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Short Communication

Public Health Section

Body Weight and Its Relationship with Muscle Strength among Adolescents in Malaysia

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ABSTRACT

Introduction: Few studies have investigated the relationship of handgrip strength as an index of nutritional status to morbidity and mortality in adults and elderly. However, it is not clear if differences exist in handgrip strength, begins at adolescent age and what are their determinants.

Aim: To describe the muscle strength of the Malaysian adolescents and to determine the predictors of handgrip strength.

Materials and Methods: The study followed a stratified sampling design. This study examined data of 933 students comprising of multi ethnic adolescents, aged 13 years, from March to May 2012. Muscle strength was measured using calibrated hand dynamometer. Data were analysed using multiple linear regression.

Results: Male adolescents had greater muscle strength compared to female adolescents (17.8 vs. 14.7 kg). The strength of the right handgrip was greater in both males and females compared to the left handgrip with a difference of 1.39 kg in male and 0.9 kg in female adolescents. Weight and Waist circumference (WC) were significant predictors for handgrip strength for both males and females.

Conclusion: This study indicates that weight and WC are among of the determinants of muscle strength for the multi-ethnic Malaysian adolescents. Future study should focus on exploring causes of the muscle strength and lifestyle.

Keywords: Handgrip, Malaysian adolescents, Waist circumference

INTRODUCTION

Muscle strength was found to be a predictor of quality of life, functional disability, physical frailty and mortality in the adult and elderly population [1,2]. Therefore, screening for loss of skeletal muscle mass using the handgrip strength test can be an effective tool for geriatric care in enhancing physical function [1]. It has also been shown that long-term obesity is associated with poor muscle strength later in life [3]. As muscle strength changes with age, baseline measurement from healthy adolescents is crucial to provide future study reference.

Muscle strength was also shown to be associated with the risk factors of cardiovascular health in adolescents [4]. Although a strong correlation between handgrip strength and total muscle strength were found among adolescents [5], further studies are required to investigate the association between muscle strength and body composition among adolescents. Hence, this study was designed to describe muscle strength of Malaysian adolescents and to determine the predictors of handgrip strength. This study is important as there is scarce available large data from the middle income developing country.

MATERIALS AND METHODS

Research Design and Sampling

The study used the stratified sampling where the following formula was applied for sample size calculation; $n=(z^2 \times p \times q/r \times e^2) \times$design effect (z=the standard normal deviate set at 1.96 at 5% level for two-tailed test, p=estimated prevalence, q=1-p, r=response rate and e=precision level). The sample size was calculated using the estimated prevalence of adolescent students aged 13-15 who smoked in school. For the handgrip study, the baseline data of a cohort study was used, reported previously [6]. This study recruited 933 public secondary school students from three states in Malaysia which is Perak, Selangor and Wilayah Persekutuan. Data were collected between March and May 2012. Ethical approval of study was obtained from the Medical Ethics Committee, University of Malaya (MEC Ref. No. 896.34). Participation in the study was voluntary and written informed consent and ascent for participation in the study was obtained from the parents or guardian as well as the participants.

Anthropometry and Physical Assessment

A calibrated vertical steadiometer (Seca Portable 217, Seca, UK) was used to measure height and the reading was recorded to the nearest 0.1 cm. A digital electronic weighing scale (Seca 813, Seca, UK) was used to measure weight and the reading was recorded to the nearest 0.1 kg. Prior to the weight and height measurement, participants were asked to remove shoes and socks and wear light indoor clothes. Hip Circumference (HC) and Waist Circumference (WC) were measured with a non-elastic Seca measuring tape (Seca 201, Seca, UK), to the nearest millimetre. Systolic (SBP) and Diastolic arterial blood pressure (DBP) were obtained using a stethoscope and a mercury sphygmomanometer (CK-101 C, Spirit Medical Co, Taiwan).

A calibrated hand dynamometer (Jamar, Sammons Preston Rolyan, Illinois, US) was used to perform the hand grip strength test. The technique was adopted from a published literature [7]. Participants were asked to show their dominant hand. The first test was performed with dominant hand and then, with the non-dominant hand. Three sets of test were repeated alternately for both hands. A non-elastic Seca measuring tape (Seca 201, Seca, UK) was used to measure the length of hand span. Participants were asked to open their hand as wide as possible in order for researcher to measure from the tip of the thumb to the tip of the little finger.

STATISTICAL ANALYSIS

The data were analysed using SPSS software for Windows (Version 21.0, Chicago, IL, US). Complex samples general linear model analysis was used. The final models were developed independently between sex.

