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ORIGINAL RESEARCH

Factors Associated with Handgrip Strength Among Older Adults in Malaysia

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Purpose: Handgrip strength (HGS) is indicative of overall physical health among older adults. A decrease in HGS may be associated with an increased risk of disease. The aim of this study is to determine the factors associated with HGS among older adults in Malaysia.

Patients and Methods: One thousand two hundred four (1204) participants from urban and rural areas in Selangor state, Malaysia, were recruited. Sociodemographic and health-related conditions were gathered through a comprehensive face-to-face interview, followed by HGS assessments by a handgrip dynamometer. Subsequently, multiple linear regression was used to test the main association with the HGS.

Results: A total of 691 participants (57.4%) were male, and 513 (42.6%) were female. Males had a mean HGS of 30.0 (SD 7.53) kg, and females had a mean HGS of 19.4 (SD 5.28) kg. Males' handgrip strength was significantly reduced with increasing age, physically inactive, and diabetes (all at the level $p<0.001$) after adjusting for social-demographic characteristics and health-related variables. Meanwhile, for females, the HGS was significantly decreased with age ($p<0.001$), physically inactive ($p<0.001$) and hypertension ($p=0.03$). However, female HGS was positively related to BMI ($p<0.001$).

Conclusion: The study contributed to a better understanding of factors associated with HGS, and thus, the HGS is recommended as a section in the health evaluation among high-risk older adults as the strategy of disease control and prevention.

Keywords: handgrip strength, elderly, risk factors

Introduction

Muscle strength is an essential determinant of healthy ageing, and it has a significant association with the development of disability and mortality risk.[1] Men's muscle strength appears to be greater than women's due to larger fibres.[2] Meanwhile, muscle weakness typically develops first in older women due to loss of muscle strength, which starts in middle age.[3] In general, a decrease in muscle strength has been shown to impair normal bodily function. Muscle deterioration occurs as a result of the ageing process, physical inactivity, and malnutrition in older adults. In contrast, if older adults were empowered with knowledge and education regarding a healthy diet and regular physical activity, reduced muscle strength could be counteracted and improved despite the physiological ageing process.[4] A study has shown that improved physical activity and resistance exercise enhance older adults' muscle strength and function, even if they are burdened with severe disability.[5]

Currently, one of the simplest and most accessible methods of determining muscle strength is the handgrip strength (HGS) test. Numerous scientific studies have established a significant correlation between handgrip strength and other muscle strength in both healthy individuals and older adults with some form of pathology. For example, a study among 70 years older adults showed handgrip is a valid method for lower limb muscle strength.[6] Therefore, this practical

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measurement of handgrip strength is widely used as a single indicator of overall muscle strength, especially in older adults.[7,8] At the same time, the link was established between HGS and health, including non-communicable diseases (NCDs). According to a recent study conducted in 17 countries with 139,691 participants shown, 2% of patients (3379) died in the median follow up of 4.0 years. The result showed that the HGS level was inversely related to all-cause mortality, myocardial infarction, and stroke. It also mentioned that all causes and cardiovascular mortality are better predictors of HGS than systolic blood pressure.[9] Furthermore, the disease status among 5271 respondents aged more than 45 years old in previous literature mentioned that those having higher HGS had a lower risk of hypertension and dyslipidemia in males while dyslipidemia among females.[10] In terms of sociodemographic such as age study in Sri Lanka among 999 respondents had shown the lower HGS associated with older adult age in both genders more than 60 years old.[11] On the other hand, a physically active lifestyle increases HGS measurement and acts as a predictor of physical functioning and for a better quality of life among the older adult.[12]

Handgrip dynamometers are widely used to measure maximum isometric HGS with excellent intertester and test-retest reliability.[13] Low HGS is commonly indicative of weak upper extremity strength and lower extremity function.[14] In the older adults' population, weak muscle strength is usually observed as reduced mobility and increased dependency in their activities of daily living and is predictive of body function and mortality.[15] Indeed, HGS is considered a reliable measure of physical decline and future outcomes among the older adults' population.[15]

Not many studies have been conducted on HGS as a general health measurement among Malaysia's older adults' population. Indirectly, this may result from a lack of usage of handgrip measurements in clinical practice. Previous studies involving a small sample of Malaysian older adults showed that men were significantly stronger than women in HGS.[16–18] The HGS was positively associated with body mass index (BMI) and functional ability while negatively associated with depression for both sexes.[17] Since gender is the known associated factor with HGS, therefore, this study was carried out to determine the factors associated with HGS in a large older adults' population coinciding with the gender differences. This is important as the approach later in public health intervention among male and female older adults pertaining to their related factors. As a result of this study, we expect that HGS will be integrated into older adults' assessments in the clinical setting.

