in adults, while is lower in elderly. It has been shown to be effective as a predictor of all types of risks for death, increased risk of vascular causes of death(3, 4), myocardial infarction and diabetes (5, 6), especially in elderly. Autonomic dysregulation also serves as a predictor of postoperative complications in surgery, providing a reference for the assessment of surgical risks(7). Vagal modulation is regarded as an important mechanism of sudden death(8). Thus, HRV is an important indicator to evaluate the cardiovascular health of the elderly.

Besides HRV, elderly people were more likely to have obesity and poor physical performance (such as poor grip) than adults, which related to cardiovascular disease (CVD), that are widely studied in current researches. Obesity, usually accompanied by metabolic diseases, is more likely to lead to cardiovascular

diseases, thus increasing the incidence of chronic diseases(9) and mortality. In addition, geriatric individuals with obesity may have a high risk of muscle loss and a related decline in physical performance, with underlying changes in body composition(10). As a measure of physical performance, low grip strength is widely recognized as a simple, inexpensive stratifying risk factor associated with CVD, cardiopulmonary health, cancer, and even mortality (11, 12). The association between physical activity and risk of mortality is modulated by grip strength and cardiopulmonary fitness(13). Thus grip, obesity and autonomic function were essential key for elderly healthy life. However, the mechanism of how obesity and grip strength affects the cardiovascular system is not clear. Although some studies show that obesity might be related to the cardiac autonomic nervous system, whether obesity and grip strength are related to the cardiac autonomic nervous system and play a role in heart disease has not been determined. Therefore, further studies should focus on how these risk factors affect cardiovascular health. Studies have suggested that obesity and cardiac autonomic function might interact with each other (14–16). This in turn could lead to chronic diseases and a higher mortality risk. However, the role of sympathetic or parasympathetic activity in obesity has not reached a unified consensus(17). While isolated obesity might not be enough to impair cardiac autonomic modulation(18), concomitant poor physical performance might be a risk factor for HRV. Besides, at present, studies on HRV and physical performance only involve physical activity(19, 20), walking speed, and balance function(21). This raises the concern of whether obesity accompanied by poor grip strength could influence cardiac autonomic modulation and result in cardiac disease in the elderly.

Here we conducted a cross-sectional study to determine whether grip-strength and obesity are associated with HRV among elderly, community-dwelling, Chinese individuals. Our results will provide a reference for a possible pathway to explain the impact of obesity and low grip strength on cardiovascular disease in the elderly.

Method

We conducted a cross-sectional study to observe the relation between grip-strength and obesity with HRV in Chinese elderly.

Participants

Our study population comprised residents of township central hospital of Chadian, Tianjin, China. We conducted a cross-sectional study to find the relationship. We enrolled 566 participants over the age of 60 in 2018 at baseline, who were invited to participate in a comprehensive geriatric assessment. Major reasons for exclusion included: (1) age < 60 years; (2) serious arthropathic deformation of hand joint causing severe mobility impairment or localized loss of strength; (3) having history of heart disease, serious arrhythmia, pacemaker use, or >20% ectopic beats; (4) consuming any medication that can presumably influence autonomic functions, such as antihypertensives, anticholinergics, or antidepressants, for at least 1 month prior to the beginning of the study; (5) artifacts in the electrocardiography signal acquisition; (6) inability to perform a specific test independently or safely

based on the judgment of the geriatric nurse or subjects themselves; (7) medical record diagnosis of dementia and other memory system disease and (8) refusal to participate in our study.

The methodological sessions were carried out in accordance with the approved journal guidelines and regulations. The investigation was conformed to the principles outlined in the Declaration of Helsinki, and the informed written consent was given prior to the inclusion of people in the study. This study was approved by ethics committee at Tianjin Medical University, China (2018–0626–4). Excluded persons included 10 participants that were not competent to give informed consent, 8 patients did not perform handgrip strength because of arthritis and pain in their fingers, 6 participants were diagnosed as dementia, and 8 participants had artifacts in the electrocardiography signal acquisition. 534 had information regarding HRV and physical function at baseline, the flow of our study was showed in Figure 1.

