Relationship between handgrip strength and body composition and laboratory indicators in diabetic and hypertensive patients

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ABSTRACT

Introduction: The change in handgrip strength (HGS) is an indicator of the emergence of some chronic diseases, such as diabetes mellitus (DM) and systemic arterial hypertension (SAH). **Objective**: Analyze the relationship between HGS and body composition and laboratory indicators of diabetic and hypertensive patients assisted in Primary Health Care. **Methods**: The sample consisted of 185 users of a Basic Health Unit in the city of Santarém, Pará, distributed into two groups: control (CTL) – users without a diagnosis of DM and/or SAH (n=66); and DM/SAH (n=119) – users with DM or SAH or both diseases. Data collection involved sociodemographic, clinical, anthropometric, biochemical, and HGS information. Data were analyzed using descriptive and inferential statistics, adopting $p<0.05$. **Results**: It was noted that low HGS in the DM/SAH group was associated with high values of body mass index, abdominal circumference, fat percentage, fat mass, total cholesterol, and triglycerides and with more factors for metabolic syndrome ($p<0.05$). The CTL group, in relation to DM/SAH for the same HGS classification, demonstrated significance for lower blood pressure values, body mass index, abdominal circumference, fat percentage, and fat mass, as well as a lower chance of developing metabolic syndrome ($p<0.05$). **Conclusion**: According to the study proposal, it is concluded that the evaluation and follow-up of HGS in individuals with chronic diseases, especially DM and SAH, is relevant to monitor body adiposity and dyslipidemia and avoid the aggravation of existing diseases or the emergence of new ones.

Keywords: Hand strength, Hypertension, Diabetes mellitus, Basic health indicators.

INTRODUCTION

Handgrip strength (HGS) can be used as a strategy to define levels of total muscle strength, in addition to being recognized as a global health indicator and even a predictor for the onset of some diseases, that is, people with a chronic disease present reduced values of HGS[1]. According to Brasil[2], non-transmissible chronic diseases were responsible for 41.8% of all premature deaths between 30 and 69 years of age. In this way, many deaths could be avoided by controlling certain diseases, such as diabetes, obesity, and hypertension. It should be noted that systemic arterial hypertension (SAH) and diabetes mellitus (DM) are the most frequent chronic diseases[3].

DM is an imposing and progressive public health problem, directly affecting morbidity, mortality, and disability of the population[4]. In Brazil, it is estimated that more than 15 million people live with DM and that in 2045, there will be more than 23 million, with the country occupying the sixth place in the world with the highest prevalence[5]. Likewise, the reduction in hypertension in the population is considered a global goal, as it is estimated that more than 1 billion people worldwide, aged 30 to 79 years, have hypertension, with 46% of adults being unaware of its existence and only 42% being diagnosed and treated[6].

In this sense, the assessment of HGS could be an important predictor for the onset of DM and SAH, that is, low values for HGS are associated

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with the development of these diseases[7]. In addition, lifestyle habits, such as physical inactivity, malnutrition, smoking, and high consumption of alcoholic beverages, can negatively influence muscle strength and mass, as well as lead to the onset or worsening of these and other diseases[8]. Thus, based on the importance that HGS has as a predictor for the development of morphological, metabolic, and disease alterations, the present study aimed to analyze the relationship between HGS and body composition and laboratory indicators of diabetic and hypertensive patients assisted in Primary Health Care.

METHODS

The study is descriptive, cross-sectional, and quantitative, with a convenience sample of 185 participants from the area covered by the three Family Health Strategies (FSH) belonging to the Basic Health Unit of Floresta, located in the neighborhood of Floresta, an urban area of the municipality of Santarém, Pará, Brazil. Participants of both sexes were grouped into: control (CTL) - group of people without a diagnosis of DM/SAH (n=66); and DM/SAH - group of people with DM and SAH, isolated or combined (n=119). The diagnosis for the diseases was observed in the medical records, through the medical notification, and confirmed during the interviews with the patients.

The following inclusion criteria were adopted: age ≥18 years; accompanied by one of the FSH teams. Exclusion criteria were: bedridden patients; with severe or unconscious health problems; women in pregnancy or postpartum period; visitors to the neighborhood, or individuals who did not have a fixed residence of at least six months in the neighborhood.

Data collection involved socioeconomic information (sex, age, marital status, skin color, and education), presence of diseases, physical assessment (body composition and grip strength), blood collection (biochemical markers), metabolic syndrome (MetS), and cardiovascular risk (CVR).

To carry out body mass measurements, a calibrated digital scale (Welmy Indústria Comércio, Santa Bárbara D'Oeste-SP, Brazil) was used, with a precision of 100 g, and a stadiometer attached to it to measure height, with a precision of 0.5 cm. The body mass index (BMI) was calculated by dividing body mass by height squared (kg/m^2).

