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308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorpjn@gmail.com

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Associations Between Muscle Grip Strength with Age, Body Mass Index, Waist-to-Hip Ratio, Level of Independent, Physical Activity Level and Macronutrient Intake in Elderly Women

Fatmah Hutasuhut and Vergie Ryoto
Department of Public Health Nutrition, Faculty of Public Health,
University of Indonesia, Depok-16424, West Java Province, Indonesia

Abstract: The grip strength reduction in older people often related with reduced physical performance and functional decline. The study aimed to identify factors associated with muscle grip strength among elderly women i.e. nutritional status (body mass index) and waist-to-hip ratio (WHR), level of independent, physical activity level and macronutrient intake. A cross-sectional study used in the study towards a total of 88 elderly women from a geriatric group at a hospital and in a community setting was used. Grip strength was measured using a handgrip dynamometer. Measurement tape was used to measure height and waist and hip circumferences, which were used to calculate the WHR and a digital scale was used to measure body weight. A semi-quantitative food frequency questionnaire was used to evaluate macronutrient intake. Most subjects had a moderate level of grip strength, with an average strength of 24.017 kg. A majority of the subjects were independent according to Basic Activities of Daily Living (BADL) and Intermediate Activities of Daily Living (IADL) scores. The mean BMI was normal (24.60±3.73 kg/m^2) and the average WHR was 0.85±0.05. Most of the subjects had a moderate level of physical activity. Age, level of independence with IADL or BADL, physical activity, fat and energy intakes were significantly associated with grip strength ($p<0.05$). Regular physical activity and consumption of adequate energy and protein are needed to maintain muscle strength and prevent disability.

Key words: Muscle grip strength, age, BADL, IADL, physical activity

INTRODUCTION

Organ function naturally declines in the elderly, for example changes to the musculoskeletal system in the form of degenerative loss of muscle mass (sarcopenia) and decreased muscle strength lead to various body dysfunctions (Budiharjo *et al*., 2004). Loss of muscle strength decreases the body's ability to balance and disrupts functional mobility. As a result, the risk of falling increases and, in turn, an elderly person's dependence on others for completing normal activities also increases (Basuki and Aryanto, 2008).

Decreasing functional capacity may also reduce physical and social function, which further increases dependency on others. This phenomenon is most likely caused by degrading physical and psychological conditions. Overall, aging is associated with a decreasing sense of self-sufficiency or independence in performing everyday tasks.

Maintenance of muscle strength increases bone stability, muscle size and connective tissue strength. Studies have shown that muscle strength among elderly women is less than elderly men (Primana, 1998; Dhara *et al*., 2011). However, muscle strength declines with advancing age among both men and women (Basuki, Aryanto, 2008; Rosmalina *et al*., 2001).

Factors correlate with muscle strength include nutritional status, macronutrient intake, physical activity and sleep patterns. Proper nutrition, which helps maintain muscle strength, can be assessed by calculating the waist-to-hip ratio (WHR) and body mass index (BMI). An elderly person's nutrient intake also affects the muscle's ability to contract. Protein intake is positively correlated with muscle grip strength (Rosmalina *et al*., 2001). Degenerative loss of muscle strength decreases physical activity level. Engaging in regular physical activity may increase muscle strength and promote physical fitness (Astrand and Rodahlm, 1992). A preliminary survey was conducted in two geriatric groups at Pantai Indah Kapuk Hospital and Pluit Village, North Jakarta. This initial survey found that most elderly women (63.2%) had low grip muscle strength (Ryoto, 2012). The aim of present study was to assess factors that influence muscle grip strength, including nutritional status, level of independent, macronutrient intake and physical activity level.

MATERIALS AND METHODS

Study design and subject: The study used cross sectional study on 88 elderly women who were recruited by Purposive Sampling from community (Pluit Village)

Corresponding Author: Fatmah Hutasuhut: Department of Public Health Nutrition, Faculty of Public Health, University of Indonesia, Depok-16424, West Java Province, Indonesia

and hospital (Pantai Indah Kapuk) settings in March 2012. Ethical clearance was obtained from the Research Ethics Committee of the National Institute of Health Research and Development Ministry of Health. Informed consent informing the objective and the maintaining confidentiality also taken from subjects who were participated in the study by assigning the form. The number of subjects computed by estimation proportion test with absolute precision using significance level ($Z^2 1-\alpha/2$) 1.96; proportion estimation (p) 0.63 from the preliminary research (Ryoto, 2012) and absolute precision (d) 0.1.

