ORIGINAL ARTICLE

Muscular static strength test performance: comparison between normotensive and hypertensive workers

Timothy Gustavo Cavazzotto[1], Luriam Tratis[2], Sandra Aires Ferreira[3], Rômulo Araújo Fernandes[4], Marcos Roberto Queiroga[5]

[1] Graduate in Physical Education, Laboratory of Experimental Physiology and Physiology Applied to Physical Activity (LAFEAF/DEDUF/G), Universidade Estadual do Centro Oeste (UNICENTRO), Guarapuava, PR, Brazil
[2] Graduate Student in Physical Education, LAFEAF/DEDUF/G, UNICENTRO, Guarapuava, PR, Brazil
[3] MSc in Motility Sciences, Professor, Department of Physical Education, UNICENTRO, Guarapuava, PR, Brazil
[4] PhD in Motility Sciences, Professor, Department of Physical Education, Universidade Estadual Paulista, Presidente Prudente, SP, Brazil
[5] PhD in Motility Sciences, Professor, Department of Physical Education, UNICENTRO, Guarapuava, PR, Brazil

Summary

Objective: The aim of the study was to compare static muscular strength test performance between hypertensive and normotensive workers, considering the hypothesis that hypertensive individuals have lower strength than normotensive individuals. **Methods:** The participants consisted of 354 workers (246 men and 108 women) who underwent height, body mass, waist circumference, systolic and diastolic blood pressure (BP) measurements, as well as right and left handgrip, and scapular and lumbar strength tests. Assessments were performed during three days in all three shifts, with workers from a candy and sweets factory located in Rio Claro, in the state of São Paulo, Brazil. BP measurements were performed with a 10-minute interval, with the subject in the sitting position. Before the strength tests were performed, the workers were familiarized with the equipment; the highest value was recorded after two attempts at each test. **Results:** The results showed significant differences between hypertensive and normotensive individuals for age, body mass, body mass index, and waist circumference greater for hypertensive individuals. Regarding static muscle strength tests performance, the hypertensive individuals did not differ significantly from normotensive individuals; however, this difference was observed when groups divided by body mass index (BMI) were compared. The obesity group had strength values above those of the normal weight/overweight group among normotensive individuals, but this was not observed among the hypertensive individuals. As for the intragender comparison, there were no significant differences for the strength tests. **Conclusion:** Normotensive and hypertensive workers showed no significant differences in the performance of static muscular strength tests; however, body mass and gender seem to affect the association between muscle strength and blood pressure.

Keywords: Muscle strength; hypertension; health.

Study conducted at Universidade Estadual Paulista, Rio Claro, SP, Brazil

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Correspondence to:
Timothy Gustavo Cavazzotto
R. Simeão Camargo Varela de Sá, 3
Cascavel – Guarapuava, PR, Brazil
CEP: 85040-080
Tel: +55 (42) 3629-8157
tcavazzotto@yahoo.com.br

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Introduction

Systemic arterial hypertension (SAH) is the most prevalent and most dangerous risk factor for the progression and/or development of myocardial infarction and stroke[1,2]. The prevalence of hypertension in the adult Brazilian population is approximately 30%[3,4]; however, this condition can be found in more than 50% of the elderly population[4].

Among workers, SAH suggests dependence on factors related to the characteristics of the profession, as the incidence is related to stress exposure (competition, risk of dismissal, monotony, attention level), type of occupation (task performed, organization, wages, rhythm, and duration of work) and the work environment (physical and chemical factors)[5-8]. This consideration is based on information reported in the literature that describes a prevalence of hypertension among several professional activities that can vary from 3% to 51%[5,9-15].

Scientific evidence suggests that the risk of SAH is increased in insufficiently active individuals and in those with low cardiorespiratory fitness[16]. Moreover, a higher development of muscular strength/resistance is recognized as an important component of physical fitness in chronic disease prevention[17]. However, there is little information on the association between muscle strength and SAH in workers. Considering that approximately 1/3 of the day is devoted to work activities and that the incidence of diseases in the work environment causes considerable social and economic losses[18,19], analyzing the possibility of a modifiable risk factor, such as muscle strength, to affect the incidence of hypertension in workers can contribute to the planning of public policies aimed at prevention, control, and more effective treatments. In this sense, the aim of this study was to compare the performance on static muscular strength tests between normotensive and hypertensive workers.