Materials and Methods

Study Design

A cross-sectional study design was conducted in Selangor, Malaysia, from 1 December 2018 until 30 April 2020. The study's design, sampling method and questionnaire used were identical to those described by Shah et al.[19] Selangor is located on Peninsular Malaysia's west coast and was chosen as the study location because it is Malaysia's most populous state. Following that, two districts within Selangor, Hulu Langat and Kuala Selangor, were chosen to represent urban and rural areas, respectively. We sampled participants using a multistage cluster sampling technique. The primary sampling unit is the district, and the secondary sampling unit is the sub-district. Six sub-districts from Hulu Langat (which has seven sub-districts) and Kuala Selangor (which has nine subdistricts) were selected. At the third sampling stage, ten towns/villages were randomly selected from each sub-district.

The household ledgers for the selected areas were obtained and were used as the sampling frame for households and individuals. Subsequently, a random sampling of households with an older person from the selected areas was conducted. The sample size was calculated using a Kish formula $n = Z^2 \times P(1 - P) \div e^2$ where Z is the level of confidence, p is the prevalence of "good health" among older persons, and e is the margin of error. Using Z = 1.96, p = 0.3 (estimate obtained from a previous study conducted on older adults in Japan),[20] and e = 0.05, the initial calculation for sample size was 322. This initial sample size was then multiplied by the 1.5 design effect and the two groups of estimates desired for the survey results (urban and rural), yielding a final figure of 966. Finally, 966 was divided by 0.80 to account for a 20% non–response rate. The final sample size calculation resulted in a total sample size of 1207. The inclusion criteria for the participants were: (1) aged 60 and over; (2) the ability to converse in Malay or English; (3) able to understand the research and agrees to cooperate; (4) registered residents of Malaysia (as household ledgers were used as the sampling frame); and (5) living at home.

The Research Ethics Committee of the National University of Malaysia has approved this study (FF-2018-532). The study was conducted in accordance with the principles of the Declaration of Helsinki, whereby participation was entirely at the discretion of the individuals involved. First, an explanation of the study and information sheets were given to each respondent. Then, once the respondents understood and gave consent, trained research assistants conducted face-to-face interviews.

Handgrip Strength

Handgrip strength (HGS) was measured in kilograms (kg) using a handgrip dynamometer model T.K.K. 5001 GRIP-A from Takei Scientific Instrument Co. Ltd. (Japan). The respondents were standing with their hands at their sides in a neutral position. The inner lever of the dynamometer was adjusted to fit the hand, and the respondents were instructed to squeeze the dynamometer as hard as possible for a few seconds. According to studies, a standing position with a straight elbow produces the highest grip strength readings.[21,22] The trained research assistants measured the HGS twice in each respondent's dominant hand, taking the mean for data analysis. The mean was calculated like the study conducted on the older Malaysian population.[16]

Independent Variables

Demographic variables included age, sex, marital status, household composition and education level. The household income was categorized into three groups based on the 2019 income structure of the Department of Statistics of Malaysia. The lower-income group earn less than RM4850 monthly, while middle-income group make between RM4851 and RM10,959. Lastly, higher-income group earn more than RM10,959.[23]