The subject were participants of geriatric club at the hospital and the integrated service post for older people (*posyandu*). The inclusion criteria in the study was women at least 55 years old, were clinically and physically healthy as indicated by being able to walk and stand by themselves and had the capacity to communicate verbally. Subjects were excluded if they were slouching or were not able to communicate such information as date of birth, home address, or telephone number.

We used hand-grip dynamometer, digital scales, microtoise, tape measurement and questionnaires. Questionnaire pre-test taken by the team towards 30 elderly women aged at least 60 years to validate whether all questions understood by all subjects. Questionnaire covered semi quantitative FFQ (Food Frequency Questionnaire), age, independence level, waist hip ratio and physical activity.

There were three level of muscle strength, namely: less (grip right = < 22.5 kg and grip left = < 19.8), medium (grip right = 22.5 to 33.3 kg and grip left = 19.8 to 29.7) and good (grip right = > 33.3 and gript left = > 29.7).

Independent level of subjects measured by IADL (Instrumental Activity Daily Living) and BADL (Basic Activity Daily Living). BADL measured the ability of subject to conduct some daily activities like eating, taking bath, walking, moving from sleep to sit, taking urination and defecation. While IADL assessing some mobile activities such as shopping, using telephone, cooking food, washing clothes and cleaning house (Barthel, 1965; Lawton, 1988).

BADL divided into five categories i.e., total dependence (total score 0-4), severe dependence (total score 5-8), moderate dependence (total score 9-11), mild dependence (total score 12-19) and independence (total score 20). IADL have similar category with BADL, except mild dependence (total score 12-15) and independence (total score 16), (Corbin and Lindsey, 2007).

Anthropometric measurement: A handgrip dynamometer was used to measure muscle grip strength with a precision of 0.5 kg. Briefly, each subject held the dynamometer on the dominant hand of doing daily activities, with the arm at a right angle and the elbow close to the side of the body. The handle of the dynamometer was adjusted, if required, for proper measurement so that the base of the instrument rest on the first metacarpal (heel of palm) and the handle rest on the middle of the four fingers. When ready, the subject squeezed the dynamometer with maximum isometric effort and maintained the effort for approximately 5 seconds. No other body movement was allowed during the test. The subject was strongly encouraged to give a maximum effort (Putu and Tuty, 2011). Body weight was measured using a digital scale that was calibrated to a precision of 0.1 kg. Each subject was weighed in light clothing without shoes after emptying her bladder. Height was measured with measuring tape with a precision of 0.1 cm. BMI taken from calculation of weight in kilograms divided by height in meters squared (kg/m^2) (WHO, 1995). WHR was calculated by comparing the waist and hip measurements obtained with the measuring tape with 0.1 cm precision. Waist circumference was measured at the midway point between the costal margin and the iliac crest in the mid-axillary line, with the subject standing and breathing normally. Hip circumference was measured at the widest point around the greater trochanter (Chan *et al*., 2003).

Food consumption and physical activity level: Subjects completed a questionnaire to assess demographic characteristics and nutritional status. Each subject was asked about her history of food consumption in the previous one month during an interview using a semi-quantitative food frequency questionnaire. We used this information to assess macronutrient intake (energy, protein, carbohydrate and fat). The form was also used to assess age, level of independent, WHR and physical activity. Physical activity level was classified as light, mild, or heavy using Baecke Method (1982) measuring working, sport and leisure time indexes.

Statistical analyses: Calculating means and standard deviations (SD) of weight, height, BMI, grip strength and macronutrient intakes were calculated to assess the relationship of the grip strength with subjects' characteristics. The associations between muscle grip strength and age, level of independence and physical activity were analyzed by the Chi-square test. Pearson's correlation coefficients were calculated to examine the correlations between grip muscle strength and BMI, WHR and energy, carbohydrate, protein and fat intake. All analyses were performed using SPSS 13.01 and $p<0.05$ was considered significant.