The percentage of fat was measured using a bipolar bioimpedance scale (Balmak®, model Slimtop – 180, Santa Bárbara d'Oeste-SP, Brazil) to calculate lean mass and fat mass. To measure abdominal circumference[9] (AbC), an anthropometric tape was used (Sanny®, São Bernardo do Campo-SP, Brazil).

From the BMI results, the patients were classified according to the WHO[10], using the percentage of fat according to Pollock and Wilmore[11], with those classified as average, above average, good, and excellent considered adequate. For the AbC and the classification for MetS, the guidelines of the National Cholesterol Education Program – NCEP were used[12].

The skinfolds of the triceps and biceps were measured with a precision adipometer (CESCORF®, Porto Alegre-RS, Brazil) (0.1 mm), according to the technique suggested by Miller[9]. The sum of the two folds was presented as the result.

The venous puncture was collected from patients who had fasted for 8 to 12 hours to measure the biochemical variables creatinine, triglycerides, glucose, total cholesterol, and HDL-c. Based on this information, LDL-c, using the Friedewald formula, and non-HDL-c were calculated[13]. Finally, the normality values of Faludi et al.[13] were adopted for triglycerides, total cholesterol, LDL-c, and non-HDL-c; of Grundy et al.[12] for glycemia and HDL-c -; and of Abensur [14] for creatinine.

The glomerular filtration rate (GFR) was calculated using the GFR estimation equation[15]. Values for GFR <60 ml/min/1.73 m^2 were classified as inadequate[16]. The Framingham Risk Score was obtained using the guidelines by Sposito et al.[17].

Absolute HGS was measured using an analog dynamometer (Kratos®, Model ZM, Cotia-SP, Brazil, accuracy of 1 kg). The participant was instructed to remain seated in a chair, with feet flat on the ground, arm adducted and in neutral rotation, forearm flexed at 90º, and with the hand in a semi-pronated position to grip the dynamometer.

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During the test, verbal encouragement was given and the highest value of three attempts for the dominant hand was considered as the result. The interval between attempts was 30 seconds. The relative HGS was obtained by dividing the absolute HGS by the BMI[18]. The relative HGS classification was considered according to the quartile, that is, the relative HGS values in the 1st quartile (25%) were considered as low HGS, and the relative HGS values in the other quartiles (>25%) as adequate HGS[19].

Data were worked on in descriptive statistics (mean, standard deviation, minimum, maximum, absolute and relative frequency). The association was verified by Fisher's exact test. In addition, the association and the chance of the event happening through simple logistic regression were verified. The D'Agostino-Pearson normality test was performed, adopting the independent T-test for comparisons of parametric data and the Mann-Whitney test for comparisons of nonparametric data. Correlations were analyzed using the Pearson (r; parametric) or Spearman (rs; nonparametric) tests. For statistical analysis, the BioEstat 5.3 program was used, adopting a significance level of $p<0.05$.

The study was approved by the Research Ethics Committee (CAAE: 67524517.0.0000.5168). In addition, all participants were instructed about the study and signed the free and informed consent form.

Table 1

Socioeconomic characteristics of the participants.

Variables	All	DM/SAH	CTL
	n/%	n/%	n/%
Sex			
Male	55/30	33/28	22/33
Female	130/70	86/72	44/67
Age range (years)			
18 I-I 32	4/2	0/0	4/6
33 I-I 47	25/14	10/8	15/23
48 I-I 62	85/46	59/50	26/39
63 I-I 77	54/29	37/31	17/26
78 I-I 92	17/9	13/11	4/6
Marital status			
Married/common-law marriage	112/60	71/60	41/61
Single	33/18	19/16	14/21
Divorced	9/5	6/5	4/6
Widow(er)	31/17	23/19	8/12
Skin color			
White	21/11	15/12	6/9
Brown	140/76	88/74	52/79
Black	16/8	13/11	3/5
Yellow	7/4	3/3	4/6
Indigenous	1/1	0/0	1/1
Schooling (years)			
1 to 3	28/15	23/19	5/8
4 to 7	83/45	52/44	31/47
8 to 11	38/21	23/19	15/23
≥12	19/10	10/8	9/13
Not informed	17/9	11/10	6/9

DM/SAH – Diabetes mellitus/systemic arterial hypertension; CTL – control.

RESULTS

The socioeconomic information on the 185 participants is presented in Table 1. It was observed that 10.3% (n=19) of the patients had isolated DM, 39.5% (n=73) isolated SAH, 14.5% (n=27) DM/SAH, and 35.7% (n=66) did not have a diagnosis of the diseases. Furthermore, it was observed that 6% (n=11) of the participants are smokers and, of these, 45% (n=5) belong to the DM/SAH group. On the other hand, 15% (n=27) consume alcohol, and of these, 56% (n=15) belong to the DM/SAH group.