Performance-based assessment

Performance-based assessment consisted of several physical tests and muscle mass. We have described the methods of 4-m walk tests, TUGT, grip strength in detail in our previous study(22). Grip (kg) was used as a measure of muscle strength and was quantified using a handheld dynamometer (GRIP-D; Takei Ltd, Niigata, Japan). Participants were asked to exert their maximum effort twice using their dominant hand and the average grip strength was recorded. Gait function was assessed with the 4-m walk tests and the TUGT. This method of standardization has been previously recommended in order to normalize and improve physical function testing results(23). To avoid the measurement error, the assessment was conducted by postgraduate students in the health field who received special training for testing administered all tests as part of a standard geriatric assessment. And each item shall be the responsibility of the personnel. Every project data collection is completed by the same trained staff. Muscle mass was measured using a direct segmental multi-frequency BIA (In-Body720; Biospace Co., Ltd, Seoul, Korea).

Heart Rate Variability

HRV were measured using a heart rate monitor (UCare, RG10, Nanjing China, CAS Institute of Healthcare Technologies) with beat-to-beat records using R-R intervals, and the 5 min was considered for analysis in sit after rest at least 10 min. The R-R intervals were analyzed through an R-based software package for the heart rate variability analysis of ECG recordings with the artifacts filtered at a moderate level(24) (Cardiac Rehab Exercise Monitoring and Management System, CREMS, Nanjing China). The HRV data less than 5 minutes of an effective ECG were excluded.

The HRV data was presented by linear time domain indexes: the root mean square successive difference between adjacent R–R intervals (RMSSD), and the standard deviation of all normal R–R intervals recorded in one time interval (SDNN). Frequency domain indexes analyzed using spectral analysis: low frequency spectral components, LF (with a variation of 0.04–0.15 Hz) and LF n.u. (expressed in normalized units); high frequency spectral components, HF (with a variation of 0.15 to 0.4 Hz) and HF

n.u. (expressed in normalized units); cardiac autonomic nervous balance assessed by means of the LF/HF ratio (ratio between low and high frequency components).

Obesity

Obesity was defined by body mass index (BMI), people who had BMI over 28kg/m^2 was seen as obesity. Body weight (kg) and height (m) were measured and BMI was calculated by body weight/height². The participants were instructed not to drink any liquids and not to urinate 30 min prior to the evaluation.

Covariates

Data regarding sociodemographic, behavioral characteristics, and physical illness of dates were obtained as previously (via face-to-face questions). Sociodemographic variables, including age, gender, marital status, educational level, and occupation, were assessed. Marital status was classified as married or not married/single. Educational level was defined as age at completion of schooling and divided into 4 categories: illiterate, 1–6 y, 7–12 y and ≥ 13 y. Behavioral characteristics included smoking and drinking habits. Information on smoking (never, former smoker, or current smoker) and drinking (never, former drinker, occasional drinker, or everyday drinker) was also obtained from the questionnaire. Self-reported sleep duration was measured by trained interviewers as a component of the interview. Participants were asked the time they usually went to bed and got up during the past month, we calculated the time they slept per night. Physical activity was assessed using the short form of the International Physical Activity Questionnaire (IPAQ). We have described the methods of IPAQ in detail in a previous study(25). Depressive symptoms were assessed using the Geriatric Depression Scale (GDS). Falls was defined as any event that results in a body change that forces an individual to inadvertently land on the ground or a lower level. At baseline, subjects were asked the number of falls they experienced in the past 12 months. The disease history was collected through medical records and interviews.

