

# The Association of Calf Circumference with Resting Pulse Rate in Community-dwelling Healthy Elderly Women —Pilot Study—

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**Abstract.** [Purpose] High resting blood pressure and heart rate are associated with the risk of cardiovascular events. In patients with decreasing amounts of slow twitch muscle fiber, hypertension may develop and resting heart rate may increase. Measurement of the amount of slow twitch muscle fiber and capillary density using muscle biopsy is inconvenient and expensive. Therefore, a better screening test is required to determine these parameters for prevention of cardiovascular events. In this study, relationships among calf circumference, resting blood pressure, and pulse rate in the soleus muscle were investigated. [Subjects] Healthy elderly women (n= 19, 61–84 years of age) living in the community were the subjects of this study. [Methods] Blood pressure was measured using an automatic hemodynamometer on the left arm. The calf circumference was measured, and pulse rate was measured on the left radial artery for 1 min by palpation. [Results] No correlations were observed between calf circumference, resting systolic or diastolic pressure, pulse pressure, or mean blood pressure. However, an inverse correlation was observed between calf circumference and resting pulse rate. [Conclusion] Calf circumference measurement may be used as a screening test for resting pulse rate. This test may be useful for the prevention of cardiovascular events.

**Key words:** Calf circumference, Resting pulse rate, Slow twitch muscle fiber

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## INTRODUCTION

The first and second leading causes of death worldwide are ischemic heart disease and cerebrovascular disease, respectively, according to a report projecting mortality data from 1990 to 2020<sup>1)</sup>. Arterial stiffness is a risk factor for cardiovascular events<sup>2)</sup>. It develops due to hypertension, inflammation, AGEs (advanced glycation end products), and changes in heart rate<sup>3, 4)</sup>. According to the World Health Organization, 51% of stroke (cerebrovascular disease) and 45% of ischemic heart disease deaths are attributable to high blood pressure<sup>5)</sup>. Moreover, high resting heart rate has been reported to increase cardiovascular events<sup>6)</sup> and cause persistent hypertension<sup>7)</sup>. Thus, prevention of hypertension and high resting heart rate could lead to a decrease in the number of cardiovascular events.

The most common form of hypertension is called essen-

tial hypertension. Hernelati et al.<sup>8)</sup> reported an inverse correlation between the amount of slow twitch muscle fiber and hypertension. Lower capillary density has been associated with higher resting heart rate and mean blood pressure as well<sup>9)</sup>. The capillary density of slow twitch muscle fiber is higher than that of fast twitch fiber<sup>10)</sup>. Moreover, sedentary lifestyle has been linked to a high household resting heart rate<sup>11)</sup>. A positive correlation has been reported between the amount of slow twitch fiber and physical activity<sup>12)</sup>. However, measurement of the amount of slow twitch fiber and capillary density using muscle biopsy is inconvenient and expensive. Although this information could be useful for preventing cardiovascular events, these measurements are difficult to perform in clinical settings.

The triceps surae forms a major part of the muscle of the posterior leg<sup>13)</sup>, and is commonly known as the calf muscle. Calf circumference is relatively easy to measure. Moreover, a positive correlation has been reported between calf circumference and appendicular muscle mass<sup>14)</sup>, and the triceps surae muscle encompasses the soleus, in which the

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**Table 1.** The characteristics of the study subjects (n=19)

Characteristics	mean±SD
Age (years)	75.1±7.2 (61–84)
Weight (kg)	46.8±5.8 (36.2–58.7)
Height (cm)	145.9±6.5 (132.6–155.5)
Body mass index (kg/m <sup>2</sup> )	22.0±2.4 (18.1–26.6)
Calf circumference (cm)	32.2±1.8 (29.5–34.9)
Resting systolic blood pressure (mmHg)	138.7±15.7 (111–171)
Resting diastolic blood pressure (mmHg)	78.4±9.6 (63–101)
Resting mean blood pressure (mmHg)	98.5±10.6 (82–124)
Resting pulse pressure (mmHg)	60.4±11.8 (43–86)
Resting pulse rate (beats/minute)	75.6±10.7 (54–98)

SD, standard deviation

proportion of slow twitch fiber is almost 90%<sup>13, 15</sup>). Thus, measurement of the calf circumference may provide valuable information regarding susceptibility toward adverse cardiovascular events. In the present pilot study, we tested the hypothesis that calf circumference is related to resting blood pressure and resting pulse rate.

## SUBJECTS AND METHODS

The subjects were healthy elderly women (n = 19) living in the community with ages ranging from 61–84 years. The subjects lived independent by themselves. None of our subjects engaged in any regular exercise. Women were excluded if they had edema of the lower leg, or had a previous history of lower leg fracture. All subjects read and signed a written informed consent form.

We have often had difficulty in measuring maximum calf circumference due to atrophy and other factors. Setting the distance from the inferior pole of the caput fibulae to the center of the lateral malleolus as the length of the lower limb, maximum calf circumference is the point 26% below the inferior pole of the caput fibulae in young people<sup>16</sup>). Thus, maximum calf circumference was measured at a point 26% below the inferior pole of the caput fibulae. We measured the length from the inferior pole of the caput fibulae to the center of the lateral malleolus using a tape measure and calculated 26% of the length. Two investigators measured the calf circumference from the left side of the subjects using a tape measure. The measurements were recorded with the subjects in the sitting position with the sole of the foot touching the floor. The hip, knees, and ankles were flexed at 90°, 90°, and 0°, respectively. The interclass correlation coefficient (1,1) was determined to ensure inter-rater reliability for calf circumference measurement.