In the DM/SAH group, patients with adequate HGS represented 74% (72% women) and with low HGS 26% (73% women). In the CTL group, 79% (71% women) presented adequate HGS and 21% (50% women) low HGS. It is also noteworthy that HGS was not associated with the presence of DM/SAH (p=0.592).

Table 2 presents the participants' mean values for age, blood pressure, body composition, and biochemical variables, in addition to the comparison of these variables within groups and between groups according to the HGS classification. In the DM/SAH group, it was noted that low HGS, compared to adequate, was linked to higher BMI (p=0.002), AbC (p<0.001), fat percentage (p=0.004), and fat mass (p=0.005).

For adequate HGS, the DM/SAH group, in relation to the CTL, presented higher values for age (p<0.001), systolic (p<0.001) and diastolic blood pressure (p=0.003), BMI (p=0.005), AbC

Table 2

Presentation of mean values of clinical, body composition, and laboratory variables according to the handgrip strength classification in the studied groups.

Variables	All	DM/SAH		CTL	
		Handgrip strength		Handgrip strength	
	mean±SD	Adequate mean±SD	Low mean±SD	Adequate mean±SD	Low mean±SD
Age (years)	59.4±12.6	62.1±11.3	61.5±11.3	54.2±13.8†	57.4±13.9
SBP (mmHg)	131.7±21	136.7±19.8	140.7±26.3	122.5±16.7†	116.4±9.3‡
DBP (mmHg)	83.5±12.4	85.9±12.7	87.6±13.5	79.8±10.2†	75±7.6‡
BMI (Kg/m^2)	27.5±4.3	27.6±3.9	30.8±5.3*	25.7±3.7†	26.6±2.8‡
AbC (cm)	95.5±10.3	96.5±8.7	103.9±10.1*	89.6±9.6†	93.4±9.4‡
SD (mm)	31.7±13.2	31.9±13.2	36.2±12.7	30.1±13.1	26±12.9‡
%F (%)	25.4±9.9	25.6±9.5	31.3±9.6*	22.7±10.4	23.1±6.4‡
LM (Kg)	49±8.7	49.6±9	49.4±8.7	47.8±8.2	49±8.8
FM (Kg)	17.4±8.8	17.5±8.2	23.5±9.9*	14.7±8.5†	14.8±5‡
Glucose (mg/dL)	103±66.7	114.8±78.6	96.1±49.7	89.5±47.9†	100.9±80.2
TC (mg/dL)	225±45.3	230±44	234±47.2	216.9±47.2	205.2±35.6
HDL-c (mg/dL)	44.7±8.6	44.6±8.4	42.5±8.1	46.2±8.8	44.2±9.9
LDL-c (mg/dL)	139.3±37.1	145.9±38.9	139.7±37.3	132.8±36.1	125.2±26.3
Non-HDL-c (mg/dL)	177.8±43.6	184.2±44.8	184.1±42	169.4±43.8	161±33
Triglycerides (mg/dL)	223.1±152.7	227.3±152.4	274.8±172.8	198.8±152.9	179.2±64
Creatinine (mg/dL)	1.0±0.3	1.0±0.3	1.0±0.3	0.9±0.2	0.9±0.1
GFR	73.5±18.7	71.1±18.7	68.9±18.6	77.6±19.5	83.7±7.9‡

DM/SAH – Diabetes mellitus/systemic arterial hypertension; CTL – control; SD – standard deviation; SBP – systolic blood pressure; DBP – diastolic blood pressure; BMI – body mass index; AbC – abdominal circumference; SD – sum of skinfolds; %F – fat percentage; LM – lean mass; FM – fat mass; TC - total cholesterol; HDL-c – high-density lipoprotein; LDL-c – low-density lipoprotein; GFR – glomerular filtration rate (ml/min/1.73 m^2); *Statistical difference from adequate HGS in the same group; †Statistical difference from adequate HGS in the DM/SAH group; ‡Statistical difference from low HGS in the DM/SAH group; p<0.05.

(p<0.001), fat mass (p=0.016), and glucose (p=0.007). For low HGS, the DM/SAH group, in relation to the CTL, showed higher systolic (p<0.001) and diastolic (p=0.006) blood pressure, BMI (p=0.001), AbC (p=0.001), the sum of skinfolds (p=0.017), fat percentage (p=0.010) and fat mass (p=0.001), Table 2.

