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The association between muscle strength and sociodemographic and lifestyle factors in adults and the younger segment of the older population in a city in the south of Brazil

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Abstract *Adequate muscular strength is required to perform daily activitiesand is considered a marker of overall health. The aim of this study was to identify sociodemographic and lifestyle factors associated with handgrip strength (HGS) in adults and the younger segment of the older population. A cross-sectional,population-based study was conducted with 705 individuals aged between 25 and 65 years in the city of Florianópolis, capital of the State of Santa Catarina, Brazil.HGS was assessed usinga manual hand dynamometer. Interviews were conducted with the participants to collect sociodemographic and lifestyle data.Multiple linear regressionwas performed to identify the predictors of HGS. The findings revealed that women and individuals from older age groups showed lower HGS, while being active during leisure time was associated with higher HGS.Interventions aimed at maintaining HGS levels in individuals should pay special consideration toaging and individuals who are physically inactive or insufficiently active during leisure time.*

Key words *Muscle strength dynamometer, Epidemiology, Cross-sectional studies, Hand strength, Public health*

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Introduction

Muscular strength is an important indicator of health for both sexes[1,2]. An adequate level of muscular strength is necessary to ensure functional independence for undertaking daily work tasks and recreational activities and for physical performance[3]. Low levels of muscular strength have been associated with osteoporosis, metabolic syndrome, myocardial infarction, strokes, and cardiovascular mortality in adults of both sexes[1,4].

In addition to the above problems, other factors have been associated with low levels of handgrip strength, higher fall prevalence, functional dependency, prolonged hospital recovery period, decline in quality of life, and increased blood pressure and total cholesterol levels[2,5].

Handgrip strength reaches its peak in our 40s, followed by a gradual decline in both sexes due to muscle atrophy in aging[6]. In addition to the curvilinear relationship between handgrip strength and age[6-10], low levels of muscular strength have been shown to be associated with sociodemographic (sex and economic status) and lifestyle (reduction in daily sleep time, smoking and lower levels of physical activity) factors.

Several studies have sought to determine the relationship between low levels of handgrip strength and sociodemographic and lifestyle factors. However, the majority of research has been conducted in high and middle-income countries[4,7,8,11,12] largely concentrating on non representative samples of population[6,12,13].

Another inherent limitation of previous studies[4,7,8,11,12] is the fact that they generally fail to consider temporal changes in levels of handgrip strength. One of the few studies to investigate temporal changes, conducted in Canada, showed that there was a 10% fall in levels of handgrip strength during the period 1981 to 2007-2008[11]. Changes in lifestyle and in the global disease burden observed over recent decades[14] suggest that the factors associated with muscle strength may have changed, meaning that it is important to determine whether the determinants of a given outcome have also changed.

Given the health effects of low levels of handgrip strength, further research is warranted to identify correlated factors and encourage health prevention and promotion initiatives to minimize future spending related to the treatment of this condition[15]. The present study differs from others[7,9,12,16,17] in that it investigates the concomitant relationship between sociodemographic and lifestyle factors and handgrip strength among adults. Other studies[7,9,12,16,17] have investigated these factors separately; however, it is not clear whether the associations observed would be maintained after adjusted analysis. Thus, the aim of this study was to identify the sociodemographic and lifestyle factors associated with handgrip strength among adults and the younger segment of the older population in a city in the south of Brazil.

Methods

This study derives from the third edition of the population-based cohort study *EpiFloripa Adultos* conducted in 2014/2015. The aim of the *EpiFloripa Adultos* was to determine the prevalence of health problems and investigate health protection and risk factors among adults living in Florianópolis, the capital city of the State of Santa Catarina with a population of approximately 421,240 people. The population had a per capita income of R$1,770.20 and a municipal human development index, dependency ratio, and Gini index of 0.847, 41.6%, and0.547, respectively, in 2010[18].

