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Original Article

Predictors of Handgrip Strength among the Free Living Elderly in Rural Pahang, Malaysia

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Abstract

Background: Reduced handgrip strength is an aging process that significantly influences the living activities of elderly. It is linked to premature mortality, disability and other health complications among elderly. Therefore, we aim to determine the associated predictors with handgrip strength among the free living elderly in Malaysia.

Methods: This was a cross sectional study conducted in a rural state in Malaysia. A total of 434 elderly individuals performed handgrip assessment. Socio-demographic characteristics, medical conditions, occupational history, functional ability (ADL) and depression (GDS) were enquired. Anthropometric measurements (weight and height) were also obtained.

Results: Majority of the respondents were Malays with mean age of 67.9 $\pm$ 6.3 years. Maximum handgrip strength of males and females were 28.8$\pm$9.2 kg and 18.9$\pm$6.9 kg respectively (P<0.05). The aborigines had significantly lower handgrip strength (P<0.05) compared to Malays, Chinese and Indians. Handgrip strength was positively correlated (P<0.05) with weight, height and ADL, while negatively associated (P<0.05) with GDS for both gender. In the multivariate linear regression analysis; weight, height and race significantly predicted handgrip strength among both male and female elderly after adjustment for all potential confounders. However, GDS and ADL were only found to significantly predict handgrip strength among the male elderly; while age was only significant among the females.

Conclusion: Our sample population has significantly lower handgrip strength than the Western counterpart. Weight, height and race significantly predict handgrip strength among both male and female elderly. GDS, ADL are only found to be significant in males while age was only significant among the females.

Keywords: Elderly, Handgrip strength, Anthropometry, Malaysia

Introduction

"Malaysia is experiencing improved health, longer life expectancy, and low mortality as well as declining fertility" (1). This has brought about a change in the demographic profile of the country. Based on our population projections, the number of elderly in Malaysia will grow from 1.4 million (6.3%) in 2000 to 4.9 million (12.0%) by the year 2030, thus doubling in proportion, but more than tripling in numbers over the 30 year period (2) .

With this increased proportion, there is an increasing demand for the needs of elderly. These increased needs of elderly are largely due to the aging process that occurs. Studies have shown that decrease muscle mass and muscle size is one of the aging processes that will decrease handgrip strength (3-7). Reduced handgrip strength has also been consistently linked to premature mortality, disability and other health complications among elderly (8-10).

It is crucial to maintain muscle strength throughout life to reduce functional limitations that might closely relate to early death among the elderly. Evidences showed handgrip strength declined with advancing age (4-7) and positively related to nutritional status (4, 11-

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12). However, occupation history gave controversial results on handgrip strength. Some studies (13-14) demonstrated that elderly with history of doing heavy agricultural or manual work performed better handgrip strength as age progressed while another study showed contradicting results (15). Other factors such as depression (16) and medical conditions (10, 17) were also found to be predictors of handgrip strength. All the above have been extensively studied in the West; however there is a lack of such studies in Malaysia. We need to know the predictors of handgrip strength among elderly in our country to facilitate appropriate intervention programs. Therefore, our study aimed to determine the baseline handgrip strength and associated predictors of handgrip strength among free living elderly in the state of Pahang, Malaysia.

Materials and Methods

Study location and sampling method

This was an analytical cross-sectional study conducted in the state of Pahang, Malaysia. Pahang is a geographically diverse state that locates at the centre of Peninsular Malaysia which ranges from mountainous country in its west to its coastline in the east. About 50% of its total land area is covered by forest, 23.4% agricultural land and the rest are government land (16.3%), urban and industrial land (10.8%). The population consists of majority Malays, follows by Chinese, Indians and Aborigines. This study was conducted in the rural area of Pahang. The sampling method was multi-staged sampling of households from villages of five districts in the state. Sampled households were considered non-responsive if the household members were not available after being approached twice.

The total number of elderly from selected households in the five districts was 547 of whom 434 had their handgrip measurements taken (response rate=79.3%). Reasons of non response were unavailability (after two visits) or decline to participate, and inability to perform handgrip assessment among those severely ill elderly.