When performing the correlation between HGS with age, systolic and diastolic blood pressure, glucose, glomerular filtration rate, HDL-c, LDL-c and cardiovascular risk for both groups (DM/SAH and CTL), no significant differences were observed (p>0.05), data not shown. However, inversely proportional correlations were verified between HGS and the body mass index (Figure 1A), abdominal circumference (Figure 1B), sum of skinfolds (Figure 1C), fat percentage (Figure 1D), fat mass (Figure 1F), total cholesterol (Figure 1G), triglycerides (Figure 1H), non-HDL-c (Figure 1J), and number of factors for metabolic syndrome (Figure 1K); and directly proportional correlations between HGS with lean body mass (Figure 1E) and creatinine (Figure 1I) for the DM/SAH group.

Regarding the CTL group, no correlations were found between HGS and body mass index (Figure 2A), abdominal circumference (Figure 2B), total cholesterol (Figure 2G), triglycerides (Figure 2H), creatinine (Figure 2I), non-HDL-c (Figure 2J), and the number of factors for metabolic syndrome (Figure 2K). On the other hand, inversely proportional correlations were verified between HGS and the sum of skinfolds (Figure 2C), fat percentage (Figure 2D), and fat mass (Figure 2F); and a directly proportional correlation between HGS and lean body mass (Figure 2E).

Table 4 presents the association of HGS with sex, age, smoking, alcohol consumption, blood pressure, body composition, and biochemical variables, and the presence of MetS and CVR for the groups

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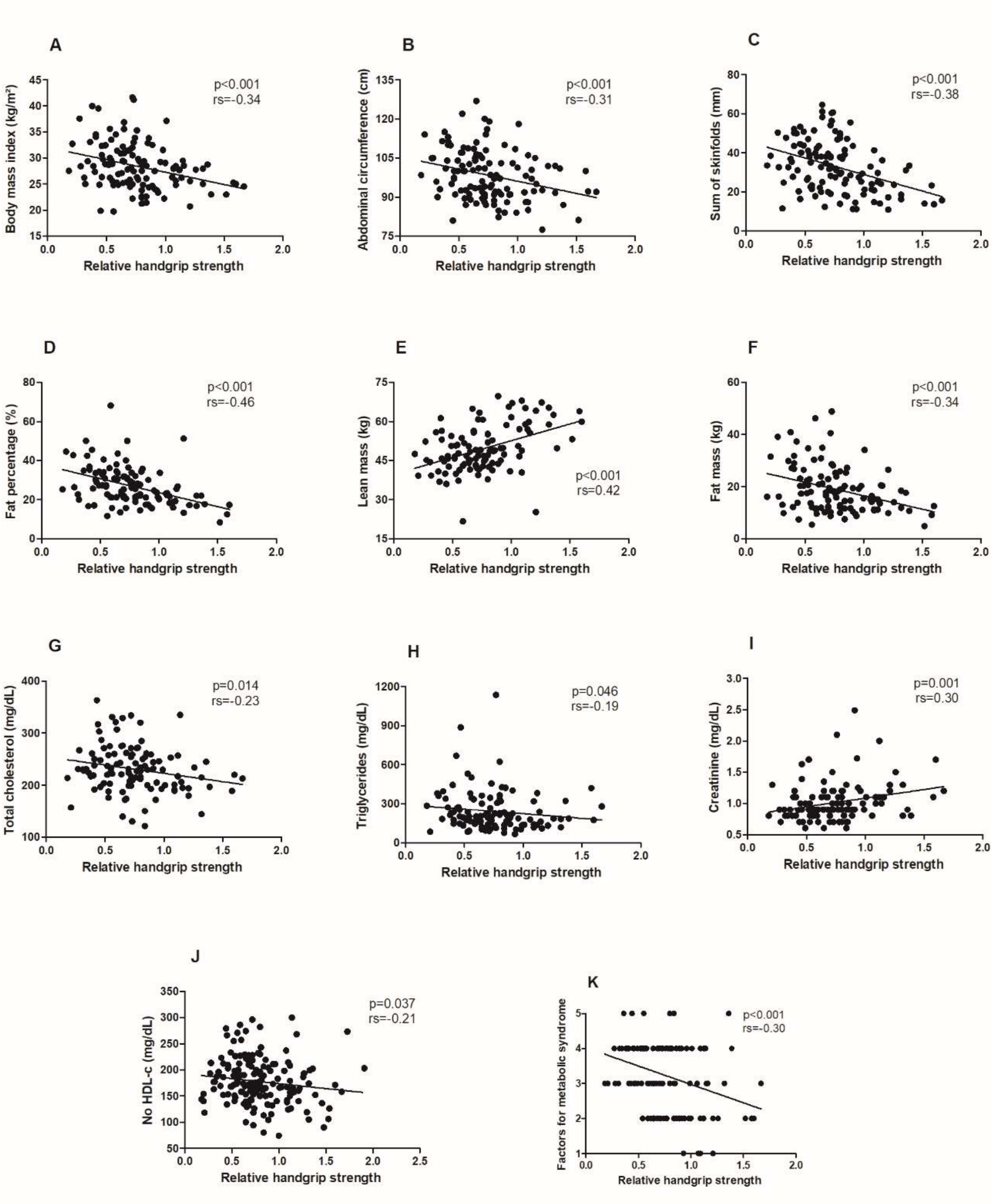