Statistical analysis

The HRV measures were natural log transformed to normalize the distribution(26). Patients with a grip strength value at low 20% of the whole level were divided into the lower grip strength group. We separated people into four groups at baseline, that normal group, isolated obesity group, isolated low grip strength (low GS) group, and obesity + low GS group. Differences between variables were examined by ANOVA with Bonferroni correction on continuous variables. And we use the chi square test on categorical variables between groups (Table 1). Data are presented as means (with 95% confidence intervals) or as percentages. Covariates were added sequentially to the linear model to evaluate association at different levels of adjustment. Logistic regression analysis was used to assess the relation between obesity and low grip strength with HRV. Covariates were added sequentially to the regression model. Crude was unadjusted, adjusted model was adjusted for age; gender; widow; live alone, drinking, smoking, hypertension, cardiac disease, falls, walk speed, sleep duration, muscle mass, TUGT. All statistical analyses were performed with the SPSS V20.0 software package (SPSS Inc, China).

Results

Subject characteristics

A total of 534 participants (200 men and 334 women) aged 60 to 89 had complete data in 2018 at the baseline and were included in the analysis. Among these people, we found that 365 participants were divided into normal group, 63 people had isolated obesity, 86 people grip strength under the low 20% of the whole level, and 20 persons had obesity and low grip strength. Mean age between the four groups were 68.4 ± 5.9 , 67.8 ± 5.7 , 70.8 ± 6.3 , 69.7 ± 6.2 . After listing the characteristics in Table 1, we found that age; gender; widow; live alone, drinking, smoking, hypertension, cardiac disease, falls, grip, walk speed, sleep duration, muscle mass, TUGT were significant difference between four groups.

At baseline, we found that gender, age, live alone, widow, smoking, drinking, walk speed, ASM, TUGT, sleep duration, diabetes, cardiac disease were significantly difference between groups. LF/HF ratio was significant difference between groups, the obesity group (2.8 ± 2.4), low GS group (2.7 ± 2.3), and obesity+low GS group (2.0 ± 1.9) were lower than normal group (3.3 ± 2.9). $\ln(\text{LF}/\text{HF})$ value were (0.8 ± 0.8), (0.6 ± 0.9), (0.6 ± 0.8), (0.4 ± 0.8). The $\ln(\text{LF})$ also found the similar trends between the groups showed the values were (3.8 ± 1.1), (3.5 ± 1.1), (3.5 ± 1.1), (3.2 ± 0.6).

Relation between obesity/grip and HRV

For further analysis, we put obesity, low grip strength, obesity+low grip strength with HRV into logistic regression, to explore the relation between these factors. In crude, the risk of obesity+low GS were LF n.u. [$0.97(0.94-0.99)$], $\ln(\text{LF})$ [$0.56(0.34-0.89)$], $\ln(\text{LF}/\text{HF})$ [$0.50(0.27-0.92)$], respectively. Low GS only had significant difference in $\ln(\text{LF})$, for $0.78(0.62-0.99)$. We haven't found any difference in obesity group. After adjusted age; gender; widow; live alone, drinking, smoking, hypertension, cardiac disease, falls, walk speed, sleep duration, muscle mass, TUGT, the relation got more clearly in obesity+low GS group, presented as LF n.u. [$0.94(0.90-0.98)$], $\ln(\text{LF})$ [$0.50(0.29-0.95)$], $\ln(\text{LF}/\text{HF})$ [$0.41(0.20-0.83)$], respectively. And there wasn't significant difference in low GS and obesity groups any more.

Discussion

Our findings suggest that in elderly Chinese individuals, lower HRV level is associated with obesity combined with poor grip strength, but not isolated obesity or isolated poor grip strength. To our knowledge, this is the first cross-sectional study investigating the relationship between HRV and combined obesity and low grip strength. We found that obese individuals with low grip strength were more likely to be of older age and living alone or widowed, have slower walking speed, lower skeletal muscle mass (ASM), poor balance function (longer TUGT), shorter sleep duration, a higher prevalence of diabetes and cardiac disease, and higher incidence of falls at baseline. In the obesity plus low grip strength group, individuals had lower LF/HF, $\ln(\text{LF})$, and $\ln(\text{LF}/\text{HF})$ value (Table 1).