Methods

A total of 354 workers (246 men and 108 women) from a company that manufactures candies and sweets in the city of Rio Claro voluntarily participated in the study. The company has a workforce of approximately 1,300 employees, distributed in the security, packaging, transportation, and administrative sections, with morning, afternoon, and evening shifts. Each year, a sample of the workers is submitted to clinical evaluations during the accident prevention week in the company's outpatient clinic, which has two nurses and a doctor. On these occasions, a team of examiners was asked to perform functional/motor evaluations.

Routine evaluation includes systolic (SBP) and diastolic (DBP) blood pressure measurements, anthropometric measurements (height, body mass, and waist circumference), and three static muscular strength tests (hand grip, lumbar, and scapular strength) for three days in the three shifts. The study was descriptive, with a cross-sectional design. It was approved by the Ethics Committee of the Universidade Estadual Paulista Julio de Mesquita (UNESP-RC; protocol No. 1916) and the participants, after being informed of the risks and procedures of the study, signed an informed consent.

Blood pressure (BP) measurements were obtained using a mercury column sphygmomanometer (Mecurial®). For analysis purposes, the mean value of two measurements recorded on the day of evaluation was used, respecting a period of ten minutes between each measurement, with the patient in the sitting position.

The recommendations of the Brazilian Guidelines of Arterial Hypertension[20,21] were used to analyze BP measurement and to establish SAH diagnosis in adults of both genders. Thus, workers were considered as having SAH when they had SBP and DBP ≥ 140 and 90 mmHg, respectively. Workers who had been diagnosed by a physician and/or regularly used antihypertensive medication were also considered to be hypertensive, regardless of the values measured at the collection site. The mean arterial pressure (MAP) was calculated based on the SBP and DBP values, according to the following formula: $MAP = [SBP + (2\ DBP)]/3$[21].

Body mass was estimated using a mechanical anthropometric scale with 100-g precision (Welmy®). Height measurements were obtained using a wooden stadiometer with 0.1 cm precision[22]. Body mass index (BMI) was calculated based on the body mass measurements and expressed as kg/m^2[11]. Waist circumference (WC) was measured in duplicate at midpoint between the last rib and the iliac crest using a non-extensible tape measure (Mabis® – Japan)[11].

Static strength tests were performed using a Crown® dynamometer for measuring handgrip strength (hand dynamometer), scapular region muscle strength (scapular dynamometer), and lumbar spine muscle strength (lumbar dynamometer)[23]. Before the tests, all participants were instructed on the handling of the equipment and the protocol for carrying out the measurements. To get participants acquainted with the equipment, two to three attempts with submaximal force were made.

The standardized protocol for each test consisted of two maximum attempts, followed by an interval of approximately one minute for recovery. The tests were performed in the order described, and once performed, the next test was immediately started, as different muscle groups were required.

The handgrip test was conducted with the individual in the standing position, holding the dynamometer in one hand and extending the arm along the body. The grip adjustment was individualized, so that only the last four distal phalanges exerted force on the handle. Based on this position, the subject was instructed to perform a maximal contraction. After recording the measurement, the dynamometer was transferred to the other hand, in which the same procedure was performed.

The scapular strength test was also performed in the standing position. The subject held the dynamometer at chest level, with elbows parallel to the ground and looking forward. From this position, the individual was asked to perform a maximal contraction with both arms (extension of the shoulders), horizontally.

The lumbar strength test was performed with the trunk semi-flexed and with outstretched arms and legs. The individuals held the instrument handle, performing a maximal contraction, seeking to exert force with the lumbar muscles. Participants who reported the presence of lumbar pain did not perform this test.

Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS) version 15.0 for Windows (SPSS, Inc. – Chicago, IL) with a significance level set at $p < 0.05$. The Shapiro-Wilks test showed that the data were asymmetric, and thus, were shown descriptively as medians and interquartile variance, whereas the comparison between groups was performed by the Mann-Whitney U-test for independent asymmetric variables.

Results

Table 1 shows the anthropometric characteristics, BP values, and muscle strength performance of the participants in accordance with the condition (normotensive and hypertensive). Normotensive workers had significantly lower values of body mass (BM), BMI, and WC when compared to hypertensive individuals. Of the total sample, 8.9% were classified as hypertensive. When separated by gender, it was observed that men and women (normotensive and hypertensive) differed for the same variables (BM, BMI, and WC), except for age in women. Although the hypertensive workers had higher values (median) in three of the four tests of strength (right handgrip [RHG], left handgrip [LHG], and lumbar strength [LS]), performance did not significantly differ between normotensive and hypertensive individuals.