Figure 1: Correlation of relative handgrip strength with body mass index (1A), abdominal circumference (1B), the sum of skinfolds (1C), fat percentage (1D), lean mass (1E), fat mass (1F), total cholesterol (1G), triglycerides (1H), creatinine (1I), non-HDL-c (1J), and with the number of factors for metabolic syndrome (1K) of the DM/SAH group (diabetes mellitus/systemic arterial hypertension); rs – Spearman Correlation Test; minimum significance index of p<0.05.

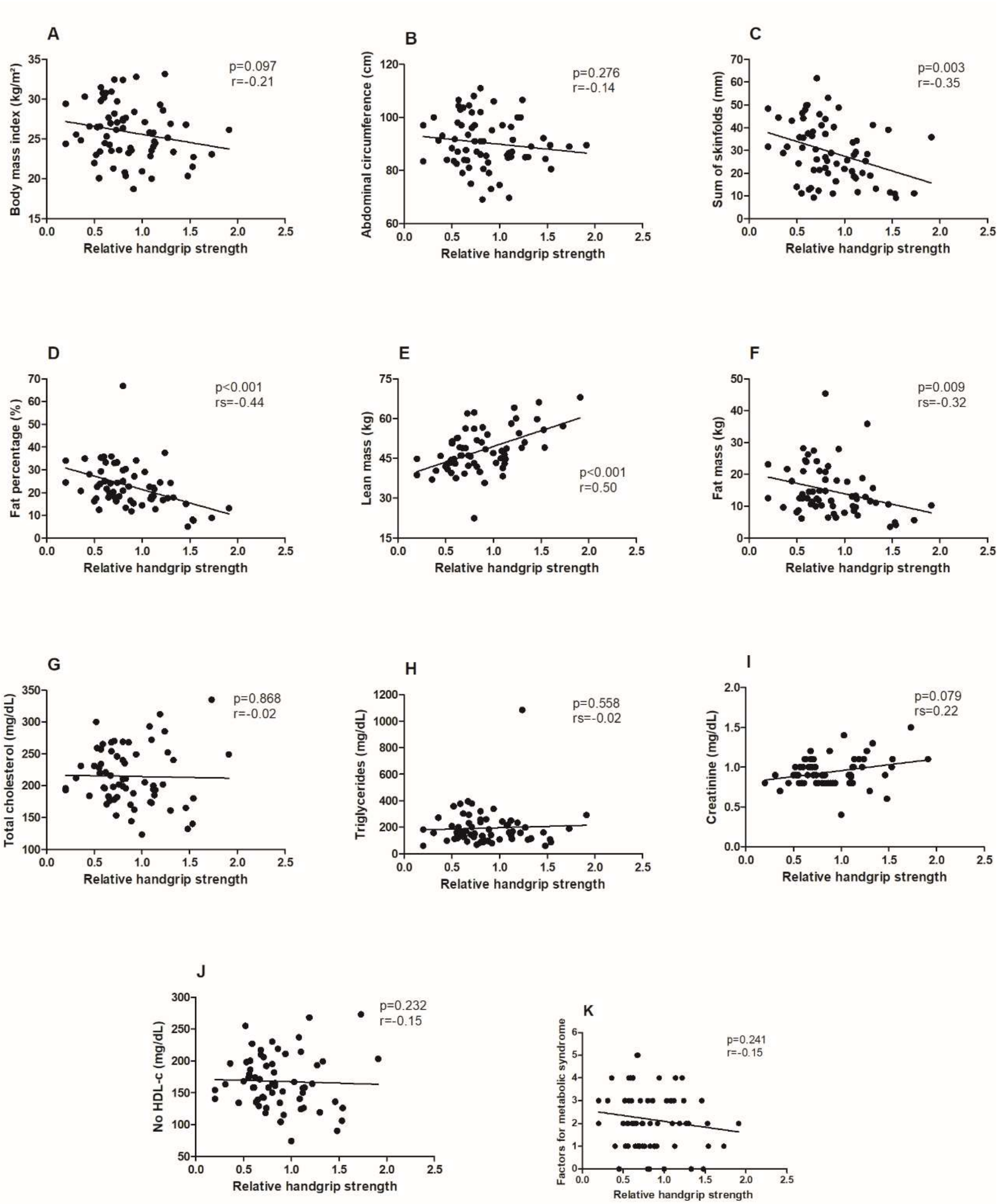

Figure 2: Correlation of relative handgrip strength with body mass index (2A), abdominal circumference (2B), the sum of skinfolds (2C), fat percentage (2D), lean mass (2E), fat mass (2F), total cholesterol (2G), triglycerides (2H), creatinine (2I), non--HDL-c (2J), and with the number of factors for metabolic syndrome (2K) in the control group; rs – Spearman Correlation Test; r – Pearson Correlation Test; minimum significance index of p<0.05.