RESULTS

The overall mean handgrip strength of Malaysian adolescents was 15.8 (95% CI: 15.4, 16.2) kg [Table/Fig-1]. The highest handgrip strength of male (n=378) and female (n=555) adolescents were 17.8 (95% CI: 17.0, 18.6) kg and 14.7 (95% CI: 14.3, 15.2) kg, respectively. The strength of the right handgrip was higher in both males and females compared to the left handgrip with a difference of 1.39 kg in male and 0.9 kg in female adolescents. Resting pulse rate was significantly higher in female adolescents compared to male adolescents by 4.3%. Furthermore, the HC was significantly higher in female compared to male adolescents by 4% but WC was significantly greater in male compared to female adolescents by 3.7% [Table/Fig-1].

The regression coefficients for male and female adolescents were adjusted for weight, height, ethnicity, right hand span, left hand span, SBP, DBP, resting pulse, HC, Tanner staging and abdominal obesity [Table/Fig-2]. In addition, left hand span

	Male (n= 378)%	Female (n= 555)%	All (n= 933)%
Ethnicity			
Malay	79.1	83.5	82.0
Chinese	8.9	7.3	7.9
Indian	8.7	6.6	7.3
Others	3.3	2.6	2.8
	Male (n=378) Mean (95% CI)	Female (n=555) Mean (95% CI)	All (n=933) Mean (95% CI)
Weight (kg)	46.04 (44.46, 46.62)	45.99 (44.91, 47.08)	46.01 (45.12, 46.90)
Height (cm)	1.51 (1.50, 1.52)	1.52 (1.51, 1.52)	1.51 (1.51, 1.52)
BMI (kg/m^2)	19.92 (19.35, 20.49)	19.90 (19.49, 20.32)	19.91 (19.57, 20.25)
Length of right hand from little finger to thumb	18.82 (18.61, 19.04)	18.18 (18.04, 18.32)	18.40 (18.28, 18.52)
Length of left hand from little finger to thumb	19.00 (18.78, 19.21)	18.27 (18.12, 18.41)	18.51 (18.39, 18.63)
On average, strength of hand grip of right hand (kg)	18.47 (17.63, 19.31)	15.19 (14.72, 15.67)	16.33 (15.88, 16.77)
On average, strength of hand grip of left hand (kg)	17.08 (16.29, 17.86)	14.27 (13.81, 14.74)	15.24 (14.82, 15.66)
Hand grip highest average (kg)	17.79 (16.99, 18.58)	14.74 (14.29, 15.18)	15.79 (15.37, 16.21)
Systolic blood pressure (mmHg)	109.33 (107.91, 110.75)	109.96 (108.85, 111.08)	109.75 (108.87, 110.64)
Diastolic blood pressure (mmHg)	67.67 (66.51, 68.83)	67.46 (66.51, 68.41)	67.53 (66.79, 68.27)
Resting pulse rate (bpm)	85.48 (83.88, 87.09)	89.13 (88.00, 90.26)	87.91 (86.98, 88.84)
Resting SpO_2 (5)	98.48 (98.36, 98.60)	98.35 (98.26, 98.44)	98.39 (98.32, 98.46)
Measurement of hip (cm)	83.90 (82.70, 85.11)	87.28 (86.40, 88.16)	86.14 (85.43, 86.86)
Measurement of waist (cm)	70.30 (68.91, 71.68)	67.77 (66.81, 68.72)	68.62 (67.83, 69.41)

[Table/Fig-1]: Characteristics of the study participants.