The study included smoking, alcohol consumption, and physical activity as lifestyle factors. Smoking and alcohol consumption were categorized into dichotomous variables, ie, "yes" forever smoking/alcohol consumption and "no" for never smoking/consuming alcohol. Physical activity for older adults was evaluated through three questions that assessed the intensity of the physical activities, including strenuous, moderate, and light physical activities. Each question has six options of answers to evaluate the frequency of the activities. A participant who achieved the following requirement were categorized as physically active; (1) Once a week of strenuous activities such as running, swimming, cycling, tennis, exercise at the gym, mountain climbing, or (2) Two to three times a week of moderate physical activities such as brisk pace walking, dancing, gymnastics, golf, farming, gardening, car washing; or (3) four or more times a week of light physical activities such as stretching/callisthenics workout, bowling, walking to shops or the station, or doing laundry. The questions have been adopted from the Bahasa Malaysia version of the Japan Gerontological Evaluation Study (BM-JAGES) questionnaire.[24]

The body mass index (BMI) was calculated using measurements of weight and height. The Malaysian BMI classification was used as a reference,[25] whereby the cut of points for obese is 27.5kg/m^2. Thus, we categorized the BMI into two groups that were non-obese (<27.5 kg/m^2) and obese (≥27.5 kg/m^2). Respondents have also been asked if they had hypertension, diabetes, dyslipidemia, heart disease, stroke, or cancer. The answer was either yes or no, and it was solely dependent on the respondent's reply. Additionally, we assessed depressive symptoms in older adults using the 15-item Geriatric Depression Scale (GDS). The GDS score is a numeric value between 0 and 15, with a higher value indicating more severe symptoms. A score of fewer than 5 points indicates no depression.[26]

Data Analyses

First, we checked the continuous data for normality using Kolmogorov–Smirnov (K-S) test. Then, the mean difference of HGS between groups of categorical variables was analyzed using the independent sample *t*-test or one-way analysis of variance (ANOVA). Post hoc Bonferroni tests were used for the ANOVA test when homogeneity of variance assumptions was met. Meanwhile, a value from Welch's ANOVA test was used for any violation of homogeneity of variance. Subsequently, post hoc Tamhane's test was used for within-group comparison.

Meanwhile, analysis of covariance (ANCOVA) was used to measure age-adjusted HGS. Age-adjusted was used to get relative HGS measurement when comparing the HGS between sex and other independent variables. Simple linear regression was used to estimate the relationship between two quantitative variables. The BMI was included as a continuous variable. Meanwhile, household income was a categorical variable as it was not normally distributed.

Multiple linear regression was used for multivariable analysis to test the main association with the HGS. The variables included in the regression model were age (as continuous data), sex, sociodemographic (marital status and education level), socioeconomic (employment status and household income), health-related behaviors (smoking status, alcohol consumption status, betel chewing status and physical activity), and NCDs (BMI, hypertension, diabetes and depression). The enter method of linear regression was used for multivariable analysis. In addition, we check interaction and multicollinearity. Variation inflation factor (VIF) was used for multicollinearity checking, whereby residual plot was used to check model assumption. A P-value of less than 0.05 was considered to indicate significance in all tests. Analyses were performed using IBM SPSS version 21.0 (IBM Corp., Armonk, NY, USA).

Results

Sociodemographic Characteristics

The majority of participants (83.2%) were Malay, followed by Indians (9.0%), Chinese (7.5%), and others (0.3%). The participants ranged in age from 60 to 91 years, with a mean of 68.7 (SD 6.36) years. Age was further classified into three age groups, and the overall older age group was significantly associated with lower handgrip strength (HGS) ($p<0.001$). Males (57.4%) outnumbered females (42.6%) slightly. There was a significant difference in mean HGS between males (30.0 kg (SD 7.5)) and females (19.4 kg (SD 5.28)) ($p<0.001$). After controlling for age, the mean HGS for males was 29.8 kg (95% CI; 29.31, 30.20). Meanwhile, the mean HGS for females was 19.6 kg (95% CI: 19.08, 20.12). The age-adjusted mean difference of HGS between males and females was 10.2 kg (95% CI:9.48, 10.84; $p<0.001$). Most participants were married and lived with their spouses (65.6%). Meanwhile, the number of married respondents who lived separately was too small [n=12, (1.0%)]. Thus, we have combined the two groups into one category, ie, married. Our study discovered that higher HGS among older people was significantly associated with marital status ($p<0.001$). Married respondents have significantly higher HGS than unmarried, widowed, or divorced respondents. Most participants lived with family members (94.7%), and high HGS was significantly associated with living with family members over living alone ($p<0.001$). However, the within-sex analysis revealed no significant relationship between HGS and household composition. Regarding educational level, 10% of participants had no formal education, 45.2% had a primary school education, 35.4% had a secondary school education, and 9.4% had studied at the tertiary level, including university and college. Those who studied at the tertiary level had a significantly higher HGS than those who had no school, primary and secondary level ($p<0.001$). A significant proportion of participants (86.0%) were unemployed, including pensioners and those who have never had a job. Those who were employed had a significantly higher HGS than those who were unemployed ($p<0.001$). Finally, when it comes to household income, most older adults (90.9%) fall into the low-income category. Those in the lower-income group had a significantly lower HGS than those in the middle income ($p<0.001$). However, there was no significant difference when comparing the HGS in the income group by sex. Table 1 shows the overall sociodemographic characteristics and health-related behaviours of the respondents, including the differences according to sex.