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Table 4

Association of handgrip strength classification in the presence or absence of diseases with metabolic syndrome, cardiovascular risk, body composition, socioeconomic and biochemical variables.

Variables	DM/SAH HGS		CTL HGS		A	B	C	D
	AD n/%	Low n/%	AD n/%	Low n/%	p	p	p	p
Sex								
Male	25/28	8/27	15/29	7/50	1.0	0.201	1.0	0.176
Female	64/72	22/73	37/71	7/50				
Age (years)								
<60	42/47	12/40	32/62	7/50	0.531	0.543	0.117	0.744
≥60	47/53	18/60	20/38	7/50				
Smoking								
Yes	3/3	2/7	6/12	0/0	0.599	0.328	0.077	0.556
No	85/97	28/93	46/88	14/100				
Alcohol consumption								
Yes	7/8	8/30	11/22	1/7	0.007	0.270	0.032	0.130
No	81/92	19/70	38/78	13/93				
Systolic blood pressure								
Adequate	48/55	14/48	41/79	14/100	0.668	0.102	0.003	<0.001
Altered	40/45	15/52	11/21	0/0				
Diastolic blood pressure								
Adequate	47/53	13/45	40/77	13/93	0.521	0.269	0.006	0.002
Altered	41/47	16/55	12/23	1/7				
Body mass index								
Adequate	24/27	3/10	25/48	4/29	0.076	0.235	0.016	0.184
Altered	65/73	27/90	27/52	10/71				
Abdominal circumference								
Adequate	32/36	3/10	33/63	7/50	0.005	0.538	0.002	0.006
Altered	57/64	27/90	19/37	7/50				
Fat percentage								
Adequate	64/79	12/46	40/78	9/75	0.002	0.997	1.0	0.161
Altered	17/21	14/54	11/22	3/25				
Glucose								
Adequate	53/65	22/73	46/88	12/92	0.498	1.0	0.003	0.236
Altered	28/35	8/27	6/12	1/8				
Total cholesterol								
Adequate	11/14	4/13	15/29	5/38	1.0	0.517	0.043	0.101
Altered	70/86	26/87	37/71	8/62				
HDL-c								
Adequate	29/40	6/23	22/43	5/38	0.714	1.0	0.714	0.452
Altered	44/60	20/77	29/57	8/62				
LDL-c								
Adequate	24/33	11/42	24/47	8/62	0.474	0.374	0.135	0.320
Altered	49/67	15/58	27/53	5/38				
Non-HDL-c								
Adequate	19/26	7/27	23/45	7/54	0.999	0.756	0.034	0.157
Altered	54/74	19/73	28/55	6/46				
Triglycerides								
Adequate	26/32	7/23	23/44	4/31	0.484	0.532	0.197	0.708
Altered	55/68	23/77	29/56	9/69				

(Continuação)

Tabela 4
(Continuação)

Variables	DM/SAH HGS		CTL HGS		A	B	C	D
	AD n/%	Low n/%	AD n/%	Low n/%	p	p	p	p
Creatinine								
Adequate	75/93	25/83	49/94	13/100	0.163	1.0	1.0	0.171
Altered	6/7	5/17	3/6	0/0				
Glomerular filtration rate								
Adequate	60/74	22/73	43/83	13/100	1.0	0.185	0.291	0.045
Altered	21/26	8/27	9/17	0/0				
Metabolic syndrome								
Yes	61/69	29/97	21/40	6/43	0.001	1.0	0.001	<0.001
No	28/31	1/3	31/60	8/57				
Cardiovascular risk								
Low	7/58	0/0	44/86	8/62	0.200	0.104	0.041	0.200
Moderate/High	5/42	3/100	7/14	5/38				

HGS – handgrip strength; AD – adequate; HDL-c – high-density lipoprotein; LDL-c – low-density lipoprotein; A – association between adequate and low strength in the DM/SAH group; B - association between adequate and low strength in the CTL group (control); C – association between DM/SAH and CTL for adequate strength; D – association between DM/SAH and CTL for low strength.

studied, as well as the association of adequate HGS between groups and low HGS between groups. It is noteworthy that HGS (adequate vs low) was not associated with the presence or absence of DM/SAH (p=0.666). For the DM/SAH group, it is possible to observe a positive association of low HGS with alcohol consumption (p=0.007), altered AbC (p=0.005), altered percentage of fat (p=0.002), and with the presence of MetS (p=0.001). For CTL, no association was observed between HGS (adequate vs. low) and the evaluated variables.