The relation between HRV and isolated obesity

We noted that at baseline obese individual had lower trends of LF/HF, ln(LF) and ln(LF/HF) values compared with the normal control group at baseline. After full adjustment, there were no significant differences in LF n.u., ln(LF) and ln(LF/HF). This result was similar to a previous study(18, 27) that it showed isolated obesity is not enough to impair cardiac autonomic modulation. The previous study mentioned that even overweight and obese individuals who were considered metabolically healthy present with an increased risk of cardiovascular events and death compared with metabolically healthy normal weight individuals(28). Thus, metabolic disorders might be a serious factor for cardiac automatic function than isolated obesity. Some previous studies showed that obesity had an impact on autonomic modulation and was related to sympathetic excitation(14–16). In fact, an earlier study hypothesized that lipid accumulation in obesity could be either due to a decrease in sympathetic activity or an increase in parasympathetic activity, so that modulating insulin-mediated glucose uptake and free fatty acid metabolism in an anabolic way would promote lipid accumulation(29). However, other studies failed to demonstrate parasympathetic innervations in white adipose tissue(30). These studies also have some differences with our study. One study involved younger individuals(16) where the influence of autonomic function is greater than in the elderly population used in this study. Though the study on the relation between obesity and HRV showed that obesity might be associated with HRV(14), BMI itself has a weak relationship with HRV cardiac autonomic markers. Moreover, waist-hip ratio (WHR) was related to HRV. BMI and WHR were both indicators of obesity, but many studies use these two methods to diagnose obesity differently. We also used WHR data to classify central obesity and found the same results as the recent study (LF n.u. 95%CI, 0.97–1.14, P>0.05).

The relation between HRV and isolated low grip strength

We found that in a crude model low grip strength was associated with ln(LF). However, after adjustment the association disappeared. Insulin is involved in the action of the central nervous system pathways, and it can act on the receptors around the nodule ganglia(31). Abnormal glucose metabolism may lead to abnormal sympathetic nerve activity, thus promoting the fluctuation of insulin(32). The depressed anabolic action of insulin in stimulating protein synthesis may contribute to progressive loss of muscle mass strength and quality(33). But there is no definite study that showed that isolated grip strength was associated with abnormal HRV. Recent studies showed that muscle mass in obese patients is more likely to be related to HRV(34). Our study also found that lower muscle mass (lower than 25%) was related to HRV (OR, 95%CI; 0.92, 0.89–0.95) in obese but not in healthy individuals. This indicates that isolated low grip strength might be not enough to affect HRV. But it is still a key point that needs consideration and intervention as necessary for autonomic nervous function stability. Until now studies on HRV and physical performance have only involved physical activity(19, 20), walking speed and balance function(21). Physical activity was positively correlated with HRV in older people(35), but it cannot represent physical performance or function in the elderly. However, it reminds us there might be a way to improve HRV levels by exercising(36).

The relationship between HRV and obesity combined with low grip strength

Our study showed a highly positive association between HRV and obesity combined with low grip strength even after excluding the impact of age, gender, disease, and living status. Grip strength reflects whole body muscle strength level and physical function. Compared with isolated obesity and isolated low grip strength, in overweight and obese older adults, reduced physical function can be linked to the effect of excessive adiposity in muscles, which plays a crucial role in metabolic adaptation in obesity(37, 38). In addition, the autonomic nervous system dysfunction in elderly individuals with obesity was marked by low muscle mass, which further highlights the relationship between autonomic dysfunction and muscle impairment(39). Furthermore, the effect of an increased amount of adipose tissue may be enhanced by loss of muscle mass and strength(40), and the influence of insulin may contribute to the progressive loss of muscle mass, strength, and quality(33). Our study also verified this conclusion. Compared with the normal group (7.3 ± 2.1 kg/m²), the obesity+low grip strength group had lower muscle mass (7.0 ± 0.8 kg/m²). This result is similar to the study on the association of walking speed and balance function(21) with HRV in obese individuals. If the hypothesis that obesity could occur either due to a decrease in sympathetic activity or an increase in parasympathetic activity were true(29), decreased sympathetic activity or increased parasympathetic activity might be related to decreased muscle strength and therefore related to lower grip strength. A vicious cycle is formed between HRV and low grip strength in obese individuals.

