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ASSOCIATION BETWEEN MUSCLE MASS AND A SINGLE MEASUREMENT OF HYPERTENSION IN COMMUNITY-DWELLING ADULTS IN KOREA

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ABSTRACT

Hypertension is a well-known global and social health problem affecting all-cause mortality significantly. It is strongly associated with the risk of heart attack, coronary artery disease, cardiovascular disease, stroke and liver disease. The relationship between muscle mass and a diagnosis of hypertension in a sample of Korean adults (N=225) was investigated. The participants included adults aged >20 years who visited the S-gu Public Health Centre, Seoul, Korea for a medical check-up in 2011. The Joint National Committee on Prevention, Detection, Evaluation and Treatment of High Blood Pressure VII defined hypertension as blood pressure >140/90 mmHg. The prevalence of hypertension was 28.4% in the present study. The association between muscle mass quartiles was determined using bioelectrical impedance analysis. The presence of hypertension was assessed using multivariate logistic regression analysis adjusted for BMI and self-reported personal demographic and lifestyle information. The odds ratios (95% confidence interval) for each of the quartiles compared to the very low muscle mass quartile were: 0.617 (0.190–2.004, p=0.422) for low muscle mass; 2.564 (0.873–7.531, p=0.087) for high muscle mass; and 2.975 (0.893–9.907, p=0.076) for very high muscle mass. These results indicated that muscle mass was not associated with a single measurement of hypertension in this sample.

Key words: Hypertension, Body Mass Index (BMI), Lean body mass; Muscle mass; Adults; Korea.

INTRODUCTION

According to a report by the World Health Organization in 2013, the global number of people with hypertension increased from 600 million in 1980 to 1 billion in 2008, with approximately 40% of the adults older than 25 years of age living with hypertension (World Health Organization, 2013). In the United States, hypertension was present in 31.7% of men and 32.8% of women aged >20 years in 2011 (National Centre for Health Statistics, 2012). Similarly, a 2011-report in Korea indicated that the prevalence of hypertension in adults older than 30 years was 33.9% in men and 27.8% in women, and these rates are increasing (Korea Ministry of Health and Welfare, 2012). Owing to its strong associations with the risk of heart attack, coronary artery disease, cardiovascular disease, stroke and liver disease, hypertension is a global public health problem (McInnes, 1995; Henriksen & Møller, 2004; World Health Organization, 2011; Korea Ministry of Health and Welfare, 2012; National Centre for Health Statistics, 2012; World Health Organization, 2013).

The risk for hypertension is affected not only by behavioural factors, such as diet, smoking, physical activity and alcohol consumption, but also by globalisation, urbanisation, aging, income, education and housing (World Health Organization, 2013). There are also a number of metabolic factors, such as obesity, diabetes and increased blood lipids, which increase the risk for hypertension (World Health Organization, 2013).

RESEARCH PROBLEM

Recently, evidence has suggested that hypertension is also associated with inflammation (Bautista *et al*., 2005; Stefanadi *et al*., 2010; El Chami & Hassoun, 2012), and inflammation may contribute to hypertension (Libby *et al*., 2002). Furthermore, inflammatory processes may be important contributors to the patho-physiology of hypertension and cardiovascular disease (Savoia & Schiffrin, 2006). The role of the inflammatory system in muscle strength and muscle mass has already been established (Schaap *et al*., 2006; Ruiz *et al*., 2008; Wang *et al*., 2010). Therefore, the authors hypothesised that there may be a link between muscle mass and hypertension. However, to our knowledge, this potential relationship has not been explored, particularly in the Korean population. Therefore, the present study aimed at examining the relationship between muscle mass and a hypertension diagnosis using a single blood pressure measurement of community-dwelling adults in Korea.

METHODS

Participants

Adults aged >20 years who visited the S-gu Public Health Centre in Seoul, Korea, for a medical check-up in 2011 (N=225) participated in this cross-sectional study. All of the participants provided written informed consent before participation, and the study procedures were approved by the S-gu Public Health Centre. Each participant underwent blood pressure and anthropometric measurements and provided personal information about lifestyle factors.

Measurements

Blood pressure

Participants spent 10 minutes resting in a seated position before a nurse specialist measured their blood pressure 3 times over a 2-minute interval using a mercury sphygmomanometer (Alpk, Tanake Sangyo Co., Ltd., Tokyo, Japan). The nurse specialist then calculated the average values for systolic and diastolic blood pressure from the 3 measurements (Lynn & Peter, 2012). Normal blood pressure was defined as blood pressure <140/90mmHg, and hypertension was defined as blood pressure ≥140/90mmHg according to the guidelines provided by the Joint National Committee on Prevention, Detection, Evaluation, and

Treatment of High Blood Pressure VII (National High Blood Pressure Education Program, 2003).