Table 2 shows the frequency of workers separated by the conditions, hypertensive and normotensive, and classified according to BMI values in three groups: normal weight (≤ 24.9 kg/m^2), overweight (25.0 ≤ BMI ≤ 29.9 kg/m^2), and obese (> 30 kg/m^2). Among the hypertensive workers, 15 were overweight, 12 were obese, and only two had BMI values within the normal weight range. As for the normotensive individuals, 150 workers had normal weight, 37 were obese, and 138 were overweight.

Table 2 – Frequency of participants in normotensive and hypertensive conditions, divided by BMI: normal weight (≤ 24.9 kg/m^2), overweight (25.0 ≤ BMI ≤ 29.9 kg/m^2), obesity (> 30 kg/m^2)

	Normotensive	Hypertensive
Normal weight	150	2
Overweight	138	15
Obesity	37	12

Table 1 – Median and interquartile variance (P75-25) for the anthropometric and BP characteristics of participants

	All	Normotensive	Hypertensive
Participants n (%)	354 (100)	326 (92)	28 (8)
Age – years	33.0 (15.0)	32.0 (15.0)*	40.0 (15.0)
Body mass – kg	73.5 (19.0)	71.7 (19.0)*	87.3 (20.0)
Height – cm	169.2 (13.0)	169.0 (13.0)	171.4 (14.0)
BMI – kg/m^2	25.5 (5.1)	25.3 (4.9)*	29.2 (5.3)
Waist circumference – cm	85.5 (16.0)	84.6 (15.0)*	96.5 (17.0)
Systolic BP – mmHg	120.0 (20)	120.0 (18.0)*	144.5 (15.0)
Diastolic BP – mmHg	80.0 (13.0)	77.0 (10.0)*	98.7 (12.0)
Mean BP – mmHg	93.3 (13.5)	91.7 (12.5)*	114.9 (8.5)
Left handgrip strength – kg	50.0 (20)	49.8 (21.0)	53.1 (14.2)
Right handgrip strength – kg	46.3 (20)	45.9 (20.0)	49.7 (14.0)
Lumbar strength – kg	115.0 (64)	114.5 (67.0)	130.5 (45.0)
Scapular strength – kg	27.2 (14)	27.2 (15.0)	27.5 (7.0)

*$p < 0.05$ between the conditions, normotensive, hypertensive; median (interquartile variance); BMI, body mass index; BP, blood pressure.

For the following analysis, workers classified as having normal BMI and overweight were combined into one group and compared with the workers classified as obese.

Thus, performance in the strength tests was analyzed in normotensive and hypertensive workers according to BMI in normal weight/overweight (≤ 29.9 kg/m^2) and obese (> 30 kg/m^2) individuals (Table 3). Significant differences regarding strength tests were observed among normotensive workers classified as normal/overweight and obese according to the BMI. In this case, the heavier normotensive individuals (> 30 kg/m^2) had an advantage over the thinner ones (≤ 29.9 kg/m^2). On the other hand, no differences were observed among hypertensive workers with a similar classification.

It is noteworthy that hypertensive individuals with normal BMI/overweight (≤ 29.9 kg/m^2) had higher medians for handgrip strength (right and left), and lower medians for scapular and lumbar strength (Table 3). The difference observed among normotensive individuals, however, which was not observed among hypertensive individuals regarding the classification of obesity, also suggests that this difference (strength/pressure) depends on body weight.

The intragender comparison showed no significant differences for static muscle strength testing (Table 4). However, a clear difference was observed in the values of all strength tests when comparing genders, regardless of BP condition (normotensive or hypertensive). This was attributed to the inherent differences between genders. Another important observation is the number of hypertensive men, which was higher than the number of hypertensive women. This evidence may attribute higher values in the total median of hypertensive individuals, causing confusion in the comparison of hypertensive/normotensive results for strength tests.

Discussion

The differences observed between the hypertensive and normotensive workers for indicators of obesity (BMI, WC, BM) may indirectly reflect their health status, as they represent variables used to define risk factors[11,13,24-27]. It was observed that 26 individuals, or 89% of the hypertensive workers, were overweight/obese. These data corroborate studies that show a strong association between obesity and SAH[26,27]. Additionally, the hypertensive workers in this study were older than the normotensive individuals. This result is consistent with observations that suggest an increased incidence of SAH with age[28].

Hypertensive and normotensive subjects did not differ on static strength tests. However, hypertensive workers had higher medians in the handgrip and lumbar strength tests. One possible explanation for these results is the association between tests of muscle strength and anthropometric variables such as height, body mass, and BMI[29-31], which were higher in hypertensive individuals.