Limitations

Some limitations of our study need to be mentioned. First, because of the cross-sectional design of this study, we could not identify causality within existing associations. Second, we obtained HRV using a 5-minute ECG. Collection of long-term Holter ECG recordings is generally preferred to short-term ECG recordings because longer recordings reduce measurement variability, and HRV derived from short-term ECG recordings may not represent the sympathetic and parasympathetic activity in a 24-hour period. However, a previous study has shown that 2- to 15-minute and 24-hour HRV measures are highly correlated(41). Therefore, we believe 5-minute ECGs could be an effective measurement. The 5-minute ECG is suitable for larger field studies and investigations on large populations. Further multi-center and multi-cohort studies should be conducted to verify these results. These results could provide a reference for cardiac autonomic function with low grip strength in obese individuals.

Conclusion

The results of this study demonstrate that low HRV is associated with low grip strength level in older adults with obesity rather than isolated low grip strength or isolated obesity. This result might provide a reference for clinical rehabilitation or prevention of cardiac autonomic function disorders. We suggest that higher emphasis should be placed on the physical function of older individuals with obesity in their activities of daily living.

Abbreviations List

BMI

Body mass index

CVD

Cardiovascular disease

GDS

Geriatric Depression Scale

GS

Grip strength

HF

High frequency spectral components

HRV

Heart rate variability

IPAQ

International Physical Activity Questionnaire

LF

Low frequency spectral components

LF/HF

Ratio between low and high frequency components

n.u.

Expressed in normalized units

RMSSD

Root mean square successive difference between adjacent R–R intervals

SDNN

Standard deviation of all normal R–R intervals recorded in one time interval

TUGT

Timed up and go test

Declarations

Our study adheres to CONSORT guidelines.

Ethics approval and consent to participate

The investigation was conformed to the principles outlined in the Declaration of Helsinki, and the informed written consent was given prior to the inclusion of people in the study. This study was approved by ethics committee at Tianjin Medical University, China (2018–0626–4)

Consent for publication

Not applicable

Availability of data and materials

Due to the privacy and confidentiality of patient information, the datasets generated and/or analyzed during the current study are partly available at the Research Registry website for some core data (URL: <http://www.chictr.org.cn/index.aspx>), the registry number was ChiCTR1800018306.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

LF and BS wrote the main manuscript text.

JG and XC done the statistical analyze.

XY and LH had done the investigation of this study.

YZ and PS had done all the tables in the manuscript.

FY was responsible for project administration.

QG supervised the whole working.

All authors read and approved the manuscript.

