THE RELATIONSHIP BETWEEN CARDIAC MUSCLE, SKELETAL MUSCLE MASS, AND VESSEL STRUCTURE IN ELDERLY WOMEN

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Abstract

The purpose of this study was to clarify the relationship between left ventricular muscle mass, skeletal muscle volume and vessel structures in elderly women ($n=15$, 76.0 ± 5.4 years). We measured the thigh muscle thickness, and brachial and common carotid arterial diameter using B-mode ultrasound method. Posterior wall thickness, interventricular septal thickness, left ventricular end-diastolic internal diameter, and aorta artery were measured by B-mode echocardiography. No significant relationship was obtained between brachial and common carotid arterial diameters, and aortic diameter. On the other hand, significant correlation coefficients were obtained between cardiac muscle thickness and thigh muscle thickness ($r=0.674$, $p<0.01$). A significant correlation coefficient was also obtained between the estimated skeletal muscle volume and left ventricular mass [LVmass] ($r=0.542$, $p<0.05$). The slope of regression equation between estimated thigh muscle volume and LVmass in elderly women in this study was ($y=0.11x+75.65$) steeper than in children ($y=0.06x+14.02$) reported previously. These results indicate that the ventricular muscle (LVmass) is closely related to the skeletal muscle volume in ordinary elderly women and skeletal muscle mass at a given LVmass is smaller in elderly women than children.

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key word : LVmass, thigh muscle thickness and ultrasound method

Introduction

Cardio-vascular function is activated by skeletal muscle activities to meet oxygen demands from skeletal muscle tissues. The muscle pump caused by skeletal muscle contraction increases venous return, which in turn increases pre-loading to the heart⁴). One of the major modifications of the vessel with advancing age was widening of the arterial diameter and reduction of blood flow velocity at baseline in peripheral artery^{1,7}). In addition, arterial compliance decreases and arterial resistance decreases with advancing age, which resulted in, an elevation in systolic blood pressure, and after-loading to left ventricle.

We hypothesized that the reduction of skeletal muscle volume in elderly women decreases the amount of stimulus to cardiac muscle and vessel

structure. However, no previous studies have reported a relationship between cardiac muscle, skeletal muscle mass and vessel structure in elderly women. Only one study exists with respect to this topic⁵) conducted on children but not on elderly. They reported that ventricular muscle development is closely related to the development of skeletal muscle in children⁵).

The purpose of this study, therefore, was to clarify the relationship between cardiac muscle mass, skeletal muscle and vessel structure, and to elucidate whether the relationship between skeletal and cardiac muscle mass in elderly differs from that in children.

Methods

Subjects and experimental design

Fifteen elderly women, who live in urban part of

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Tokyo, participated in this study after giving their informed consent. Their mean age was 76.0 ± 5.4 years. Their physical characteristics are shown in Table 1. Before voluntarily participating in this experiment, each subject was fully informed of the purpose, protocol, voluntarily participating and associated risk. All the subjects were normotensive, no take medications, and no history of cardiovascular disease.

Physiological measurements

Measurement of skeletal muscle thickness

While standing, the subject's thigh length of the right side was measured as the distance from the lateral epicondyle of the femur to the greater trochanter. The measurement site of the thigh was determined at 50% of its length. Both measurement sites were marked on the dermal surface with a pen. Using a B-mode ultrasound apparatus(SSD-1000, 7.5 MHz, Aloka), we measured layer tissue thickness at 2 sites ; vastus intermedius[VI]and rectus femoris[RF]

Measurement of cardiac dimension

The echocardiographic investigations were carried out at rest in a left lateral decubitus position. B-mode images of the heart were obtained using an ultrasound apparatus(VIVID7, GE)with a 2.5 MHz transducer positioned at the level of the chordar tendinae to exsure simultaneous visualization of the left ventricular posterior wall tickness[LVPWT] the interventricular septal thickness[IVST] the left ventricular end-diastolic internal diameter[LVIDd] and the aorta arterial diameter[AO] LVmass(g) was calculated by Devereux and Reichek²⁾, as follows :

$$\text{LVmass} = 1.04 \{ (\text{IVST} + \text{LVIDd} + \text{LVPWT})^3 - \text{LVIDd}^3 \} - 13.6$$

Measurement of vessel structure

The blood vessel diameter of the common carotid artery[Cca]and brachial artery[Ba]were measured by B-mode ultrasound method(HP 8500 GP, Hewlett-Packard)with a 7.5 MHz transducer. The longitudinal two-dimensional ultrasound images were obtained using a linear array transducer from 2 different arteries at following sites ; at 1~2 cm proximal to the bifurcation of the common carotid and brachial artery. All the signals were stored on a video cassette recorder(VCR)for later analysis.