RESULTS

Table 1 provides the anthropometric and demographic characteristics of subjects in the study. Mean age, weight and height were 65.4 years, 59.157 kg and 153.641 cm, respectively. The mean grip muscle strength was 24.018 kg (range 12.0-38.0 kg). A majority of the subjects had medium grip muscle strength; only a few subjects had good muscle strength. The mean

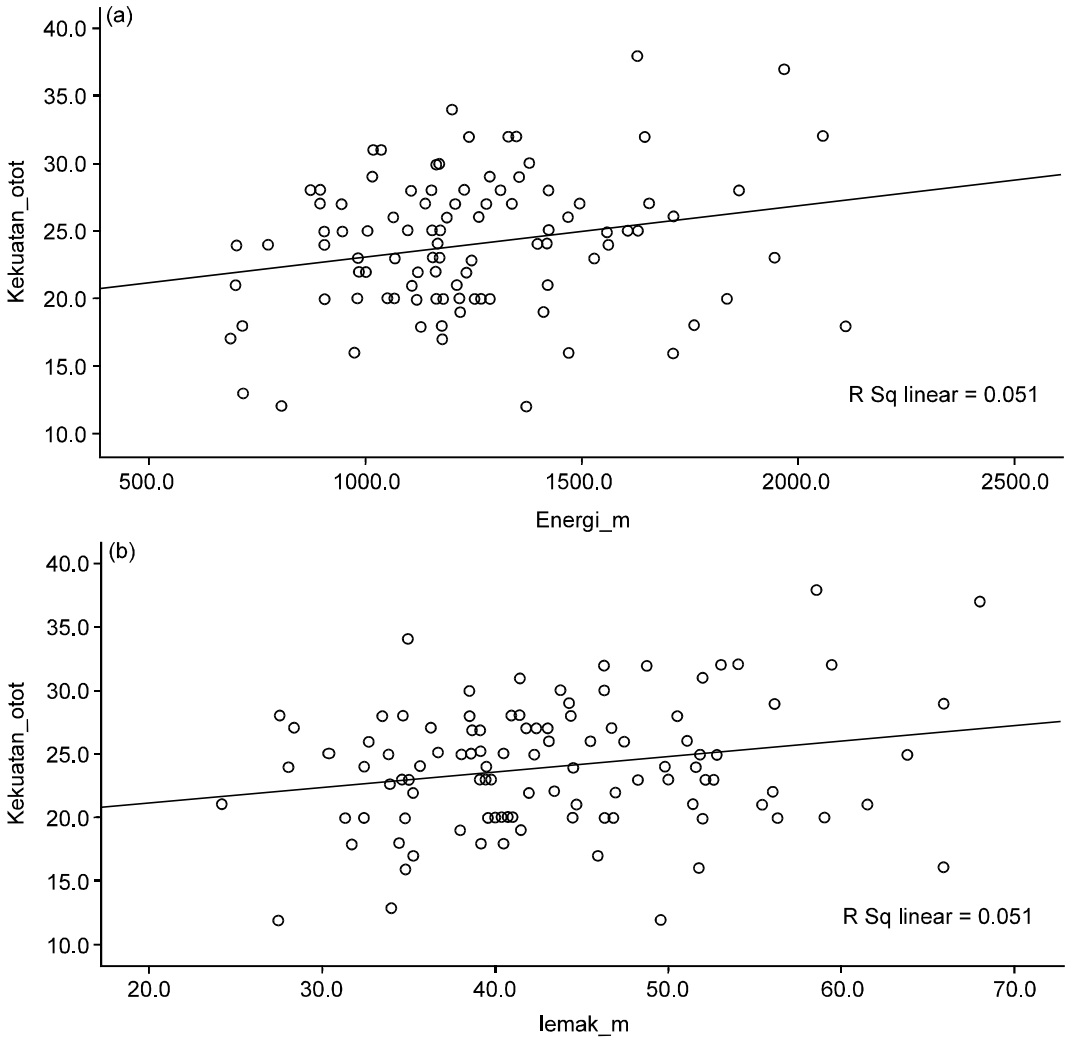

Fig. 1(a-b): Association between (a) Energy, r = 0.227, p = 0.023 and (b) Fat, r = 0.225 p = 0.024 intakes with muscle strength