Data collection

Ethics approval was obtained from the ethics committee of University Malaya Medical Centre and informed consent (Appendix A) was obtained from all respondents. Face to face interview was performed using a standardized questionnaire (examples as attached in Appendix B). Data collection included details of socio-demographic characteristics, medical history, Activity of Daily Living (ADL), Geriatric Depression Scale (GDS), occupational history, anthropometric measurement (height and weight) and handgrip measurement by Jamar handgrip dynamometer (Model 5030J1 by Lafayette Instrument). All measurements were taken following standardized protocols (18-19). Barthel Index (20) was used to measure the activities of daily living (ADL). GDS-15 was used to evaluate the depressive symptoms of the elderly (21-22). Body Mass Index (BMI) was calculated using the formula of weight in kilogram / (height in meter) (2). The handgrip measurement (Fig. 1) was repeated three times on both hands each with at least 15 seconds recovery between each effort. All readings were recorded in kilogram (kg) with one highest reading chosen for the analysis.

Occupational history

The occupational history was evaluated based on “ever worked”, “current working status”, “type of job” and a modified ‘Dutch Musculoskeletal Questionnaire' (DMQ). The modified 'Dutch Musculoskeletal Questionnaire' (23) focused on force, dynamic and static load; and vibration components in the past occupation. For each question, a Likert scale (24) of 0 to 3 was used. Zero was taken for “not at all”, 1 for “2 hours in a day”, 2 for “exposure between 2 to 4 hours per day”, 3 for “more than 4 hours per day”. All scores were summed up in order to measure the amount of force and workload in one’s occupation. Types of job was classified

into professional (with a university degree), semi-professional (with diploma or equivalent), skilled (undergone training or short courses), semi-skilled (never undergone training but job requires specific skill) and unskilled (job does not require specific skill) (23).

Statistical analysis

All continuous variables were tested for normality using the Kolmogorov–Smirnov test and Levene's test was used to test for homogeneity of variances before conducting *t*-test or one-way ANOVA. Categorical variables were analyzed using Chi^2 tests. All statistical analyses were stratified by gender as evidences showed gender difference in handgrip strength (6, 25). Independent t-test was used to test the difference between the mean handgrip measurements of two groups such as marital status, ever attended school, medical conditions and working status. One-way ANOVA was used to test the difference between mean handgrip measurements of multiple groups (eg: race, occupation etc). Correlation was used to assess the strength of association between handgrip strength and continuous variables such as age, BMI, DMQ, ADL, GDS and anthropometric measurements (height and weight). These analyses enabled an assessment of their potential confounding influence on handgrip strength.

Backward multiple regression analyses were carried out to assess possible predictors of handgrip strength. Predictors entered into the models were those found to have significant association with handgrip strength with entry and exit limits set at $P<0.05$ and $P<0.1$ respectively. Assumptions of multiple linear regressions were checked. Colinearity among possible predictors was carefully examined and tested before the final model was produced. Body Mass Index (BMI) was excluded from the final model as there was strong colinearity with weight and height as shown by Tolerance and Variance inflation factor (Male: TOL=0.01, VIF=105; Female: TOL= 0.009, VIF=108.0). Data entry and analysis was conducted using Statistical Package of Social Science (SPSS) for windows version 15.0.

Results

There were 547 respondents with a mean age of 67.9 $\pm$ 6.3 years. About half of them were males and majority was Malays and married. Table 1 shows the gender specific socio-demographic characteristics of the elderly. There were more widowed females than males. More males were working currently compared to female elderly. Hypertension, diabetes mellitus and hyperlipidemia were the most common medical conditions among these elderly. About 60 to 70% of the elderly were overweight and obese using the WHO criteria for Asians (26); however, there were more obese females than males.

Table 2 shows the mean age, weight, height, BMI, handgrip strength, ADL, DMQ and GDS of the elderly. The female elderly were significantly older than the males. Both their mean weight and height were significantly lower than the male elderly. However, their mean BMI were higher than the males. The male elderly had significantly higher handgrip strength, ADL and DMQ than their counterpart. On the other hand, the female elderly had higher GDS score.