The first wave of the study took place between August 2009 and January 2010, involving the systematic sampling of 1,720 adults aged between 20 and 59 years, representing all the regions and socioeconomic conditions in the city. Further information about the methodology adopted during this stage of the study can be found in the literature[19,20].

Data collection for "*EpiFloripa Adultos*2014/2015" (third wave of the cohort) began in August 2014 and finished in June 2015. All individuals that participated in the study in 2009 were considered eligible. Individuals who were unable to remain in the positions necessary to perform anthropometric measurements or answer the questionnaire and those who had undergone amputations or were bedridden were considered ineligible.

The measurers/interviewees received prior training to ensure test and data standardization. Study participants were invited to take part in the study via telephone. In contrast to the previous waves of the study (2009 and 2012), where interviews were performed at the participant's home, in 2014/2015 the clinical assessments (test for flexibility and handgrip strength, densitometry, carotid ultrasound, pulse wave velocity, blood tests, body mass, height and blood pressure)were scheduled via telephone and conducted at the

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Federal University of Santa Catarina. In the last months of the data collection period, the interviews and anthropometric and blood pressure tests were conducted by trained interviewers at the homes of participants who were unable to attend the interview and clinical assessment sessions.

A total of 852 individuals participated in the third wave (49.5% of the original cohort), of which 705 presented complete information for the purposes of this study (82.7% of the interviewees in 2014/15). Power was calculated a posteriori based on this number, as well as the prevalence of the distinct exposure variables and outcome, based on a design effect of 1.2 and alpha level of 5%. The association between handgrip strength and sex, age, per capita income, sleep time, physical activity during leisure-time, and physical activity in the category getting around, at work, and at home showed >80% statistical power, while the association with smoking based on the combined results "up to 10 cigarettes and at least 11 cigarettes" showed 6.5% statistical power.

A SAMSUNG® Galaxy Tab 3 (Daegu, South Korea) was used to input and store data.

The dependent variable was handgrip strength, measured using a Saehan® hand dynamometer (Seoul, South Korea), which has 2 kg accuracy and shows concurrent validity with the Jamar® dynamometer (Lafayette, US) (r = 0.976) and intra-rater reliability (r=0.985)[21]. For each participant, the grip aperture of the dynamometer was adjusted so that it could be grasped between the fingers at the palm at the base of the thumb in order to exert pressure on the intermediate interphalangeal joint. For measurement, the individual should be in a standing position with the arm fully extended and straight beside the body so that it does not touch the body or any other object during the test. After a verbal command, the individual squeezes as hard as possible for five seconds. After checking the result, the same procedure is carried out with the other hand, allowing two attempts. The result is recorded in kilograms force (kgf), taking the sum of the best result for each hand to give total strength[22]. For the purposes of this study, handgrip strength was treated continuously.

The independent variables were sex (male, female), continuously collected age in full years, and per capita income used continuously.

The following health variables were also analyzed: daily smoking (never smoked, up to 10 cigarettes, at least 11 cigarettes, and ex-smoker); daily sleep time, which was analyzed continuously; the practice of leisure-time physical activity and physical activity in the category getting around, at work, and at home, using the Brazilian System of Surveillance of Risk and Protection Factors for Chronic Diseases telephone survey[23]. Being physically active during leisure time was taken as at least 30 minutes of moderately intensive activity during five or more days during the week or at least 20 minutes of intensive activity during at least three days of the week[24]. With respect to getting around, physically active was taken as at least 150 minutes of walking or cycling during the week to get around[24]. Very physically active at work was taken as walking a lot and lifting weight at work at least five times a week[24]. Physically active at home was considered strenuous cleaning at home at least once a week[24]. For each category, those who did not meet these criteria or did not undertake such activities were considered insufficiently physically active.

Descriptive and inferential statistics were drawn from the data, testing for normality of the data using median versus average comparison, skewness, kurtosis, and graphs. Per capita income was transformed because it showed a skewed (non symmetric) distribution, with logarithmic correction providing the best fit for the data. The continuous variables were described using mean and standard deviation.