Statistics

Pearson's correlation coefficient test was used to determine the relations between cardiac muscles mass and skeletal muscles mass. Differences at $P < 0.05$ were accepted as a significant.

Results

No significant correlation coefficients were obtained among brachial, common carotid and aortic diameters, and between left ventricular end-diastolic internal and aortic diameters. Figure 1 shows the relationship between cardiac muscle thickness and thigh muscle thickness. A significant correlation coefficient was obtained between cardiac muscle thickness(the sum of posterior was thickness and interventricular septal thickness)and thigh muscle thickness(the sum of vastus intermedius and rectus femoris)($r = 0.246$, $p < 0.05$). The skeletal muscle volume was estimated and its relationship to LVmass in elderly women is illustrated in Figure 2 compared with that in children. A significant correlation coefficients was also obtained between two parameters($r = 0.360$, $p < 0.05$). The regression equation in elderly women was $y = 0.09x + 108.1$. When LVmass at a given skeletal muscle mass was compared, the elderly women tended to be larger values than that in children⁵⁾.

Table 1. Physical characteristics of the subjects

Number of subjects	Age (years)	Height (cm)	Weight (kg)	Number of steps (steps/days)	Consumption (kcal/day)
14	76.0±5.4	148.3±5.3	50.7±8.6	4867±480	1415±40

Values are mean±SD.

Fig. 1. Relationship between cardiac muscle thickness and thigh muscle thickness. A, B : VI, RF and IVST, C, D : VI, RF and PWT, E : cardiac muscle thickness (the sum of PWT and IVST) and thigh muscle thickness (the sum of VI and RF). VI : vastus intermedius, RF : rectus femoris, IVST : inter ventricular septal thickness, PWT : ventricular posterior wall thickness

Fig. 2. Relationship between skeletal muscle volume and LVmass in elderly women (76 ± 5.4 years) [A] and children (12 ± 0.8 years) [B]

Discussion

In this study, we estimated left ventricular muscle mass (LVmass), thigh muscle volume and vessel structure in elderly women. The major finding of this study was that cardiac muscle thickness and volume were closely related to thigh muscle thickness and volume in elderly women. This coordinative aging in cardiac muscle and skeletal muscle is functionally important. If the prevention of skeletal muscle atrophy will contribute to maintain stimulus to cardiac muscles, this stimulus makes cardiac muscle mass at a high level. In contrast, $\dot{V}O_{2\max}$ decreases with advancing age³⁾ and the cardiac index

decreases with age⁸⁾. This contributes to the reduction in physiological, functional capacity with advanced age. Radegran and Saltin⁶⁾ reported that the common femoral artery diameter correlated to peak pulmonary oxygen uptake during ergometer cycle exercise. Corresponding to the increased oxygen demand, cardiac muscle develops as a way to adapt to the increased blood supply to skeletal muscle tissue. We hypothesized that the reduction of skeletal muscle volume in elderly women decreases the amount of stimulus to cardiac muscle and vessel structure. In this study, the elderly women were surveyed for a physical activity level during consecutive 10 days by using Lifecorder (Szuken CO.). As a result, a sig-

nificant correlation coefficients was obtained between the estimated skeletal muscle volume and physical activity level ($p < 0.01$). That means, when the amount of physical activity level is low, the estimated skeletal muscle volume should be small. Therefore, the reduction of cardiac muscle volume with close relationship to skeletal muscle mass will provably be due to the diminished exercise stimulus to the heart and skeletal muscles.

Another finding in this study was that the relationship between cardiac and skeletal muscle mass differed in elderly and children reported previously. During growth, the cardiac muscles developed as shown in following equation ($y = 0.06x + 14.02$, $p < 0.01$). This equation was obtained from the data on children aged 6~17 years old⁵⁾. In this study, the obtained regressions between the estimated skeletal muscle volume and LVmass was $y = 0.09x + 108.13$. The slope of the regression equation between cardiac and skeletal muscle mass tended to be higher in elderly but did not differ significantly between elderly and children⁵⁾. Therefore, the skeletal muscle mass at a given cardiac muscle volume was smaller in elderly. The linearity between both parameters was obtained when the estimated skeletal muscle mass was lower than 1000 cm^3 in elderly. In contrast, this linearity existed over the wide range of skeletal muscle mass in children.

In conclusion, these results indicate that the ventricular muscle (LVmass) is closely related to the skeletal muscle volume in ordinary elderly women. When this relationship was compared with children reported in the previous study⁵⁾, muscle mass at a given LVmass is smaller in elderly women.

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