Table 1: Mean, SD, minimum, and maximum of age, weight, height, BMI, WHR, macronutrient intakes and grip strength in the subjects

Variable	Mean±SD	Minimum	Maximum
Age (years)	65.43±8.45	55.0	88.0
Weight (kg)	59.16±9.08	37.0	82.0
Height (cm)	153.64±6.56	143.5	194.0
BMI (kg/m2)	25.08±3.73	16.5	34.0
WHR (weight hip ratio)	0.86±0.06	0.7	1.0
Grip strength (kg)	24.02±5.03	12.0	38.0
Macronutrient intakes			
Energy (kkal)	1.242±3.01	689.5	2,112.00
Protein (g)	40.5±15.2	11.3	83.1
Carbohydrate (g)	164.79±58.9	53.3	351.2
Fat (g)	43.5±9.3	24.2	68.0

BMI was 25.08 kg/m^2 (range 16.49-34.00 kg/m^2). The mean WHR was 0.86 (range 0.7-1.04). The mean energy intake was 1242 kcal, with mean protein, carbohydrate and fat intakes of 40.54, 164.79 and 43.538 g, respectively.

Table 2: Distribution of independence level and physical activity level of subjects

Indicator	Frequency (person)	Proportion (%)
BADL (basic activity daily living)		
Totally	0	0
Severe	0	0
Moderate	0	0
Mild	24	24
Independence	76	76
IADL (instrument activity daily living)		
Totally	0	0
Severe	1	1
Moderate	9	9
Mild	62	62
Independence	28	28
Physical activity level		
Light	26	26
Moderate	46	46
Heavy	28	28

The level of independence was measured using two indicators, namely the Basic Activities of Daily Living

Table 3: Association between age, independence level and grip strength level of subjects

	Grip strength level								
	Poor		Moderate		Good		Total		
Variable	n	%	n	%	n	%	n	%	p-value
Age									
High risk age	26	54.2	22	45.8	0	0.0	48	100.0	*0.009
Early age	8	30.8	17	65.4	1	3.8	26	100.0	-
Virility	4	15.4	20	76.9	2	7.7	26	100.0	-
BADL level									
Total	0	0.0	0	0.0	0	0.0	0	0.0	*0.015
Severe	0	0.0	0	0.0	0	0.0	0	0.0	-
Moderate	0	0.0	0	0.0	0	0.0	0	0.0	-
Mild	15	62.5	9	37.5	0	0.0	24	100	-
Independent	23	30.3	50.00	65.8	3	3.9	76	100	-
IADL level									
Total	0	0	0	0	0	0.0	0	0	*0.001
Severe	1	1	0	0	0	0.0	1	1	-
Moderate	8	88.9	1	11.1	0	0.0	9	100	-
Mild	17	27.4	45	72.6	0	0.0	62	100	-
Independent	12	42.9	13	46.4	3	10.7	28	100	-
Physical activity level									
Light	21	80.8	5	19.2	0	0.0	26	100	*0.001
Moderate	14	30.4	30	65.2	2	4.3	46	100	-
Heavy	3	10.7	24	85.7	1	3.6	28	100	-

*p<0.05

Table 4: Association between grip muscle strength with BMI, WHR, carbohydrate and protein intakes

Variable	r	p-value
BMI	-0.105	0.301
WHR	-0.184	0.067
Carbohydrate intake	0.157	0.118
Protein intake	0.146	0.148

(BADL) and the Intermediate Activities of Daily Living (IADL) scores. Table 2 shows the distribution of independence level and physical activity level of the subjects. None of the subjects were considered to be of average independence, to have severe impairment in activities, or to be totally dependent for completing activities. Three-fourths of the subjects were considered to be self-sufficient and independent based on BADL scores. Most of the subjects were considered to be mildly dependent based on IADL scores. Almost half of the subjects had mild physical activity levels. The proportion of subjects with light and heavy physical activity levels were nearly equal.

Table 3 presents the associations between muscle grip strength and BMI, WHR and carbohydrate and protein intakes. No significant associations were observed between these variables and grip muscle strength. Only weak correlations were observed with these four variables, indicated by Pearson's correlation coefficients of less than 0.25. The associations between muscle grip strength and age and independence level are presented in Table 4. Muscle grip strength was associated with age, BADL and IADL scores and physical activity level ($p<0.05$). Muscle grip strength was also correlated with energy and fat intakes (Fig. 1a, b).