Adequate HGS in the DM/SAH group, in relation to CTL, showed a negative association with alcohol consumption (p=0.032) and a positive association with changes in systolic (p=0.003) and diastolic (p=0.006) blood pressure, BMI (p=0.016), AbC (p=0.002), glucose (p=0.003), total cholesterol (p=0.043), non-HDL-c (p=0.034), and with the presence of MetS (p=0.001) and with moderate/high CVR (p=0.041). Low HGS in the DM/SAH group, in relation to CTL, showed a positive association with high systolic (p<0.001) and diastolic (p=0.002) blood pressure, altered AbC (p=0.006), altered GFR (p =0.045), and the presence of MetS (p<0.001), Table 4.

Simple logistic regression in the DM/SAH group showed that alcohol consumption favored the chance of having low HGS by 4.87 times (p=0.006; 95%CI=1.57-15.09), and that low HGS favored by 13.31 times the presence of MetS (p=0.013; 95%CI=1.73-102.69), by 5.05 times a change in AbC (p=0.012; 95%CI=1.42-17.97), and 4.39 times an increase in fat percentage (p=0.002; 95%CI= 1.72-11.23). When evaluating the regression with the CTL group, no significance was observed (p>0.05).

The regression showed that the DM/SAH group, with adequate HGS, presented 2.5 times more chance of presenting an altered BMI compared to the CTL (p=0.001; 95%CI=1.22-5.14), as well as 3.09 times more chance of altered AbC (p=0.001; CI95%=1.52-6.3), 3.21 times more chance of MetS (p=0.001; CI95%=1.58-6.55), 4.69 times more chance of moderate/high CVR (p<0.001; 95%CI=1.99-11.11), 3.1 times more chance of elevated systolic blood pressure (p=0.004; 95%CI=1.41-6.82), 2.9 times more chance of elevated diastolic blood pressure (p=0.006; 95%CI=1.35-6.27), 4.05 times more chance of altered blood glucose (p=0.004; 95%CI=1.54-10.64), 2.57 times more chance of altered total cholesterol (p=0.033; CI95%=1.08-6.18), and 2.33 times more chance of elevated non-HDL-c (p=0.028; CI95%=1.09-4.99). In addition, the CTL was 3.34 times more likely to consume alcohol than the DM/SAH (p=0.020; 95%CI=1.2-9.32) for adequate HGS.

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On the other hand, the DM/SAH group with low HGS was, in relation to the CTL, 9 times more likely to have high AbC (p=0.006; 95%CI=1.84-44.03), 38.66 times more likely to present MetS (p =0.001; CI95%=4.05-369.48) and 16 times more likely to present high diastolic blood pressure (p=0.011; CI95%=1.84-138.97). For the other variables, no significance was observed (p>0.05).

DISCUSSION

In the literature, it is observed that age has a negative impact on HGS, that is, strength may suffer a reduction after around 40 years of age[7,20]. This is explained by the fact that strength and muscle mass decrease with aging due to several factors, such as the CTL of physical activity, decreased hormone production and protein synthesis, as well as poor nutrition and changes in motor units[21]. In the present study, no relationship between age and HGS was observed in the evaluated groups, only that age was lower in the CTL group for adequate HGS in relation to the DM/SAH.

The relationship between HGS and blood pressure showed no association or correlation; however, between the groups analyzed, it was possible to note that the DM/SAH group, in relation to CTL, showed a positive association for altered systolic and diastolic blood pressure, for both individuals with adequate HGS and low HGS. Thus, it is noted that for the groups analyzed, the presence of the disease was the factor associated with the change in blood pressure, probably because the hypertensive patients did not have their condition under control. In addition, users with chronic diseases generally have a high percentage of fat, as well as BMI, which are associated with physical inactivity and do not favor disease control[7,22]. When the authors report high values for fat accumulation, it is noteworthy that the DM/SAH group, both for adequate and low HGS, showed higher values for BMI, AbC, and fat mass in relation to CTL. In addition, the same was noted for low HGS for the sum of skinfolds and percentage of fat.

In this sense, it is noteworthy that the high waist-hip ratio in DM favors the presence of altered glycemic values[23]. In addition, excess fat and other high anthropometric variables predispose to greater chances of developing SAH[24].