Anthropometric measurements

Height and weight were measured after a 12-hour fasting period using a digital scale (InBody-720, Biospace, Seoul, Korea) and a stadiometer. Body mass index (BMI, kg/m^2) was calculated from these values. Muscle mass was evaluated using an 8-polar bioelectrical impedance device (InBody-720, Biospace, Seoul, Korea), which has demonstrated validity and reliability for this use (Jensky-Squires *et al*., 2008). The InBody-720 uses multiple frequencies (1, 5, 50, 250, 500, 1000kHz) to measure the resistance of the arms, legs and trunk through 8 tactile electrodes: 2 on each hand (1 each in contact with the palm and thumb) and 2 on each foot (1 each in contact with the anterior and posterior aspects). The recommendations outlined in Applied Body Composition Assessment (Heyward & Wagner, 2004), were followed for the lean body mass assessment. All of the participants were prohibited from exercising for 12 hours before the measurement. All of the participants were also required to urinate immediately prior to the impedance measurement and to wear light clothing and remove all metallic items.

Quartiles were determined from the muscle mass data, and the participants were grouped accordingly: very low muscle mass (n=56); low muscle mass (n=56); high muscle mass (n=56); and very high muscle mass (n=57). According to the central limit theorem, if the number of participants in each group is >30, the data are likely to approximate a normal distribution and be reliable (Johnson & Bhattacharyya, 2010).

Lifestyle factors

Self-reported personal information about lifestyle factors was collected for each participant using 10 questions: gender (male or female); age; education level (up to and including elementary school, middle school, high school, or at least a college education); economic status (very poor, poor, rich, or very rich); nightly sleep duration (≤5 hours, 6 hours, 7 hours, or ≥8 hours); frequency of alcohol consumption per month (none, once, 2 to 3 times, or ≥4 times); cigarette smoking (non-smoker, ex-smoker, or current smoker); and 3 questions to determine the weekly frequency of vigorous exercise, moderate exercise and walking for exercise (none, once, twice, 3 times, 4 times, or ≥5 times).

Statistical analysis

All results are presented as mean±standard deviation or frequencies and percentages, where appropriate. Multivariate logistic regression analysis (Johnson & Bhattacharyya, 2010) was conducted to determine the relationship between muscle mass, in quartiles, and the outcome variable, hypertension, after adjustment for gender, age, BMI, education level, economic status, nightly sleep duration, alcohol consumption, cigarette smoking, and exercise. The *Hosmer-Leme show of goodness of fit test* was conducted, resulting in a value of 7.098 (p=0.526), which is an acceptable appropriateness of model for this study (Johnson & Bhattacharyya, 2010). Statistical significance was set at $p<0.05$ and all analyses were conducted using SPSS v18.0 (SPSS Inc., Chicago, IL, USA).

TABLE 1. **DEMOGRAPHIC/LIFESTYLE CHARACTERISTICS AND HYPERTENSION MEASURES: MEAN±SD OR FREQUENCY/PERCENTAGE**

Variables (n=225)			
Personal Body measures	Age (years)	53.24±10.31	
	Height (cm)	159.54±7.16	
	Weight (kg)	60.90±10.28	
	Body mass index (BMI, kg/m^2)	23.85±3.05	
Prevalence of hypertension	Hypertension BP (≥140/90 mmHg)	64	28.4%
	Normal BP <140/90 mmHg)	161	71.6%
Gender	Male	53	23.6%
	Female	172	76.4%
Education level	Elementary school	23	10.2%
	Middle school	26	11.6%
	High School	89	39.6%
	College level	87	38.6%
Economic status	Very poor	81	36.0%
	Poor	38	16.9%
	Rich	91	40.4%
	Very rich	15	6.7%
Nightly sleep duration	≤5 hours	17	7.6%
	6 hours	35	15.6%
	7 hours	33	14.7%
	≥8 hours	140	62.1%
Alcohol consumption	None	160	71.1%
	1 time per month	35	15.6%
	2-3 times per month	19	8.4%
	≥4 times per month	11	4.9%
Cigarette smoking	Non-smoker	204	90.7%
	Ex-smoker	11	4.9%
	Current smoker	10	4.4%
Vigorous physical activity	None	148	65.8%
	1 time per week	21	9.3%
	2 times per week	16	7.1%
	3 times per week	15	6.7%
	4 times per week	12	5.3%
	≥5 times per week	13	5.8%
Moderate physical activity	None	138	61.2%
	1 time per week	20	8.9%
	2 times per week	22	9.8%
	3 times per week	20	8.9%
	4 times per week	8	3.6%
	≥5 times per week	17	7.6%
Walking for exercise	None	95	42.2%
	1 time per week	15	6.7%
	2 times per week	13	5.8%
	3 times per week	27	12.0%
	4 times per week	9	4.0%
	≥5 times per week	66	29.3%