Association of HGS with the Health-Related Conditions

HGS was significantly associated with smoking status and alcohol consumption with p-values of <0.001 in both groups, whereby respondents with positive exposure to smoking and alcohol have higher HGS. However, analysis of sex, the HGS was not significantly associated with smoking and alcohol consumption in both sexes. Physical activity was also associated with HGS. Overall, older adults who performed a minimum of light activity four or more times weekly had a significantly higher HGS than those who less exercised ($p<0.001$). Analysis of sex groups also supported the association.

The presence of hypertension, diabetes mellitus, cancer and depression were also significantly associated with a reduction of HGS with a p-value of <0.001, <0.001, 0.009 and 0.011, respectively. However, only diabetes was significantly associated with HGS for males after controlling for age, while obesity was associated with HGS among females. The mean HGS for diabetes males was 28.5 kg (95% CI; 27.65, 29.33). Meanwhile, the mean HGS for non-diabetes males was 30.8 kg

Table 1 Demographic, Socioeconomic Characteristics, and the Behavioral Lifestyles of Respondents

Variables	Total			Male			Female		
	N (%)	HGS (kg) Mean (SD)	P-value	N (%)	HGS (kg) Mean (SD)	P-value	N (%)	HGS (kg) Mean (SD)	P-value
Sex									
Male	691 (57.4)	30.0 (7.53)	<0.001[a]						
Female	513 (42.6)	19.4 (5.29)							
Age group[d]									
Young old (60–74 years)	996 (82.7)	26.7 (8.19)	<0.001[c]	588 (85.1)	31.1 (7.16)	<0.001[c]	408 (79.5)	20.5 (4.82)	<0.001[c]
Middle old (75–84 years)	186 (15.4)	19.9 (6.97)		96 (13.9)	23.8 (6.49)		90 (17.5)	15.7 (4.66)	
Old old (≥85 years)	22 (1.8)	14.6 (6.37)		7 (1.0)	20.9 (4.57)		15 (2.9)	11.6 (4.74)	
Marital status									
Married	802 (66.6)	28.1 (8.13)	<0.001[a]	615 (89.0)	30.3 (7.54)	<0.001[a]	187 (36.5)	20.7 (5.02)	<0.001[a]
Unmarried/widowed/divorced	402 (33.4)	20.2 (6.51)		76 (11.0)	27.2 (6.75)		326 (63.5)	18.6 (5.28)	
Household composition									
Live alone	64 (5.3)	20.8 (6.31)	<0.001[a]	13 (1.9)	27.9 (7.12)	0.308[a]	51 (9.9)	19.0 (4.64)	0.568[a]
Live with family/friend	1140 (94.7)	25.7 (8.51)		678 (98.1)	30.0 (7.53)		462 (90.1)	19.4 (5.35)	
Location									
Rural	602 (50.0)	25.3 (8.63)	0.403[a]	339 (49.1)	29.9 (7.82)	0.775[a]	263 (51.3)	19.3 (5.29)	0.668[a]
Urban	602 (50.0)	25.7 (8.34)		352 (50.9)	30.1 (7.25)		250 (48.7)	19.5 (5.28)	
Education Level[d]									
No school	121 (10.0)	19.9 (6.98)	<0.001[c]	25 (3.6)	26.6 (8.85)	<0.001[c]	96 (18.7)	18.2 (5.18)	0.006[c]
Primary	544 (45.2)	24.1 (8.13)		285 (41.2)	28.7 (7.57)		259 (50.5)	19.1 (5.31)	
Secondary	426 (35.4)	27.6 (8.24)		289 (41.8)	31.0 (7.00)		137 (26.7)	20.4 (5.03)	
Tertiary	113 (9.4)	29.9 (8.02)		92 (13.3)	32.0 (7.52)		21 (4.1)	21.0 (5.85)	
Current employment									
Employed	169 (14.0)	29.3 (7.86)	<0.001[a]	128 (18.5)	31.8 (6.88)	0.002[+]	41 (8.0)	21.4 (4.95)	0.011[a]
Unemployed	1035 (86.0)	24.8 (8.42)		563 (81.5)	29.6 (7.60)		472 (92.0)	19.2 (5.28)	
Household income[e]									
B40 (lower income)	1094 (90.9)	25.2 (8.42)	<0.001[b]	609 (88.1)	29.8 (7.57)	0.074[b]	485 (94.5)	19.3 (5.23)	0.555[b]
M40 (middle income)	98 (8.1)	28.5 (8.70)		71 (10.3)	31.9 (6.91)		27 (5.3)	19.6 (6.25)	
T20 (upper income)	12 (1.0)	29.3 (7.41)		11 (1.6)	29.7 (7.64)		1 (0.2)	25.0 (0.0)	