The association between the correlated sociodemographic and lifestyle variables and handgrip strength was tested using multiple linear regression (continuous outcome), where results were expressed as regression coefficients (β with a 95% confidence interval (CI95%).

The exposure variables were included in the adjusted linear regression models regardless of the p-value produced by the crude analysis. We tested the interactions between sex and age and between sex and age and the other variables. Data modeling was performed using the backward selection method adopting $p < 0.05$ as the criterion for permanence in the adjusted models. The significance level was set at 5%.

Comparison of various parameters (the coefficient of determination, regression coefficients, the Akaike and Bayesian information criterion, and/or likelihood ratio test) was used to test the final model(containing the variables associated with the outcome that obtained $p < 0.05$ in the adjusted analysis: sex; age; sex and age interaction; and physical activity during leisure-time) using a saturated model (including interactions with all the independent variables) and null model (without independent variables). These tests showed that the variables included in the final model were adjusted to each other and in relation to the outcome. The residuals of the final multiple linear regression model were tested for heteroscedasticity and normality. Multicollinearity of predictor variables was tested by calculating the variance inflation factor (VIF).

The analyses were performed using the Stata 12.0 statistical software package (Stata Corp, College Station, Texas, US) considering the sampling design and weights. For the sampling weights, the probability of selection of census tract used in 2009 was combined with the probability of location in 2014/15. These weights were recalculated considering the estimated population structure of adults in the municipality in 2012 (by sex and age group).

Results

The average age of the participants of the EpiFloripa was 45.5 (±11.6) years, the majority of the sample were female, and per capita income was R$ 1,500 (data not shown in the table).

Information on handgrip strength was obtained from 705 individuals (82.7% of interviewees in 2014/15),the majority of which (57.4%) were female. Average age was 45.5 (± 11.3) years and monthly family income was $2,380 (± 2,411). Participants slept an average of 7.6 (± 1.6) hours a day. With respect to physical activity, 50.6% of the sample was inactive during leisure-time, approximately nine out of ten individuals were inactive or insufficiently active in th category getting around (86.3%), 42.8% were inactive at work, and 61.1% were inactive or insufficiently active at home (Table 1).

Handgrip strength (measured in kgf) was lowest among women, individuals who smoked at least 11 cigarettes a day, individuals who were physically inactive during leisure-time, individuals who were insufficiently active in the category getting around, and individuals who were physically active at home (Table 1).

The factors that showed an association with handgrip strength in the crude analysis were sex, age, per capita income, smoking, leisure-time physical activity, physical activity in the category getting around, and physical activity at home (Table 1).

Table 2 shows the coefficients of the adjusted analysis and final model including the factors that showed an association with handgrip strength. In the adjusted analysis, sex was associated with handgrip strength and age was inversely associated with handgrip strength, indicating that women and older people have lower handgrip strength values. Being active during leisure time was directly associated with strength. In contrast to the crude analysis, there was no association between per capita income, being an ex-smoker, being insufficiently active in the category getting around, and being active at home with handgrip strength in the adjusted analysis. The test for interactions between variables showed that the level of handgrip strength decreased with aging and that this association was more pronounced among men (Figure 1). The final model produced a coefficient of determination of 0.7068, indicating that approximately 71% of the variance in muscular strength was simultaneously associated with sex, age, sex/age interaction, and physical activity during leisure-time. The VIF (VIF = 1.02) showed that multicollinearity was not present in the final model (Table 2).

Discussion

The findings reveal that women and individuals from older age groups showed lower handgrip strength. The results also show that there was an interaction between sex and age, indicating that the negative effect of age on muscular strength was more pronounced in men than in women. In addition, the findings show that being active during leisure time was associated with higher handgrip strength scores.