RESULTS

The demographic characteristics of the participants and the responses to the questions about lifestyle factors are provided in Table 1. Most participants (76.4%) were women, and 28.4% were diagnosed with hypertension.
The results of the multivariate logistic regression analysis are provided in Table 2. An increase in muscle mass did not significantly increase the odds of a hypertension diagnosis for any of the quartiles, compared to the very low muscle mass quartile (low muscle mass, odds ratio [OR]=0.617, 95% confidence interval [CI]=0.190–2.004, p=0.422; high muscle mass, OR=2.564, 95% CI=0.873–7.531, p=0.087; and very high muscle mass 2.975, 95% CI=0.893–9.907, p=0.076).

TABLE 2. **MULTIVARIATE LOGISTIC REGRESSION ANALYSIS: RELATIONSHIP BETWEEN MUSCLE MASS AND HYPERTENSION**

Group (n=225)	**Beta**	**Standard error**	**Odds ratio**	**95% confidence interval**	**p-Value**
Very low muscle mass	Reference		1.000		
Low muscle mass	-0.482	0.601	0.617	0.190-2.004	0.422
High muscle mass	0.941	0.550	2.564	0.873-7.531	0.087
Very high muscle mass	1.090	0.614	2.975	0.893-9.907	0.076

Note: Adjusted for body mass index (BMI), and self-reported gender, age, education level, economic status, sleep duration, alcohol consumption, cigarette smoking, and frequency of vigorous exercise, moderate exercise and walking for exercise

DISCUSSION

The results of the current study indicate that muscle mass was not associated with hypertension in this sample of Korean adults when adjusted for lifestyle factors that could also affect blood pressure.

Several conditions such as arthritis, diabetes and hypertension have been previously associated with high fat-free mass (Visser *et al*., 1998). Left ventricular mass, which is a predictor of hypertension, is also highly correlated with fat-free mass (Bella *et al*., 1998; Whalley *et al*., 1999; Kuch *et al*., 2001) and independently related to fat-free mass but not body size or composition (Whalley *et al*., 1999; Kunch *et al*., 2001). Interestingly, cardiovascular disease occurs more often in patients with left ventricular hypertrophy, compared to other patients (Koren *et al*., 1991), and left ventricular hypertrophy is an independent cardiovascular risk factor for primary and secondary hypertension, as well as coronary artery disease in the general population (Levy *et al*., 1990; Koren *et al*., 1991; Ghali *et al*., 1992; Foley *et al*., 1995).

Although the relationship between fat-free mass and left ventricular hypertrophy in addition to those between left ventricular hypertrophy and both hypertension and cardiovascular disease could imply a relationship between fat-free mass and both hypertension and cardiovascular disease, to the best of our knowledge, there is little evidence to support the latter relationships. However, the present study failed to demonstrate a relationship between hypertension and fat-free mass. Well-designed studies are necessary to determine if there is an association between muscle mass and hypertension.

This study has certain limitations. Firstly, the use of self-reported information on lifestyle factors might have resulted in inaccurate data for the covariates in the analysis. Secondly, participants of this study were recruited from one public health centre in Seoul, Korea, limiting the generalizability to the entire Korean adult population and results are based on a small sample size drawn from one geographic area only. Thirdly, inflammation was not measured, which may have shed some light on the potential relationship with hypertension. Fourthly, the single blood pressure measurement for the clinical diagnosis of hypertension should be considered a major limitation, as guidelines recommend diagnosis based on two separate measurements. Finally, due to the retrospective and cross-sectional nature of the study, causality could not be determined.

CONCLUSION

In conclusion, muscle mass was not associated with the presence of hypertension in this sample of Korean adults, when adjusted for gender, age, BMI, education level, economic status, nightly sleep duration, alcohol consumption, cigarette smoking, and exercise frequency.

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