(*Continued*)

Table 1 (Continued).

Variables	Total			Male			Female		
	N (%)	**HGS (kg) Mean (SD)**	**P-value**	**N (%)**	**HGS (kg) Mean (SD)**	**P-value**	**N (%)**	**HGS (kg) Mean (SD)**	**P-value**
Smoking status									
Yes	424 (35.2)	29.9 (7.64)	<0.001[a]	405 (58.2)	30.3 (7.43)	0.148[a]	19 (3.7)	20.1 (5.08)	0.524[a]
No	780 (64.8)	23.1 (7.94)		286 (41.4)	29.5 (7.63)		494 (96.3)	19.3 (5.30)	
Alcohol consumption									
Yes	120 (10.0)	29.4 (8.18)	<0.001[a]	104 (15.1)	33.5 (6.33)	0.179[a]	16 (3.1)	20.2 (5.95)	0.547[a]
No	1084 (90.0)	25.0 (8.40)		587 (84.9)	29.8 (7.51)		497 (96.9)	19.3 (5.27)	
Physically active									
Yes	877 (72.8)	26.5 (8.10)	<0.001[a]	510 (73.8)	31.1 (6.64)	<0.001[a]	367 (1.5)	20.1 (5.00)	<0.001[a]
No	327 (27.2)	22.8 (8.89)		181 (26.2)	26.9 (8.89)		146 (8.5)	17.6 (5.58)	

Notes: [a]Independent sample *t*-test. [b]One-way ANOVA. [c]Welch's ANOVA test as homogeneity of variance was violated. [d]Post hoc Tamhane's test for overall are all significant. [e]Post hoc Bonferroni, the only significance in the overall group was "B40" with "M40".

Abbreviations: HGS, handgrip strength; SD, standard deviation; kg, kilogram.

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(95% CI: 30.99, 31.42). The age-adjusted mean difference of HGS between diabetes and non-diabetes male participants was 2.3 kg (95% CI: 1.27, 3.36; p<0.001). The mean HGS for obese females was 19.8 kg (95% CI; 19.24, 20.42). Meanwhile, the mean HGS for non-obese females was 18.9 kg (95% CI: 18.4, 19.5). Thus, the age-adjusted mean difference of HGS between obese and non-obese female participants was 0.9 kg (95% CI: 0.08, 1.71; p=0.032). The values of unadjusted mean HGS and age-adjusted mean HGS for selected NCDs are shown in Table 2.