Various studies have reported similar findings in relation to lower handgrip strength among women[11,12,16,25]. This can be explained by the fact that women have less muscular mass than men[25], due to lower plasma levels of anabolic hormones such as testosterone, and differences in insulin-like growth factor-1 (IGF-1) and the growth hormone (GH) between men and women[26]. These factors are aggravated by the fact that women practice less physical activity in their leisure time than men, which directly affects handgrip strength[12,27]. In the present study, prevalence of physical inactivity during leisure time was 50.4% among women and 44.2% in men (data not presented in the Tables/Figures).

Aging was shown to be inversely associated with handgrip strength, corroborating the results of other studies[11,12,16,25]. Possible explanations for lower levels of handgrip strength in older age groups include weakening of the skeletal muscles with aging and a decline in the quantity and qual-

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Table1. Mean values and standard deviation of handgrip strength in relation to independent variables and simple linear regression analysis of the factors associated with handgrip strength among participants of the Epifloripa study. Florianópolis, Santa Catarina, Brazil, 2014-2015.

Variáveis			Muscular strength (kgf)	Crude analysis		
	n	Sample	Mean (SD)	ß[b]	(CI95%)	p
Total	705		64.4 (22.3)			
Sex (%, CI95%)						
Male*	297	42.6 (38.0-47.3)	85.5 (17.2)			
Female	408	57.4 (52.7-62.0)	49.0 (8.9)	-36.23	(-38.27; -34.18)	<0.001
Age (Mean, SD)	705	45.5 (11.3)	-	-0.33	(-0.45; -0.22)	<0.001
Income† (Mean, SD)	705	2.380.0 (2.411.0)	-	3.06	(1.45; 4.67)	<0.001
Sleep time (Mean, SD)	705	7.6 (1.6)	-	-0.25	(-1.39; 0.88)	0.659
Smoking (%, CI95%)						
Never smoked‡,	379	56.3 (50.8-61.7)	62.2 (22.1)			
Up to 10 cigarettes	50	7.7 (5.1-11.5)	61.5 (24.3)	-2.67	(-10.76; 5.42)	0.002
At least 11 cigarettes	54	9.3 (6.9-12.5)	61.2 (19.6)	-0.52	(-7.07; 6.02)	
Ex-smoker	222	26.6 (21.9-31.9)	69.2 (22.0)	7.21	(2.82; 11.60)	
PAleisure (%, CI95%)						
Inactive§	331	50.6 (43.5-57.7)	61.0 (20.5)			
Insufficiently active	157	21.6 (17.3-26.7)	67.3 (23.7)	7.14	(-2.71; 11.57)	0.002
Active	217	27.8 (21.8-34.5)	67.8 (23.2)	7.55	(2.68; 12.41)	
PAgetting arounda (%, CI95%)						
Inactive||	359	57.1 (49.9-64.1)	70.1 (23.1)			
Insufficiently active	128	29.2 (23.1-35.9)	60.5 (20.2)	-8.54	(-14.30; -2.79)	0.031
Active	68	13.7 (9.6-19.2)	65.2 (23.2)	-4.88	(-12.15; 2.38)	
PAat work (%, CI95%)						
Inactive¶	153	42.8 (35.9-50.1)	67.8 (23.1)			
Active	133	27.6 (22.4-33.4)	66.1 (22.0)	-0.42	(-4.76; 3.92)	0.904
Very active	171	29.6 (23.0-37.1)	67.3 (23.0)	0.41	(-5.32; 6.14)	
PAat home						
Inactive**,	263	44.8 (39.0-50.8)	72.1 (22.4)			
Insufficiently active	156	16.3 (12.8-20.3)	66.7 (25.6)	-5.41	(-10.88; 0.05)	<0.001
Active	286	38.9 (32.9-45.4)	56.0 (16.7)	-15.29	(-19.68; -10.9)	