	Model 1 (unadjusted)		Model 2 (adjusted)	
	β (95% CI)	p-value	β (95% CI)	p-value
Males				
Weight (kg)	0.566 (0.122, 0.329)	<0.001*	0.432 (0.240, 0.625)	<0.001*
Height (cm)	0.104 (0.001, 0.133)	0.046*	0.061 (-0.091, 0.214)	0.429
Ethnicity	-0.004 (-0.838, 0.754)	0.917	-0.193 (-0.980, 0.594)	0.630
Right hand span	-0.057 (-0.897, 0.478)	0.549	-0.246 (-1.153, 0.661)	0.594
Left hand span	0.294 (0.389, 1.755)	0.002*	1.111 (0.134, 2.088)	0.026*
Systolic blood pressure (mmHg)	0.153 (0.028, 0.139)	0.003*	0.036 (-0.030, 0.102)	0.281
Diastolic blood pressure (mmHg)	-0.059 (-0.086, 0.022)	0.246	-0.032 (-0.110, 0.046)	0.423
Resting pulse (per minute)	-0.024 (-0.042, 0.022)	0.546	-0.002 (-0.047, 0.043)	0.936
Hip circumference (cm)	0.280 (0.001, 0.301)	0.050*	-0.276 (-0.487, -0.064)	0.011*
Tanner staging	0.004 (-0.084, 0.094)	0.909	0.772 (-0.370, 1.914)	0.184
Abdominal obesity/waist circumference	-0.546 (-0.338, -0.139)	<0.001*	-3.186 (-5.967, -0.406)	0.025*
Females				
Weight (kg)	0.268 (-0.007, 0.228)	0.050*	0.175 (0.057, 0.293)	0.004*
Height (cm)	0.168 (0.055, 0.209)	0.001*	0.132 (0.060, 0.204)	<0.001*
Ethnicity	-0.092 (-1.308, -0.091)	0.024	-0.166 (-0.679, 0.347)	0.525
Right hand span	-0.036 (-0.586, 0.348)	0.618	-0.301 (-0.792, 0.189)	0.228
Left hand span	0.158 (0.049, 0.993)	0.031*	0.621 (-0.014, 1.257)	0.055
Systolic blood pressure (mmHg)	-0.063 (-0.067, 0.016)	0.231	-0.016 (-0.057, 0.025)	0.436
Diastolic blood pressure (mmHg)	-0.034 (-0.061, 0.030)	0.499	-0.016 (-0.063, 0.030)	0.487
Resting pulse (per minute)	-0.005 (-0.030, 0.026)	0.896	-0.008 (-0.040, 0.023)	0.613
Hip circumference (cm)	0.222 (-0.008, 0.230)	0.066	-0.024 (-0.145, 0.097)	0.698
Tanner staging	0.047 (-0.199, 0.711)	0.269	0.002 (-0.780, 0.784)	0.996
Abdominal obesity/ waist circumference	-0.264 (-0.234, -0.030)	0.011*	-3.057 (-5.467, -0.647)	0.013*

[Table/Fig-2]: Gender specific Multiple Linear Regression Models with Complex Sample General Linear Model.
Model 1 is the unadjusted results. Model 2 is adjusted for weight, height, ethnicity, right hand span, left hand span, systolic blood pressure, diastolic blood pressure, resting pulse, hip circumference, Tanner staging and abdominal obesity. *Significant at p<0.05

and HC significantly predicted handgrip strength for male adolescents whereas height predicted handgrip strength for female adolescents [Table/Fig-2]. In this multivariate model, it appears that the model of handgrip strength among male adolescents fitted better than the females.

DISCUSSION

Handgrip strength can be influenced by several factors that include age, gender, puberty, hand size and grip span [8]. In this study, the handgrip strength for Malaysian adolescents was lower than the adolescents from the western countries [9,10]. This may be due to the differences in this population age whereby Malaysian adolescents were aged 13 years and Americans (12 to 15 years) and [Healthy Lifestyle in Europe by Nutrition in Adolescence, HELENA) (13 to 18 years). A study by McComas MJ et al., has shown the muscle strength changes as human is ageing [11]. In addition, it appears that obesity can impact the hangrip strength but it could not be ascertained whether the force was due to muscle quality or muscle mass [12]. Gender also does play an effect modifier on muscle strength during adolescence. Male does experiences growth spurt in muscle mass between 5 and 16-year-old from 42 to 54% of body mass. Whilst female' muscle mass increases from 40 to 45% of body mass between 5 to 13-years and subsequently declines because of increased in fat mass during adolescence [13]. Another observation study found that there is differences in term of muscle strength based on gender. Their adolescent males had greater growth magnitude of muscle strength and it happen earlier than females while the females' muscle strength begin to slow down at the age of 17-years [14]. In view of all the above mentioned, we have analysed the models based on gender separately.

The study has shown that abdominal obesity or WC in male and female adolescents is highly associated with muscle strength. The significant negative association between WC and muscle strength were also found in other studies [5,10]. These findings are parallel to the HELENA study, whereby greater upper body muscular strength in adolescents was consistently associated with higher levels of abdominal obesity [10]. Nevertheless, it was not clear whether the muscle mass or muscle quality that influence HGS. Anthropometric parameters such as weight, height and central obesity were also found to significantly predict muscle strength in female adolescents whereas in male adolescents, weight and HC were significantly associated. The strengths of the Malaysian Health and Adolescents Longitudinal Research Team (MyHeARTs) study is due to its large adolescents' cohort and for being the first to investigate muscle strength of Asian adolescents.

LIMITATION

Nevertheless, this analysis used the first wave data of the cross sectional study, the temporal relationship could not be ascertained. It is unclear if the disproportionate sample among males and females may cause error in validity but the proportion from current study is similar to other published cohort studies.

CONCLUSION

This study provides that the prediction of handgrip strength for Malaysian male and female adolescents. Adolescents' weight and WC are correlated with their handgrip strength.

Declaration

Informed consent: Participation in the study was voluntary and written informed consent and ascent for participation in the study was obtained from the parents or guardian as well as the participants.

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