Multivariable Analysis

Finally, the multivariable analysis revealed that increasing age, inactivity, and diabetes were all associated with a decrease in HGS in males. Meanwhile, the HGS was significantly reduced with age, physically inactive, and hypertension for females. However, female handgrip strength was positively related to the BMI (Table 3). Neither interaction nor collinearity was present. The model explains 25.6% and 29.0% of the variation of an HGS value in males and females. We do not include five significant independent variables of univariate analysis in the multivariable analysis as the number of samples was too small. These independent variables include household composition, alcohol, betel chewing, cancer and stroke.

Discussion

The present study provided a better understanding of the HGS and related risk factors, as intended with the aim of the study. The HGS is part of functional assessment, and a previous study showed that functional evaluation might give an insight into multimorbidity and mortality risk, especially for older adults.[27] Thus, in our study, the value of HGS declined with increasing age, physical inactivity, diabetes for males and hypertension for females.

The value of HGS declined with increasing age and was higher among males were well understood as it is related to normal physiological changes. Therefore, we will not discuss the differences due to age and gender in depth. However, we would like to highlight a study that used a sex hormone to increase muscle mass that reported exogenous testosterone improved HGS in older men.[28] However, hormone therapy did not appear to enhance handgrip ability among older females. A recent study showed that among premenopausal females, testosterone was not associated with lean body mass or HGS.[29]

In this study, many sociodemographic factors were not associated with HGS. There was no significant relationship between HGS and older adults' location, whether they lived in urban or rural areas. The same is true for educational attainment and household income. This is probably because their sociodemographic characteristics are nearly identical. However, research conducted in Indonesia indicates that rural-dwelling older females have a lower HGS.[30] Additionally, the study discovered that older males with a higher level of education and a middle-class economic background had a significantly higher HGS.[30]

For health-related behavior, we found that being physically active have a linear association with HGS. The finding was supported by a study measuring the pre- and post-HGS after a regular physical activity intervention among older individuals.[12] A similar result was noted by Yasunaga et al.[31] Muscle strength and function can be improved through physical activity and resistance exercise.[5] Physical activity directly stimulates skeletal muscle and subsequently leads to improved muscle mass and higher HGS,[32] which reduce the likelihood of sarcopenia. Reduction of muscle mass related to defective mitochondrial energetics. Exercises or physical activity improves mitochondrial respiration, hence mitigating muscle mass losses.[33] Meanwhile, in the bivariate analysis, we found that smoking and drinking alcohol were positive associated with HGS. It is contrary to the existing evidence that smoking and alcohol cause a lack of skeletal muscle strength.[34,35] However, in this study, respondents who smoked and drank alcohol were younger, which resulted in their HGS values being higher than those who never smoked and drank alcohol. Nonetheless, a study conducted in Japan discovered that HGS levels increased significantly with increased daily alcohol consumption.[36]

In terms of HGS and comorbidities, diabetes was associated with low HGS among older males. It was consistent with a study conducted in China as the HGS level decreased from normoglycemia to prediabetes and diabetes mellitus.[37] Furthermore, the same finding was seen in the study, whereby the HGS was not statistically significant in diabetic females. The result was explained with a high-sensitivity C-reactive protein (hsCRP) level, inversely associated with the HGS. The males have a higher level of hsCRP, leading to muscle strength loss and declining HGS levels than females.[38]

Table 2 Values of Handgrip Strength (HGS) According to the Selected Noncommunicable Diseases (NCDs)