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Tables

Table 1. Subject Characteristics According to Categories on the Baseline

Characteristic	Normal (n=365)	Obesity (n=63)	Low GS (n=86)	Obesity+Low GS(n=20)	P
Male, %	47.4	32.3	7	5	0.007
Age, y	68.4±5.9	67.8±5.7 ^a	70.8±6.3	69.7±6.2	0.001
Height, cm	163.9±8.9	159.7±8.1	154.9±7.5	153.1±6.0	0.25
BMI, kg/m ²	24.87±3.3	30.0±1.7	24.9±3.8	30.4±1.6	0.001
Live alone, %	9.6	6.5	19.8	35	0.001
Widow, %	12.6	8.1	26.7	35	0.001
Illiteracy, %	21.6	25.8	29.1	25	0.752
Smoking, %	24.2	14.5	29.4	5	0.035
Drinking, %	38.4	25	12.2	5	0.001
Grip, kg	25.7±7.2	24.8±7.5	13.6±2.1 ^a	14.1±1.7 ^{a b}	0.001
Walk speed, m/s	1.1±0.2	1.0±0.2	0.9±0.2 ^a	0.9±0.2 ^{a b}	0.001
ASM, kg/m ²	7.3±2.1	7.8±0.9 ^a	6.0±0.8 ^a	7.0±0.8 ^{a b c}	0.001
TUGT, s	9.1±2.2	9.9±2.3	10.9±3.2	11.3±3.1	0.02
IPAQ	5835	4926	3862	3063	0.028
Sleep duration, h	7.8±1.0	7.6±1.1	7.8±1.2	7.3±1.2 ^{a c}	0.047
Disease					
Diabetes, %	10.7	14.5	20.9	25	0.03
Hypertension, %	44.4	54.8	40.7	55	0.273
Hyperlipidemia, %	15.6	19.4	12.8	15	0.756
Stroke, %	8.5	6.5	7	5	0.533
Cardiac disease, %	21.6	35	36	37.1	0.005
HRV					
SDNN, ms	38.8±21.5	38.7±20.4	37.3±20.6	31.8±11.3	0.591
rMSSD, ms	23.4±17.5	25.7±18.8	23.2±17.7	18.4±7.6	0.73
LF/HF	3.3±2.9	2.8±2.4	2.7±2.3	2.0±1.9	0.038
ln(SDNN)	3.5±0.5	3.5±0.5	3.5±0.4	3.4±0.3	0.54
ln(rMSSD)	2.9±0.6	3.0±0.6	2.9±0.5	2.8±0.4	0.859
ln(LF)	3.8±1.1	3.5±1.1	3.5±1.1	3.2±0.6 ^{a b c}	0.011
ln(HF)	3.0±1.2	2.9±1.2	2.9±1.1	2.9±0.9	0.42
ln(LF/HF)	0.8±0.8	0.6±0.9	0.6±0.8	0.4±0.8 ^{a b c}	0.040
LF n.u.	67.3±16.7	63.7±18.4	64.3±16.6	57.4±17.6 ^{a b c}	0.043
HF n.u.	32.7±16.7	36.3±18.4	35.7±16.6	42.6±17.6 ^a	0.043
Falls, %	13.7	8.1	20.9	30	0.032
Depression, %	9.9	12.9	17.4	20	0.151

1. GS, grip strength; IPAQ, international physical activity questionnaire; TUGT, timed up and go test; ASM, appendicular lean mass; HRV, heart rate variability; SDNN, standard deviation of all normal R-R intervals; rMSSD, root mean square successive difference between adjacent R-R intervals; LF, low frequency spectral components; n.u.; normalized units; HF, high frequency spectral components.

2. Mean; Standard error in parentheses (all such values).

3. Obtained by using ANOVA for continuous variables and chi-square for variables of proportion.

a. Significantly difference compared with normal group

b. Significantly difference compared with obesity group

c. Significantly difference compared with low GS group

Table 2. Logistic regression analysis between HRV and obesity/low grip strength/ Obesity+Low grip strength

	Normal (n=365)	Obesity (n=63)		Low grip strength (n=86)		Obesity+ Low grip strength (n=20)	
		Crude	Adjusted [#]	Crude	Adjusted [#]	Crude	Adjusted [#]
LF n.u.	1	0.98(0.97- 1.01)	0.98(0.96- 1.06)	0.99(0.97- 1.01)	0.99(0.98- 1.01)	0.97(0.94- 0.99)*	0.94(0.90- 0.98)*
ln(LF)	1	0.76(0.56- 1.01)	0.76(0.55- 1.04)	0.78(0.62- 0.99)*	0.97(0.77- 1.25)	0.56(0.34- 0.89)*	0.50(0.29- 0.95)*
ln(LF/HF)	1	0.77(0.53- 1.12)	0.72(0.49- 1.07)	0.78(0.57- 1.06)	0.98(0.69- 1.39)	0.50(0.27- 0.92)*	0.41(0.20- 0.83)*

n.u. expressed in normalized units;

[#]Adjusted for age; gender; widow; live alone, drinking, smoking, hypertension, cardiac disease, falls, walk speed, sleep duration, muscle mass, TUGT∩IPAQ;

* compare with normal group (P<0.05).