DISCUSSION

This correlational analysis proved that independence level, macronutrient intake and age were all significantly and positively correlated with muscle strength. Older people experience muscle degeneration and morphological changes more often than younger people. A decrease in muscle grip strength in older people is caused by structural changes in the hands, including the joints, muscles, tendons, bones, blood vessel supply, skin and neurological control (Carmeli *et al*., 2003). Some studies have revealed that muscle strength tends to decline with age (Basuki and Aryanto, 2008; Rosmalina *et al*., 2001; Darmojo, 2011). The findings of our study are consistent with Rosmalina's study (2001) in which muscle grip strength of the right hand differed between people in the 60-65 year age group and those in the 70-75 year age group. On average, the 60-65 year age group had better right hand muscle grip strength (35.3 kg) compared to the 70-75 year age group (32.4 kg).

Our study also revealed that the level of independence correlates with the muscle grip strength among older women. That is, subjects with a high level of BADL independence tend to have higher muscle strength than those with a light level of dependency. Similarly, subjects with a higher level of IADL independence had higher muscle grip strength. This supports a previous study that reported a correlation between lower muscle grip strength and a lower level of independence in ADL (Charette *et al*., 1991). A lower level of ADL independence accelerates loss of muscle strength and older people with lower muscle grip strength have a higher risk of having a low level of ADL independence in the future (Zeinab U. Mulla, 2012).

In this study, the subjects tended to have a high WHR. Even though WHR was not associated with grip muscle strength, but it tends to be higher in older people than in younger people. Briefly, increased WHR is in line with increasing age. Prevalence of a raised WHR was

markedly higher in older adults (64% in men and 62% in women) than in those aged 16-64 (30% in men, 36% in women). Aging is associated with significant changes in body composition, with a substantial reduction in fat-free mass (FFM) and muscle mass. Low muscle mass possibly reflecting low muscle strength in which older people with low WHC will have good muscle strength (Wannametee *et al*., 2007).

BMI did not correlate with muscle grip strength, which is supported by a previous study that revealed no significant associations between BMI and hand strength (Dhara *et al*., 2011). Energy intake was associated with muscle grip strength. This finding agrees with two studies reported energy intake has a positive and meaningful correlation with both absolute muscle strength and relative muscle strength (Rosmalina *et al*., 2001; Putu and Tuty, 2011). However, Dhara *et al*. (2011) showed that energy intake did not have a significant correlation with grip strength in older people. Energy intake may play a role in the maintenance of overall physical ability during aging. There was no significant association between protein intake and muscle grip strength. This finding supported two previous studies (Dhara *et al*., 2011) but contradicted with Rosmalina's study (2001). The first two studies showed that a meaningful correlation existed between protein intake and absolute and relative muscle strength. Older people with long-term insufficient protein intake experience decreased muscle mass. Protein intake has been related to muscle mass and frailty in several longitudinal studies of older people. Increased protein intake will stimulate muscle protein synthesis in older people. Thus, low protein intake may be partially related to the loss of muscle mass with aging (Filion *et al*., 2012).

The absence of significant correlations between carbohydrate and fat intakes with grip muscle strength were consistent with Dhara *et al*. (2011) and Rosmalina *et al*. (2001). Older people tend to reduce their carbohydrate intake, often owing to an inability to perceive the appropriate need for carbohydrates in their diets. There was a significant correlation between physical activity level and muscle grip strength which agreed with Hardy *et al*. (2013). Older people with heavy or medium physical activity levels tended to have better muscle grip strength compared to those with light physical activity levels (Zeinab U. Mulla *et al*., 2012). Likewise, regular physical activity increases muscle strength.

Conclusion: In conclusion, our study confirmed that age, independence level and macronutrient intake were significantly and positively correlated with muscle strength in older women. Elderly people should engage in regular physical activity, including sports and exercise and add a weight training program to increase muscle grip strength. Additionally, they should consume adequate energy and protein to maintain muscle strength.

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REFERENCES

Astrand, P.O. and K. Rodahlm, 1992. Textbook of Work Physiology- Physiological Bases on Exercise. McGraw-Hill Book Company, USA.