PA: Physical activity; a: variable that showed the largest number of ignored questions (n = 150); b: Regression coefficient; CI: Confidence interval; * Comparison reference values for sex (male) in the crude analysis; † Logged variable for regression analysis; ‡, Comparison reference values for nonsmoker in the crude analysis; § Comparison reference values forinactiveduring leisure time in the crude analysis; || Comparison reference values forinactivegetting aroundin thecrude analysis; ¶ Comparison reference values forinactiveat workin thecrude analysis; **Comparison reference values forinactive in thecrude analysis.

ity of muscle mass due to muscle wasting[6]. Furthermore, adults from older age groups tend to be more sedentary during leisure time than those from younger groups[7]. The present study shows that the prevalence of insufficient physical activity during leisure time was greater in the older age groups (data not shown in the Tables/Figures).

Despite higher absolute and relative levels of handgrip strength among men[4,6], the findings show that the decline in levels of handgrip strength with aging was more pronounced in men. Aging leads to negative changes in the neuromuscular system, including a decrease in the activation capacity of motor units and skeletal muscle fibers, which is apparently more pronounced in men given the larger quantity of muscle mass in comparison to women[6]. Furthermore, the decrease in the production of testosterone in men leads to an increase in the concentration of fat mass and a reduction in lean mass, which may explain why the decrease in strength levels with aging is more pronounced in men[6].

Table 2. Multiple linear regression and the final model including factors associated with handgrip strength and sociodemographic and lifestyle variables. Florianópolis, Brazil, 2014-2015.

Variable	Adjusted analysis ††			Final model		
	ß[a]	% (CI95%)	p	ß[a]	% (CI95%)	p
Female	-37.65	(-40.40; -34.90)	<0.001	-53.15	(-64.26; -42.04)	<0.001
Age (full years)*	-0.34	(-0.45; -0.22)	<0.001	-0.51	(-0.72; -0.30)	<0.001
Per capita monthly income (R$) †	0.20	(-1.30; 1.72)	0.788			
Sex*age interaction				0.36	(0.15-0.58)	0.001
Sleep (hours)*	-0.08	(-0.81; 0.64)	0.823			
Smoking						
Up to 10 cigarettes	-0.54	(-4.84; 3.76)	0.844			
At least 11 cigarettes	-1.95	(-6.30; 2.39)				
Ex-smoker	0.39	(-1.81; 2.59)				
PALeisure						
Insufficiently active§	0.28	(-3.63; 4.19)	0.011	-0.18	(-3.97; 3.93)	0.013
Active	4.43	(1.15; 7.71)		4.06	(1.04; 7.07)	
PAGetting around						
Insufficiently active‖	-0.50	(-3.38; 2.36)	0.654			
Active	-0.66	(-3.93; 2.61)				
PAat work						
Active¶	0.51	(-2.06; 3.08)	0.962			
Very active	0.01	(-2.92; 2.93)				
PAat home						
Insufficiently active**	3.21	(-0.16; 6.59)	0.262			
Active	1.59	(-1.29; 4.47)				

PA: Physical activity; a: Regression coefficient; CI- Confidence interval; *Continuous variable; †Logged variable for regression analysis; ‡Comparison reference values smoking; § Comparison reference values inactive during leisure-time; || Comparison reference values inactive getting around; ¶ Comparison reference values inactive at work; ** Comparison reference values inactive at home; †† All variables were included in the adjusted model regardless of the p-value produced in the crude analysis. Variables with p ≥ 0.20 were removed from the adjusted model. The final model made up of the variables sex, age, sex/age interaction, and physical activity during leisure time showed an R2 value = 0.7068; AIC = 4264.87; BIC = -637.05; VIF = 1.02 and F = 321.74.