Referring to Table 3, only race and ever attended school were significantly associated with handgrip strength ($P<0.05$). The aborigines had lowest handgrip strength compared to Malays, Chinese and Indians; while elderly who had ever attended school had significantly better handgrip strength. There was also no consistent trend between medical conditions and handgrip strength. Occupation history such as ever worked, job groups, currently working did not show statistical association with handgrip strength.

For males, age and GDS were negatively correlated with handgrip strength ($P<0.05$). As age and GDS increased, handgrip strength significantly declined. On the other hand, weight,

height, BMI, ADL were positively correlated with handgrip strength (P<0.05). As for females, similar results were found except ADL and GDS were not significantly correlated with handgrip strength. The findings are shown in Table 4.

Table 5 shows the Multiple Linear Regression models for males and females conducted with all significant predictors entered into the model with a backward method. The significant predictors identified for males in the final model were weight, height, race, ADL and GDS while weight, height, race and age were found to be statistically significant in the regression model for females after adjusted for all confounders.

Fig. 1: Handgrip measurement using the Jamar Dynamometer

Table 1: Socio-demographic characteristics, medical conditions and BMI categories of the elderly by sex

		Male n (%)	Female n (%)
Race:	Malay	218 (79.3)	207 (76.1)
	Chinese	43 (15.6)	49 (18.0)
	Indian	5 (1.8)	9 (3.3)
	Aborigines	9 (3.3)	7 (2.6)
**Marital status:	Married	260 (95.2)	172 (63.5)
	Widowed/Divorced/Single	13 (4.8)	99 (36.6)
** Ever attended school		235 (85.5)	158 (58.1)
**Ever worked		268 (98.5)	169 (64.5)
**Job groups:	Professional/semi-professional	22 (8.9)	2 (0.9)
	Skilled worker	21 (8.5)	12 (5.4)
	Semi-skilled worker	153 (62.2)	69 (31.1)
	Unskilled worker	43 (17.5)	36 (16.2)
	Never worked	7 (2.8)	103 (46.4)
**Currently working		132 (48.4)	33 (12.3)
Medical conditions:	*Hypertension	99 (36.0)	132 (48.5)
	High cholesterol	39 (14.2)	39 (14.3)
	Heart problem	32 (11.6)	19 (7.0)
	*Diabetes mellitus	33 (12.0)	52 (19.1)
	*Chronic lung problem	28 (10.2)	15 (5.5)
	Stroke	5 (1.8)	12 (4.4)
*BMI categories:	Underweight	18 (6.8)	20 (7.9)
	Normal weight	81 (30.6)	55 (21.7)
	Overweight	109 (41.1)	86 (34.0)
	Obese	57 (21.5)	92 (36.4)

*P<0.05, **P<0.001 – comparison between males and females

Table 2: Mean age, anthropometric measurement, handgrip strength, ADL, DMQ and GDS of the elderly by sex

	n	Male (mean + s.d.)	n	Female (mean + s.d.)	P value
Age (yr)	275	67.3 ± 5.7	272	68.6 ± 6.9	0.02
Height (cm)	265	160.3 ± 6.9	254	148.4 ± 7.5	<0.001
Weight (kg)	266	63.2 ± 12.1	253	57.0 ± 12.5	<0.001
BMI (kg/m^2)	265	24.5 ± 4.2	252	25.7 ± 5.1	0.007
Handgrip	221	28.8 ± 9.2	213	18.9 ± 6.9	<0.001
ADL	253	97.5 ± 7.0	255	95.4 ± 12.6	0.021
DMQ	259	4.2 ± 3.9	249	2.5 ± 2.8	<0.001
GDS	263	3.2 ± 2.5	261	3.8 ± 2.6	0.012

Table 3: Association of handgrip strength with socio-demographic characteristics, occupation history and medical conditions