Baecke, J.A., J. Burema and J.E. Frijters, 1982. A short questionnaire for the measurement of habitual physical activity in epidemiological studies. Am. J. Clin. Nutr., 36.

Barthel, D. and F.I. Mahoney, 1965. Functional evaluation: the Barthel Index. Maryland State Med. J., 14: 56-61.

Budiharjo, Santoso, Djokoprakoso and Soebijanto, 2004. Effect of Fitness Gym of Older People into Untrained Women Elders' Muscle Strength. University of Gadjah Mada, Yogyakarta.

Basuki and Aryanto, 2008. Corelation between Hand Grip Strengh with Timed up and Go Test in Older Person's Patients at Cipto Mangunkusumo Hospital. University of Indonesia, Jakarta.

Carmeli, E., H. Patish and R. Colemen, 2003. The Aging Hand. The Gerontological Society of America, USA.

Charette, S.I., L. McEvoy and G. Pyka, 1991. Muscle hyperthrophy response to resistance training in older women. J. Appl. Physiol., 70: 1912-1916.

Corbin, C. and Ruth Lindsey, 2007. Fitness for Life Updated 5th edition paper.

Chan, D.C., G.F. Watts, P.H. Barrett and V. Burke, 2003. Waist circumference, waist-to-hip ratio and body mass index as predictors of adipose tissue compartments in men. Oxford J., 96: 441-447.

Darmojo and Boedi, 2011. Handbook Geriatric (Geriatric Science) third edition. Balai Pustaka Faculty of Medicine-University of Indonesia, Jakarta.

Dhara, C. Prakash, Piyali Sengupta and Sujaya De., 2011. Hand grip strength of older persons in relation to body dimensions and nutritional status. J. Ind. Acad. Geriatr., 7: 143-149.

Filion, M.E., S. Barbat-Artigas, S. Dupontgand, A. Fex, A.D. Karelis and M. Aubertin-Leheudre, 2012. Relationship between protein intake and dynapenia in postmenopausal women. J. Nutr. Health and Aging, 16: 616-619.

Hardy, R., C. Rachel, A.S. Avan and B.S. Yoav, 2013. Body Mass Index, Muscle Strength and Physical Performance in Older Adults from Eight Cohort Studies: The HALCyon Programme. PLOS One, 8: 1-13.

Hardy, R., C. Rachel, A.S. Avan and B.S. Yoav, 2013. Body Mass Index, Muscle Strength and Physical Performance in Older Adults from Eight Cohort Studies: The HALCyon Programme. PLOS One, 8: 1-13.

Lawton, M.P., 1988. Instrumental Activities of Daily Living (IADL) scale: self-reported version. Psychopharmacol Bull., 24: 789-91.

Primana, Danang, A., 1998. The assessment of flexibility and muscle strenght in various body composition of older people. University of Indonesia, Jakarta.

Putu, P.I.B. and R.A.K. Tuty, 2011. Factors determining hand grip strength on older people patients at institutionalized older people of TangTu and Geriatric Polyclinic Sanglah General Hospital-Denpasar. Pediatric J., 2: 87-91.

Rosmalina, Y., Yuniar, Dewi Permaesih, Effendi Rustan, Fitrah Ernawati, Dangsina Moeloek, Susilowati Herman, 2001. Factors influencing muscle strenght in male elderly. Bull. Health Res., 29: 184-194.

Ryoto, V., 2012. Preliminary survey on female elders handgrip strength at Geriatric Club of Pantai Indah Kapuk Hospital in North Jakarta. Jakarta: (Not published).

WHO, 1995. Physical Status: the Use and Interpretation of Anthropometry. Report of a WHO Expert Committee. WHO Technical Report Series 854. WHO, Geneva.

Wannamethee, S.G., A.G. Shaper, L. Lennon and P.H. Whincup, 2007. Decreased muscle mass and increased central adiposity are independently related to mortality in older men. Am. J. Clin. Nutr., 86: 1339-1346.

Zeinab, U. Mulla, Rachel Cooper, Gita D. Mishra, Diana Kuh and Alison M. Stephen, 2012. Adult macronutrient intake and physical capability in the MRC National Survey of Health and Dev., 0: 1-7.