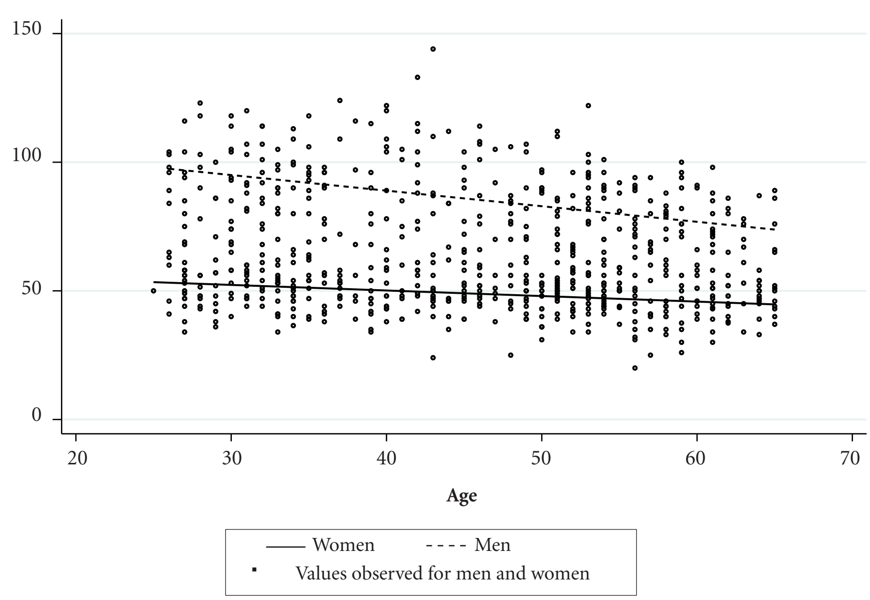

Figure 1. Relationship between handgrip strength and age by sex.

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The findings also show that being physically active during leisure time is associated with higher levels of handgrip strength, corroborating the results of other studies[7,12]. The practice of physical activity produces body movements and mechanical loads, which in turn stimulates the skeletal muscle system, leading to an increase in muscle mass and higher levels of handgrip strength[27]. Thus, regular physical activity positively contributes towards higher levels of handgrip strength[27].

No association was shown between handgrip strength and per capita income, sleep time/day, and smoking, which is contrary to the findings of another study that showed that low per capita income was associated with low levels of handgrip strength[9]. One explanation for the lack of association between low per capita income and grip strength shown by the present study is that people with lower incomes may have jobs that require greater physical effort, thus leading to the development of strength. The lack of association between handgrip strength and sleep time/day may be explained by the fact that the study did not investigate sleep deprivation, a factor that has been shown to be directly associated with handgripstrength[28]. In contrast to another study, no direct association was found between smoking and a decline in levels grip strength[8] by the present study. A possible explanation for this fact is that the statistical power of the study was too low to effectively test the association between these variables.

No association was found between handgrip strength hand physical activity in the category getting around. The use of instruments such as accelerometer to directly measure the intensity of specific physical activities could provide more accurate information for the category getting around, thus reducing response bias, which could be a possible explanation for the lack of association between this variable and handgrip strength in the present study. Likewise, no association was found between physical activity at work and physical activity at home and handgrip strength, which could be explained by the stratification of the sample in relation to number of times (volume) and duration of movements (intensity) undertaken at work or during domestic tasks, which are factors that are directly associated to levels ofstrength[27]. The instrument used to assess physical activity in these categories did not allow us to measure these aspects.

Another limitation of this study is the fact that cross-sectional studies are limited in their ability to determine causality and temporality; in this case of levels of muscular strength and the other variables under study. Furthermore, reverse causality, a common concern with cross-sectional studies, cannot be completely ruled out[29]. It is also important to highlight that the statistical power of the study may be too low to test the association between handgrip strength and some of the independent variables. Finally, the failure to use instruments that directly measure physical activity may also be viewed as a limitation.

By identifying groups that are susceptible to low muscular strength, an important indicator of overall health, the present study provides an important input to this field of research. Furthermore, the use of a single model to analyze sociodemographic and lifestyle factors means that this data may serve as a basis for comparison for future studies with this population group.

It can be concluded that being in older age groups and aging among men are factors associated with lower handgrip strength values, while being active during leisure time is associated with higher handgrip strength scores.