		Male		Female	
		n	(mean + s.d.)	n	(mean + s.d.)
Race:	Malay	174	28.7 ± 8.7	160	19.1 ± 6.9
	Chinese	35	31.8 ± 9.2	40	19.8 ± 6.6
	Indian	4	35.0 ± 4.8	8	14.5 ± 4.7
	Aborigines	8	14.9 ± 10.4*	5	11.6 ± 4.6*
Marital status:	Married	210	28.8 ± 9.4	138	18.5 ± 6.3
	Widowed/Single	11	28.5 ± 5.6	75	19.6 ± 7.9
Ever attended school:	Yes	190	29.6 ± 8.6*	126	19.8 ± 6.4*
	No	31	24.0 ± 11.5	86	17.6 ± 7.5
Ever worked :	Yes	216	28.8 ± 9.2	137	19.0 ± 7.3
	No	5	29.0 ± 12.6	76	18.7 ± 6.2
Job groups:	Professional/ semi-professional	17	25.9 ± 9.3	1	21.0
	Skilled worker	19	29.7 ± 10.6	9	20.2 ± 7.7
	Semi-skilled worker	120	29.9 ± 9.1	55	19.8 ± 7.2
	Unskilled worker	37	26.4 ± 8.6	31	17.7 ± 8.6
	Never worked	5	29.0 ± 12.6	76	18.7 ± 6.2
Currently working:	Yes	101	29.6 ± 8.7	25	20.9 ± 6.4
	No	120	28.1 ± 9.7	187	18.7 ± 6.9
Hypertension:	Yes	90	28.1 ± 9.0	110	19.6 ± 7.3
	No	131	29.3 ± 9.4	103	18.2 ± 6.4
High cholesterol :	Yes	32	31.2 ± 9.3	30	19.4 ± 7.0
	No	189	28. 1 ± 9.1	183	18.8 ± 6.9
Heart disease:	Yes	29	31.6 ± 10.6	14	18.2 ± 5.2
	No	192	28.4 ± 8.9	199	18.9 ± 7.0
Diabetes mellitus:	Yes	31	28.9 ± 11.5	41	20.6 ± 9.1
	No	190	28.8 ± 8.9	172	18.5 ± 6.2
Lung disease:	Yes	26	29.2 ± 11.1	14	18.2 ± 9.1
	No	195	28.8 ± 9.0	199	18.9 ± 6.7
Stroke:	Yes	5	29.4 ± 7.6	9	17.1 ± 6.1
	No	216	28.8 ± 9.3	204	18.9 ± 6.9

*P<0.05

Table 4: Correlation of quantitative variables with handgrip strength

Handgrip	Age	Height	Weight	BMI	DMQ	ADL	GDS
Male	-0.236***	0.346 ***	0.298***	0.150*	0.101	0.175*	-0.222**
Female	-0.280***	0.255***	0.302***	0.220**	0.085	0.064	-0.115

*<0.05, **<0.01, ***<0.001

Table 5: Gender specific Multiple Linear Regression models with backward regression analysis

		Handgrip measurement			
		R^2	Beta	SE	*P*
Male	Weight	0.24	0.11	0.05	0.035
	Height		0.37	0.09	<0.001
	Race		-0.14	0.81	0.078
	ADL		0.18	0.08	0.037
	GDS		-0.57	-0.23	0.013
Female	Weight	0.16	0.106	0.04	0.013
	Height		0.167	0.08	0.031
	Race		-1.51	0.71	0.035
	Age		-0.14	0.07	0.042

Male: Adjusted for race, age, ever attended school, weight, height, ADL, GDS
Female: Adjusted for race, age, ever attended school, weight, height

Discussion

Socio-demographic characteristics, medical conditions and others by gender

The majority of free living elderly in the rural Pahang were of Malay ethnicity. The females were significantly older than the males and there were a significantly higher proportion of females being widows. A large proportion of females had never attended school (approximately 40%), never worked (35%) and only 12% of them were currently working. Due to their lower education level, most of them who ever worked only worked as semi-skilled or unskilled worker previously. However, DMQ which reflected the amount of force and workload in one's occupation was found to be higher in males. This could be due the types of jobs that the female elderly did were less demanding in term of force.

There were also more females with hypertension and diabetes mellitus compared to males. Female elderly were older than males and older age among the females probably predisposed them to these chronic diseases. Being older and with a higher proportion of them being widows, the female elderly had lower Activity Daily Living (ADL) and higher Geriatric Depression Score (GDS) than males. Other studies too showed that depression levels tended to be higher among the female elderly (27) and those separated from their spouse due to death (28).