Table 3 – Comparison of muscle strength between normotensive and hypertensive participants with normal weight/overweight and obesity

	Normotensive		Hypertensive	
	Normal/overweight	Obesity	Normal/overweight	Obesity
n (%)	288 (81.4)	37 (10.4)	17 (4.8)	12 (3.4)
LHG – kg	45.3 (20)	49.9 (15)*	51.2 (15)	49.3 (13)
RHG – kg	49.0 (21)	55.5 (19)*	55.5 (11)	49.9 (19)
LS – kg	122.0 (66)	139.0 (45)*	127.0 (40)	135 (58)
SS – kg	27.0 (14)	30.0 (11)*	26.0 (7)	28.6 (18)

*Difference between normal/overweight (≤ 29.9 kg/m^2) and obesity (≥ 30 kg/m^2); Median (interquartile interval); $p < 0.05$; Mann-Whitney U; LHG, left handgrip; RHG, right handgrip; LS, lumbar strength; SS, scapular strength.

Table 4 – Intragender comparison for muscle strength tests between normotensive and hypertensive participants

	Normotensive		Hypertensive	
	Men	Women	Men	Women
n (%)	222 (62.7)	104 (29.4)	24 (6.8)	4 (1.1)
LHG – kg	54.3 (10)	30.9 (8)	54.4 (10)	38.0 (13)
RHG – kg	50.8 (15)	29.5 (8)	50.5 (15)	32.4 (8)
LS – kg	131.0 (34)	61.0 (25)	135.0 (34)	73.0 (48)
SS – kg	30.0 (9)	15.0 (6)	28.5 (6)	17.5 (8)

LHG, left handgrip; RHG, right handgrip; LS, lumbar strength; SS, scapular strength. Median (interquartile interval).

On the other hand, another potential confounding factor is the gender of the participants, as among hypertensive patients (n = 28), 24 were men, whereas in the normotensive group (n = 326), this number was 222. These results also help to explain the higher levels of strength among the hypertensive individuals. Moreover, because of the inherent differences for gender, the higher number of men may have influenced the results of the hypertensive/normotensive comparison.

Development of muscular strength/resistance is recognized as an important component of physical fitness in chronic disease prevention[18]. Recently, a longitudinal research study conducted by the Aerobics Center Longitudinal Study in 1,506 hypertensive men demonstrated that participants with greater muscle strength had a lower risk of death[32]. In the present study, SAH was not a condition that limited strength performance among workers, but the role of variables such as gender and body weight may have contributed to the results. In this sense, despite the positive effects of muscle strength for the control and treatment of SAH[33-36], the results of this study should be analyzed with caution.

Considering that the results did not fully confirm this study's hypothesis, it is important to point out some limitations. Initially, it is important to remember that the sample consisted of workers who were invited to participate in the assessments by the company's physician. This could have excluded participants who had known hypertension or other associated diseases. However, it is noteworthy that the data were collected during the accident prevention week and there was no interest in identifying health problems; moreover, the company submits all employees to rigorous health assessments that include biochemical and hemodynamic analysis (including BP measurement) before they are hired, and once a year after being hired.

Another important condition to be emphasized is the use of BMI as an indicator of obesity. There is sufficient evidence to show that this index is not a good reference to establish obesity, especially in physically active individuals. The IMC was able to correctly indicate obesity in only 44.3% of the men that were classified as obese by the hydrostatic weighing method[37]. Thus, many workers classified as being overweight and obese could have greater muscle development due to the work demand or to participation in physical activity programs outside the company. This remark is justified in the significant difference in muscle strength performance observed between normotensive subgroups of workers with normal weight/overweight *versus* obese workers (Table 3).

It is also important to emphasize the non-parametric distribution of the data (which remained even after logarithmic transformation). Thus, there is a limitation in the use of the obtained data in a linear regression model. This regression model could indicate the actual role of variables such as gender and muscle mass in the observed associations, and thus eliminate possible confounding factors. Moreover, the workers investigated constitute a homogeneous group, and most have very similar activities (production). That is to say that the work activities (production and administrative) may have contributed to the leveling in strength performance among the workers, regardless of their normotensive or hypertensive status.

Finally, better working conditions, access to medical care and prevention activities are strategies that must be adopted by companies to reduce workers' exposure to health risk factors, which that can significantly reduce the incidence of chronic diseases, decrease costs of treatments and leaves of absence, and improve the quality of life of employees.

Conclusion

Normotensive and hypertensive workers showed no significant differences in the performance of static muscle strength tests; however, the association between muscle strength and BP appears to be strongly affected by body mass and gender.

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