Collaborations

TR Lima participated in the elaboration, analysis and interpretation of results and in the drafting of this manuscript. DF Kovaleski contributed to drafting and revising this manuscript. DAS Silva and DA González-Chica participated in the elaboration of results, statistical analysis, and the discussion and revision of this manuscript.

References

1. Leong DP, Teo KK, Rangarajan S, Lopez-Jaramillo P, Avezum A, Orlandini A, Seron P, Ahmed SH, Rosengren A, Kelishadi R, Rahman O, Swaminathan S, Iqbal R, Gupta R, Lear SA, Oguz A, Yusoff K, Zatonska K, Chifamba J, Igumbor E, Mohan V, Anjana RM, Gu H, Li W, Yusuf S; Prospective Urban Rural Epidemiology (PURE) Study investigators. Prognostic value of grip strength: findings from the Prospective Urban Rural Epidemiology (PURE) study. *Lancet* 2015; 386(9990):266-273.
2. Norman K, Stobäus N, Gonzalez MC, Schulzke JD, Pirlich M. Hand grip strength: outcome predictor and marker of nutritional status. *Clin Nutr* 2011; 30(2):135-142.
3. Forrest KY, Bunker CH, Sheu Y, Wheeler VW, Patrick AL, Zmuda JM. Patterns and correlates of grip strength change with age in Afro-Caribbean men. *Age Ageing* 2012; 41(3):326-332.
4. Dodds RM, Syddall HE, Cooper R, Benzeval M, Deary IJ, Dennison EM, Der G, Gale CR, Inskip HM1, Jagger C, Kirkwood TB, Lawlor DA, Robinson SM, Starr JM, Steptoe A, Tilling K, Kuh D, Cooper C, Sayer AA. Grip strength across the life course: normative data from twelve British studies. *PloS One* 2014; 9(12):e113637.
5. Lawman HG, Troiano RP, Perna FM, Wang C-Y, Fryar CD, Ogden CL. Associations of Relative Handgrip Strength and Cardiovascular Disease Biomarkers in US Adults, 2011-2012. *Am J Prev Med* 2015; 50(6):677-683.
6. Hossain MG, Zyroul R, Pereira B, Kamarul T. Multiple regression analysis of factors influencing dominant hand grip strength in an adult Malaysian population. *J Hand Surg Eur Vol* 2012; 37(1):65-70.
7. Hansen AW, Beyer N, Flensborg-Madsen T, Grønbæk M, Helge JW. Muscle strength and physical activity are associated with self-rated health in an adult Danish population. *Prev Med* 2013; 57(6):792-798.
8. Kok MO, Hoekstra T, Twisk JW. The longitudinal relation between smoking and muscle strength in healthy adults. *Eur Addict Res* 2012; 18(2):70-75.
9. Hairi FM, Mackenbach JP, Andersen-Ranberg K, Avendano M. Does socio-economic status predict grip strength in older Europeans? Results from the SHARE study in non-institutionalised men and women aged 50+. *J Epidemiol Community Health* 2010; 64(9):829-837.
10. Fex A, Barbat-Artigas S, Dupontgand S, Filion ME, Karelis AD, Aubertin-Leheudre M. Relationship between long sleep duration and functional capacities in postmenopausal women. *J Clin Sleep Med* 2012; 8(3):309-313.
11. Shields M, Tremblay MS, Laviolette M, Craig CL, Janssen I, Gorber SC. Fitness of Canadian adults: Results from the 2007-2009 Canadian health measures survey. *Public Health Rep* 2010; 21(1):21-15.
12. Aadahl M, Beyer N, Linneberg A, Thuesen BH, Jørgensen T. Grip strength and lower limb extension power in 19-72-year-old Danish men and women: the Health 2006 study. *BMJ open* 2011; 1(2):e000192.