Figures

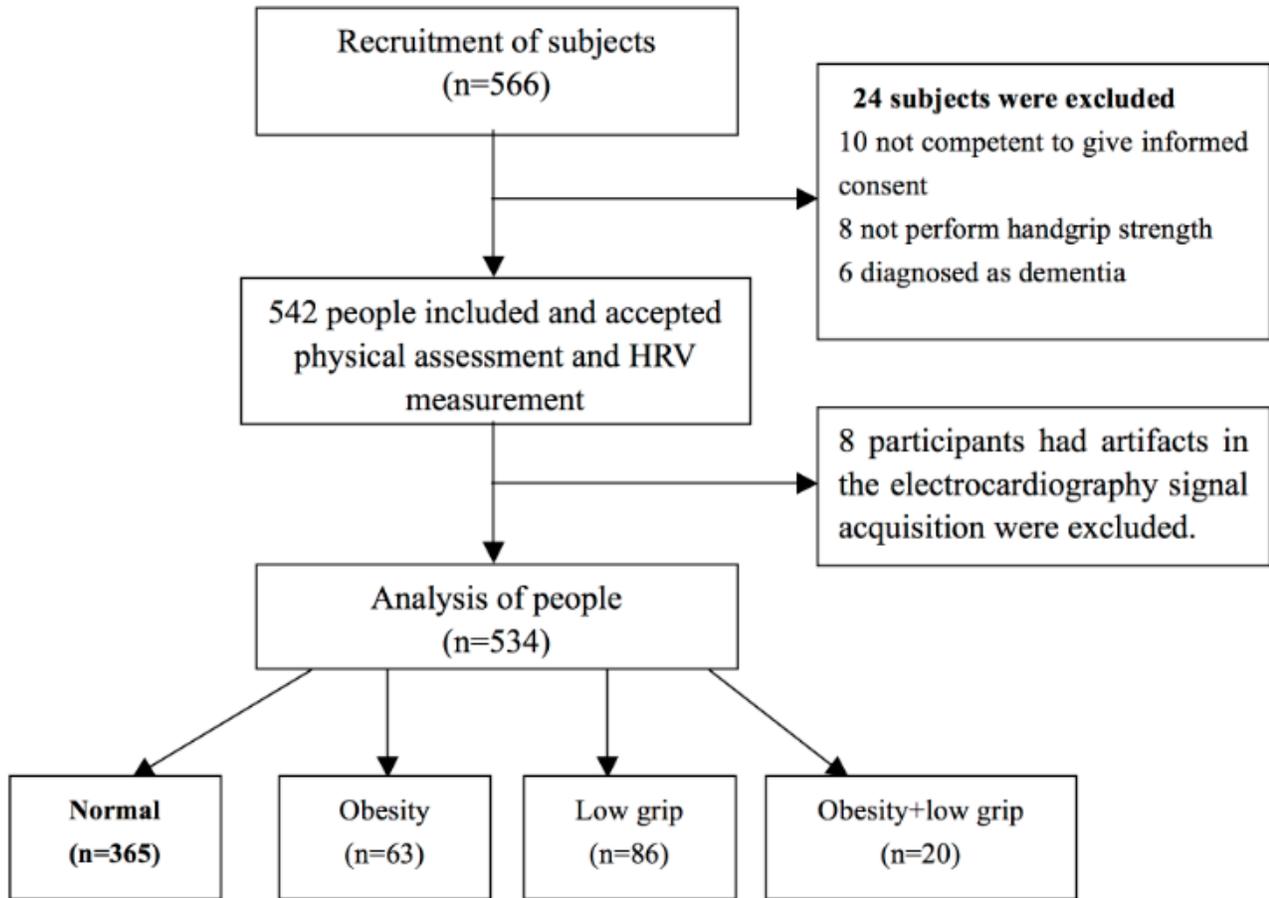


Figure 1

Supplementary Files

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