Characteristics of handgrip strength of all respondents

The maximum right and left handgrip strength of the whole sample was 23.1±9.1kg and 21.7±9.4kg respectively (results not shown). The right handgrip strength was higher than the left. These findings were much lower compared to that of the western elderly. In western populations, the mean handgrip strength can be as much as 1.5 times greater than in the Malaysian population (29). Males had significantly higher handgrip strength than females in both hands. Similar sex differences were seen in other stud-

ies (4, 25, 29-30). Lower handgrip strength among females may be due to lower strength per cm^2 arm muscle area (13). Handgrip strength was also found to be progressively declined with age ($P<0.05$) as reported in previous studies (1, 4-5, 31).

Since there were marked gender differences in most predictors as mentioned above, all analyses of handgrip strength were stratified by gender. In the Multivariate Linear Regression model for males, after adjusted for race, age, ever attended school, weight, height, ADL and GDS; only race, weight, height, ADL and GDS remained statistically significant. For females: race, weight, height and age were found to be statistically significant after adjusted for race, age, ever attended school, weight and height.

Aborigines were found to have significantly lower handgrip strength than Malays, Chinese and Indians. This might be due to these aborigines having lower height and weight compared to their counterparts (results not shown). Genetic variation, health status and different lifestyle (29, 32) could also be the reasons for the observed difference between our findings with the West as well as the difference between the aborigines with Malays, Chinese and Indians.

Handgrip strength progressively declined with age among the female elderly ($P<0.05$). This may be due to nutritional deficit (33), lower hormonal level (34), lower body weight (34), diminished use of muscle (34-35), reduced physical activity or sedentary lifestyle (5) and poor health in the elderly (35).

Elderly who had higher weight and height were found to have significantly higher handgrip measurements. Similar results were shown by Kamarul et al. on Malaysian population (29) and other studies (5, 18). Height was closely related to lean mass (muscles, bone and non-fat tissues) (36) and elderly who were taller would probably have more lean mass and better handgrip strength. Elderly who were of low body weight may have low muscle mass and hence weaker physical strength, resulting in poor handgrip measurement. Lower muscle mass could be related to under nutrition or chronic disuse commonly associated with advancing age. The result of this study was in agreement with studies by Chilima (4), Bautman et al. (37) and Ferdous et al. (12) which proved the association of elderly's poor nutritional status with poor functional ability and strength.

Activity Daily Living (ADL) is commonly used as predictors for health conditions and muscle strength among elderly (38). It was found to be positively associated with handgrip measurement in the males' model. Elderly who had higher ADL index had higher measurement in handgrip strength as found in previous studies (12, 39). GDS was found to be a significant predictor for handgrip strength in the males' model too. As GDS increased, handgrip strength declined as shown by other study (40). However, these two predictors were only significant in the males' model. It is not fully understood why GDS and ADL were not significant in the females' model. Occupation history was not found to be associated with handgrip strength among this sample population. The reason could be due to the respondents' occupations were not too diverse, hence giving a narrow range of ADL score. Further studies need to be conducted to verify these findings.

Among all predictors of handgrip strength for this group of elderly, only weight and GDS are modifiable. Policy makers for intervention programs on improving elderly's health or quality of life should place emphasis on improving their nutritional status (weight) and level of depression with advancing age.

Limitations of the study

As this study was of a cross sectional design, a causal effect association could not be established. Furthermore, the study was only conducted among elderly in the rural areas of one state within the country which Malay ethnicity was the majority; the results may not be generalized to all elderly of our multiethnic country. A prospective cohort study conducted in more

states within Malaysia with appropriate proportion of ethnicity should be conducted to verify the obtained findings.

On the other hand, this study may be the first study ever conducted on handgrip strength and associated factors among the free living rural elderly in our country. These findings could be used as a baseline data for more studies to be based on.

In conclusion, the handgrip strength of our sample population is significantly lower than the Western population. Weight, height and race significantly predicted handgrip strength among both male and female elderly. However, only GDS and ADL were found to be significantly predicting handgrip strength among the male elderly; while age was only significant among the females. Our study failed to provide evidence for occupational history as a predictor for handgrip strength. Further study with prospective study design should be carried out to verify these findings.

Ethical Considerations

Ethical issue principles including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc. have been completely observed by the authors.

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