13. Michelin E, Corrente JE, Burini RC. Fatores associados aos componentes de aptidão e nível de atividade física de usuários da Estratégia de Saúde da Família, Município de Botucatu, Estado de São Paulo, Brasil, 2006 a 2007. *Epidemiol Serv Saúde* 2011; 20(4):471-480.
14. GBD 2013 Risk Factors Collaborators, Forouzanfar MH, Alexander L, Anderson HR, Bachman VF, Biryukov S, Brauer M. Global, regional, and national comparative risk assessment of 79 behavioural, environmental and occupational, and metabolic risks or clusters of risks in 188 countries, 1990–2013: a systematic analysis for the Global Burden of Disease Study 2013. *Lancet* 2015; 386(10010):2287-2323.
15. Silva DAS, Andrade Gonçalves EC, Grigollo LR, Petroski EL. Fatores associados aos baixos níveis de força lombar em adolescentes do Sul do Brasil. *Rev Paul Pediatr* 2014; 32(4):360-366.
16. Massy-Westropp NM, Gill TK, Taylor AW, Bohannon RW, Hill CL. Hand Grip Strength: age and gender stratified normative data in a population-based study. *BMC Res Notes* 2011; 4(1):127.
17. Puh U. Age-related and sex-related differences in hand and pinch grip strength in adults. *Int J Rehabil Res* 2010; 33(1):4-11.
18. Programa das Nações Unidas para o Desenvolvimento (PNUD). *Atlas do Desenvolvimento Humano, 2013*. [acessado 2015 Jan 15]. Disponível em: http://www.atlasbrasil.org.br
19. Boing AC, Peres KG, Boing AF, Hallal PC, Silva NN, Peres MA. EpiFloripa Health Survey: the methodological and operational aspects behind the scenes. *Rev Bras Epidemiol* 2014; 17(1):147-162.
20. Peres MA, Peres KG, Boing AF, Bastos JL, Silva DA, González-Chica DA. Oral health in the EpiFloripa: a prospective study of adult health in Southern Brazil. *Rev Bras Epidemiol* 2014; 17(2):571-575.
21. Reis MM, Arantes PMM. Medida de força de preensão manual–validade e confiabilidade do dinamômetro Saehan. *Fisioter Pesqui* 2011; 18(2):176-181.
22. The Canadian Physical Activity, Fitness and Lifestyle Approach (CPAFLA). *Health and Fitness Program's Health-Related Appraisal and Counselling Strategy*. Ottawa: Canadian Society for Exercise Physiology (CSEP); 2003.
23. Moura EC, Morais NOL, Malta DC, Moura L, Silva NN, Bernal R, Rafael MC, Carlos AG. Vigilância de fatores de risco para doenças crônicas por inquérito telefônico nas capitais dos 26 estados brasileiros e no Distrito Federal (2006). *Rev Bras Epidemiol* 2008; 11(1):20-37.
24. Florindo AA, Hallal PC, Moura EC, Malta DC. Prática de atividades físicas e fatores associados em adultos, Brasil, 2006. *Rev Saúde Públ* 2009; 43(2):65-73.
25. Moy FM, Darus A, Hairi NN. Predictors of Handgrip Strength Among Adults of a Rural Community in Malaysia. *Asia Pac J Public Health* 2013; 27(2):176-184.
26. Montalcini T, Migliaccio V, Ferro Y, Gazzaruso C, Pujia A. Androgens for postmenopausal women's health? *Endocrine* 2012; 42(3):514-520.

27. Chahal J, Lee R, Luo J. Loading dose of physical activity is related to muscle strength and bone density in middle-aged women. *Bone* 2014; 67:41-45.
28. Taheri M, Arabameri E. The effect of sleep deprivation on choice reaction time and anaerobic power of college student athletes. *Asian J Sports Med* 2012; 3(1):15.
29. Silva MC, Fassa AG, Valle NCJ. Chronic low back pain in a Southern Brazilian adult population: prevalence and associated factors. *Cad Saude Publica* 2004; 20(2):377-385.

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