Variable	N (%)	HGS (kg) Mean (95% CI)	P-value [a]	N (%)	Age Adjusted HGS (kg) for Male Mean (95% CI)	P-value [b]	N (%)	Age Adjusted HGS (kg) for Female Mean (95% CI)	P-value [b]
Obesity									
Yes	491 (40.8)	25.4 (24.61, 26.12)	0.807	250 (36.2)	29.4 (28.54–30.22)	0.081	241 (47.0)	19.8 (19.24–20.42)	0.032
No	713 (59.2)	25.5 (24.86, 26.11)		441 (63.8)	30.3 (29.69–30.97)		272 (53.0)	18.9 (18.39–19.49)	
Hypertension									
Yes	775 (64.4)	24.8 (24.17, 2536)	<0.001	420 (60.8)	29.9 (29.23–30.51)	0.119	355 (69.2)	19.1 (18.63–19.59)	0.057
No	429 (35.6)	26.7 (25.94, 2754)		271 (39.2)	30.4 (29.60–31.29)		158 (30.8)	20.0 (19.24–20.68)	
Diabetes Mellitus									
Yes	434 (36.0)	24.3 (23.49, 25.08)	<0.001	242 (35.0)	28.5 (27.65–29.33)	<0.001	192 (37.4)	18.9 (18.21–19.51)	0.050
No	770 (64.0)	26.1 (25.54, 26.73)		449 (65.0)	30.8 (30.19–31.42)		321 (62.6)	19.7 (19.18–20.18)	
Dyslipidaemia									
Yes	570 (47.3)	25.1 (24.30, 26.47)	0.139	316 (45.7)	29.6 (28.88–30.37)	0.185	254 (49.5)	19.4 (18.86–20.00)	0.798
No	634 (52.7)	25.8 (25.15, 26.47)		375 (54.3)	30.3 (29.62–30.99)		259 (50.5)	19.3 (18.76–19.88)	
Heart Disease				99 (14.3)					
Yes	139 (11.5)	25.4 (24.00, 26.83)	0.936	99 (14.3)	29.7 (28.31–30.98)	0.579	40 (7.8)	18.0 (16.53–19.43)	0.05
No	1065 (88.5)	25.5 (24.97, 25.99)		592 (85.7)	30.1 (29.51–30.60)		473 (92.2)	19.5 (19.07–19.90)	
Stroke									
Yes	48 (4.0)	24.3 (21.88, 26.68)	0.323	29 (4.2)	30.0 (27.44–32.37)	0.942	19 (3.7)	18.5 (16.38–20.54)	0.380
No	1156 (96.0)	25.5 (25.03, 26.01)		662 (95.8)	30.0 (29.48–30.51)		494 (96.3)	19.4 (19.00–19.81)	
Cancer									
Yes	25 (2.1)	21.1 (14.76, 24.40)	0.009	11 (1.6)	27.2 (23.14–31.16)	0.161	14 (2.7)	17.6 (15.15–19.97)	0.135
No	1179 (97.9)	25.6 (25.08, 26.05)		680 (95.4)	30.0 (29.53–30.55)		499 (97.3)	19.42 (19.02–19.83)	
Depression									
Yes	152 (12.6)	23.8 (22.50, 25.19)	0.011	81 (11.7)	29.0 (27.50–30.44)	0.147	71 (13.8)	18.4 (17.34–19.84)	0.058
No	1052 (57.4)	25.7 (25.19, 26.22)		610 (88.3)	30.1 (29.59–30.67)		442 (86.2)	19.5 (19.10–19.96)	

Notes: [a]Unadjusted using univariate ANCOVA. [b]Adjusted for age as covariate using univariate ANCOVA.
Abbreviations: HGS, handgrip strength; kg, kilogram; 95% CI, 95% confidence interval;

Table 3 Factors Associated with Handgrip Strength (Kg) Among the Study Population