When evaluating the body composition variables, deleterious effects related to low HGS were observed in the DM/SAH group, such as changes in BMI, AbC, sum of skinfolds, percentage of fat, and fat mass, as well as for the CTL group for the sum of skinfolds, fat percentage, and fat mass. On the other hand, adequate HGS provided both the DM/SAH group and the CTL group with greater lean mass. These results are similar to those found in a study that evaluated older men, in which the relationship between low strength and the highest percentage of fat and the lowest lean mass was noted[25]. This increase in body fat triggers a decrease in strength, which is a result of possible muscle inactivity[20]. In this sense, in sedentary individuals, it is observed that high AbC is related to low HGS[25]. On the other hand, the presence of adequate strength is associated with the prevention of several diseases, including MetS [26], which, among its factors, includes abdominal obesity[12].

Regarding the laboratory variables, and regardless of the HGS classification, the DM/SAH group showed more alterations for glucose, total cholesterol, non-HDL-c, and GFR in relation to the CTL. These alterations could have a negative impact on the DM/SAH group, as altered values for glucose and total cholesterol are related to overweight/obesity, and low HDL-c with increased CVR[27]. Finally, altered GFR is associated with obesity due to an inadequate diet that generates high levels of sodium and a high BMI[28]. All these uncompensated variables and their consequences interfere in and aggravate DM and SAH, as well as contribute to the evolution of kidney disease.

Considering the relationship between HGS and laboratory variables, a negative relationship between HGS and glucose, total cholesterol, triglycerides, and non-HDL-c was observed for the DM/SAH group, as well as a positive relationship for creatinine. With regard to total cholesterol and triglycerides, both showed a negative correlation with HGS in the DM/SAH group. In this way, it is possible to observe the positive effect of HGS on the lipid profile[29]. The positive relationship of creatinine; however, suggests that the greater the muscle mass, the greater the creatinine value[30].

The presence of DM/SAH, regardless of the HGS classification, is a positive factor for the onset of MetS. Individuals with these diseases are usually those who have irregular biochemical markers, in addition to advanced age and lack of physical exercise, which, together with an unbalanced diet, promote a greater predisposition to the development of MetS[31].

The positive correlation observed in the current study between HGS and increased muscle mass was previously highlighted, as this is a potential factor for reducing the risk of MetS[32]. In this sense, the present study observed in the DM/SAH group that low HGS was positively associated with MetS. Evaluating sedentary women with and without MetS, it was noted that lower muscle strength favored the presence of MetS[33]. Furthermore, it was observed that a low HGS potentiates the onset of MetS in adults. Therefore, the measurement of strength could contribute to and help in the control and prevention of MetS[34].

Finally, in the present study, CVR was not related to the HGS; however, the DM/SAH group, in relation to the CTL, was related to moderate/high CVR for adequate HGS. In this sense, one cannot fail to report that low HGS favors the development of chronic diseases, such as excess body mass, cardiovascular problems, hypertension, diabetes, and asthma[35], elevating the CVR. In a study carried out with DM and non-DM participants, it was noted that low HGS favors cardiovascular events[36]. Likewise, the association between low HGS and increased CVR is clear, as noted in a study with older people in Finland[37]. It is also noteworthy that women are more susceptible to cardiovascular events when in the presence of low HGS[7].

Among the limitations of the study, we highlight the limited number of participants diagnosed with hypertension and diabetes, the use of only one space/environment for the selection of participants, as well as the data collection at only one moment, as a second collection would be interesting to follow the evolution of the patients.

CONCLUSION

According to the proposal presented, the data show an interaction between health indicators and their behavior considering HGS in patients with DM/SAH. Thus, it is possible to infer that alterations in BMI, blood pressure, AbC, fat percentage, fat mass, and GFR, as well as the presence of MetS, were associated with low HGS in the DM/SAH group.

Therefore, attention is drawn to the relevance of assessing and monitoring HGS in individuals with chronic diseases to avoid the onset or worsening of illnesses and, consequently, a reduction in quality of life and worsening of adiposity.

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Authors Participation

Conception and design of the research: Takanashi SYL, Gouvêa-e-Silva LF; Data acquisition: Kono EM, Souza J, Takanashi SYL, Gouvêa-e-Silva LF; Data analysis and interpretation: Basso GB, Siqueira MA, Kono EM, Souza J, Silva ML, Fernandes EV, Gouvêa-e-Silva LF; Statistical analysis: Basso GB, Siqueira MA, Kono EM, Silva ML, Fernandes EV, Gouvêa-e-Silva LF; Manuscript writing: Basso GB, Siqueira MA, Silva ML; Critical review of the manuscript for important intellectual content: Souza J, Takanashi SYL, Fernandes EV, Gouvêa-e-Silva LF; Obtaining financing: Takanashi SYL, Gouvêa-e-Silva LF.

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