Systolic and diastolic pressures were measured using an automatic hemodynamometer (HEM-907, Omron Health Care, Kyoto, Japan) after subjects had sat for a 5-min rest period. Blood pressure was automatically measured twice, and the average values of the systolic and diastolic pressures were recorded. Moreover, pulse pressure and mean blood pressure were calculated as well. The measurements were recorded from the left arm at the height of the heart. Pulse rate was measured at the left radial artery by palpat-

**Table 2.** Correlation coefficient Between Calf Circumference and Resting Blood Pressure, Pulse Rate

	Calf circumference
Resting systolic blood pressure (mmHg)	0.05
Resting diastolic blood pressure (mmHg)	0.04
Resting mean blood pressure (mmHg)	0.04
Resting pulse pressure (mmHg)	0.05
Resting pulse rate (beats/minute)	-0.57 *

Pearson's product-moment correlation coefficient \*: p&lt;0.05, N=19

ing for 1 min. Blood pressure and pulse rate were measured between 9:00 and 11:00 h by two investigators.

The associations between blood pressure, pulse rate, and calf circumference were evaluated using Pearson's product-moment correlation coefficient, and p < 0.05 was considered statistically significant.

## RESULTS

The characteristics of the study subjects are presented in Table 1. The interclass correlation coefficient (1,1) of calf circumference was highly reproducible (r = 0.98, 0.99, respectively). Pearson's product-moment correlation coefficient revealed there was no correlation between calf circumference and resting systolic or diastolic pressure, pulse pressure, or mean blood pressure (p > 0.05, Table 2). However, an inverse correlation was observed between calf circumference and resting pulse rate for 1 min (r = -0.57, p = 0.011; Table 2).

## DISCUSSION

Although no correlation was observed between calf circumference and resting systolic or diastolic pressure, pulse pressure or mean blood pressure, calf circumference correlated inversely with resting pulse rate for 1 min. Thus, we conclude that lower calf circumference may be associated with high resting pulse rate. This finding may have implications for practitioners for the prevention of adverse cardio-

vascular events in patients with smaller calf circumference.

In the soleus muscle of the triceps surae, the proportion of slow twitch muscle fiber is almost 90%<sup>14</sup>. Lower capillary density is associated with higher resting heart rate and mean blood pressure<sup>9</sup>. The capillary density of slow twitch muscle fibers is higher than that of fast twitch muscle fibers<sup>10</sup>. Therefore, in patients with smaller calf circumference, capillary density in the soleus muscle may be lower and resting pulse rate may be higher. In addition, an inverse correlation between stroke volume and heart rate has been demonstrated during rest and exercise<sup>17</sup>. Stroke volume is dependent on venous return (the Frank–Starling principle), and venous return is dependent on muscle pumping<sup>18</sup>. Muscular blood flow correlates positively with capillary density<sup>19</sup>. In the human calf, the soleus is the muscle that performs the pumping. The intramuscular pressure in the soleus during walking is about  $180 \pm 20$  mmHg, and the soleus is more responsible than the tibialis anterior for pumping blood during walking<sup>20</sup>. Venous return is dependent on calf circumference<sup>21</sup>; therefore, in patients with smaller calf circumference, the smaller soleus mass may result in reduced muscle pumping, lower venous return, lower stroke volume, and increased resting pulse rate. All of these factors may lead to a higher risk of adverse cardiovascular events. Thus, the results of the present study indicate that calf circumference measurement may be used as a screening test to determine resting pulse rate, and this information may be useful for the prevention of cardiovascular events in older women.

In the present study, no correlation was observed between calf circumference and blood pressure. The product of heart rate and stroke volume is cardiac output; in addition, peripheral vessel resistance is a determinant of blood pressure. The rise and fall in blood pressure is the results of a complex adaptation to stimulation rather than to pulse rate alone. A low proportion of slow twitch muscle fiber results in higher vascular resistance<sup>22</sup>, and capillary density is associated with systolic blood pressure, and endothelial function<sup>23</sup>. On the other hand, a higher proportion of fast twitch muscle fibers results in a higher resting mean blood pressure on account of muscular sympathetic nervous activity<sup>24</sup>. Therefore, individuals' amounts of fast twitch muscle fiber may have influenced resting systolic or diastolic pressure, pulse pressure, and mean blood pressure in the present study. Future studies may shed further light on this phenomenon.

One limitation of the present study is that the use of antihypertensive agents was not investigated or analyzed. As beta-blockers have a direct influence on heart rate, the relationships among calf circumference, blood pressure, and pulse rate with and without antihypertensive drugs must be determined by another study. Furthermore, the proportion of slow or fast twitch muscle fibers, and capillary density were not measured; therefore, it is unclear how these factors influence calf circumference and resting pulse rate.

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