	Male				Female			
Variables	**Simple Linear Regression**		**Multiple Linear Regression[a]**		**Simple Linear Regression**		**Multiple Linear Regression[b]**	
	B [c]	**(95% CI)**	**Adj. *B*** [d]	**(95% CI)**	***B*** [c]	**(95% CI)**	**Adj. *B*** [d]	**(95% CI)**
Age (year)	−0.565 *	(−0.651, −0.480)	−0.495*	(−0.588, −0.402)	−0.378 *	(−0.436, −0.321)	−0.320 *	(−0.384, −0.255)
Unmarried [e]	−3.187 *	(−4.968, −1.406)	−0.520	(−2.142, 1.102)	−2.082 *	(−3.018, −1.146)	−0.504	(−1.361, 0.352)
Primary education [f]	−2.253 *	(−3.383, −1.124)	1.643	(−1.048, 4.334)	−0.460	(−1.376, 0.457)	–	–
Secondary education [f]	1.675 #	(0.543, 2.808)	2.001	(−0.715, 4.716)	1.389 #	(0.359, 2.419)	−0.187	(−1.109, 0.736)
Tertiary education [f]	2.257 #	(0.612, 3.903)	2.650	(−0.345, 5.645)	1.672	(−0.639, 3.984)	–	–
Unemployed [g]	−2.260 #	(−3.697, −0.823)	−0.346	(−1.653, 0.960)	−2.180 #	(−3.861, −0.499)	−0.437	(−1.906, 1.031)
Lower income [h]	−1.847 #	(−3.580, −0.114)	1.249	(−2.804, 5.302)	−0.418	(−2.438, 1.601)	–	–
Middle income [h]	2.149 #	(0.305, 3.993)	2.131	(−2.094, 6.355)	0.213	(−1.842, 2.268)	–	–
Smoking history [i]	0.840	(−0.299, 1.980)	–	–	0.788	(−1.640, 3.217)	–	–
Physically inactive [j]	−4.158*	(−5.398, −2.918)	−2.896 *	(−4.032, −1.759)	−2.435 *	(−3.430, −1.441)	−1.802 *	(−2.691, −0.913)
BMI (kg/m^2)	0.143 #	(0.026, 0.261)	–	–	0.199 *	(0.114, 0.284)	0.155 *	(0.077, 0.233)
Hypertension [k]	−0.744	(−1.894, −0.406)	–	–	−1.456 #	(−2.442, −0.470)	−0.975 #	(−1.853, −0.097)
Diabetes [l]	−2.433 *	(−3.597, −1.269)	−2.197 *	(−3.260, −1.134)	−0.478	(−1.426, 0.469)	–	–
Depression [m]	−1.455	(−3.199, 0.289)	–	–		(−1.258, 0.067)	–	–

Notes: *P< 0.001, #P< 0.05. [a]R^2=0.256; Constant=61.210; The model reasonable fits well; Model assumption are met; No interaction between the variables; No multicollinearity problem. [b]R^2=0.290; Constant=39.197; The model reasonable fits well; Model assumption are met; No interaction between the variables; No multicollinearity problem. [c]Crude regression coefficient. [d]Adjusted regression coefficient. [e]Married as reference. [f]No school as a reference. [g]Employed as a reference. [h]Higher income as a reference. [i]No smoking as a reference. [j]Physically active as a reference. [k]No hypertension as a reference. [l]No diabetes as a reference. [m]No depression as a reference.
Abbreviations: *B*, unstandardized coefficient; 95% CI, 95% confidence interval; Adj, adjusted; BMI, body mass index.

Meanwhile, older females with hypertension were significantly associated with reducing HGS. A possible explanation for this effect includes improvements in skeletal muscle mass, and muscle contraction may also improve the autonomic regulation of heart rate and blood pressure.[39] However, some studies with a large sample showed positive effects on hypertension with HGS.[40]

On the other hand, this study revealed that BMI was associated with HGS for females but not males. A similar finding was observed in a few studies, which showed obesity was associated with higher HGS.[30,41–43] Furthermore, the ageing process and low muscle mass contribute to low muscle strength and vice versa.[44] Subsequently, it affects HGS measurement among older adults. Nonetheless, few studies have found contradictory results regarding central obesity and HGS.[45,46] Moreover, evidence showed that high BMI is associated with a higher risk of disability, and lower BMI has better individuals' daily functionality.[47]

This study has some limitations as the variables were self-reported and no supportive data such as health reports to confirm them. Secondly, the study did not capture other factors related to HGS, such as nutritional status and muscle mass. The study also does not include the older adults living in the institution or nursing home. However, since most older adults in Malaysia live outside the nursing home, the number of older adults in a nursing home is negligible. Besides that, given the cross-sectional design of the study, the factors cannot be said as the true cause that affects the gender differences in the HGS. Nevertheless, the study is a population-based study and managed to cover a good proportion of the older population and was similar to the demographics of the older adults in Malaysia. However, a cautious interpretation is necessary as the study may not represent older Malaysian adults.

Conclusion

Based on our aim, we have uncovered slight differences between male and female older adults in the factors associated with HGS. Overall, increasing age and being physically inactive were associated with a reduction in HGS. Diabetes was associated with HGS in males, whereas hypertension was associated with HGS in females. In addition, BMI was positively related to HGS for older females. Therefore, the routine use of handgrip measurement to assess older adults with chronic diseases should be more involved in clinical practice.

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