

Relationship between muscle strength and anthropometric, body composition parameters in Japanese adolescents

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ABSTRACT

We investigated the link between muscle strength and anthropometric, body composition parameters in Japanese adolescents. Forty eight men and 189 women, aged 15 - 19 years, were enrolled in this cross-sectional investigation study. Anthropometric and body composition parameters *i.e.* height, body weight, abdominal circumference, hip circumference and body fat percentage were measured. Muscle strength *i.e.* grip strength and leg strength were also evaluated. In men, grip strength was positively correlated with height and lean body mass. Leg strength was significantly correlated with height, body weight, hip circumference and lean body mass ($r = 0.708$). However, leg strength per body weight was negatively correlated with body mass index (BMI), abdominal circumference, hip circumference, body fat percentage ($r = -0.719$) and body fat mass. In women, grip strength was positively correlated with height. Leg strength was positively correlated with lean body mass ($r = 0.482$). Leg strength per body weight was negatively correlated with body fat percentage ($r = -0.457$) and body fat mass. Grip and leg strength was positively correlated with height and lean body mass, especially in men. However, leg strength per body weight was closely linked to body fat percentage in both sexes.

Keywords: Anthropometric Parameters; Body Composition; Grip Strength; Leg Strength; Leg Strength per Body Weight

1. INTRODUCTION

It is also well known that low and declining muscle strength is associated with increased mortality, independent of physical activity and muscle mass [1]. It has been well reported that there is significant loss in muscle strength with aging [2,3]. Aging is associated with alterations in body composition; there is an increase in body fat percentage and a concomitant decline in lean body mass [4]. Aging, therefore, results in substantial alterations in body composition, with a marked reduction in skeletal muscle mass. Loss of muscle strength may be an important cause of the age-related loss in bone strength resulting in osteoporosis and can also influence the ability to perform simple tasks such as sitting on a chair or visiting the toilet [5]. We have previously evaluated muscle strength, aged 20 - 79 years, and found that age-related changes in muscle strength were noted. In addition, lower leg strength per body weight was fundamental feature in subjects with obesity [6]. In this respect, it is important to evaluate muscle strength of adolescents for preventing future decline in muscle strength in adults. However, the relation between muscle strength, especially leg strength and anthropometric, body composition parameters still remains to be investigated.

In this study, we evaluated muscle strength *i.e.* grip strength and leg strength and its relation to anthropometric, body composition parameters in Japanese adolescents.

2. SUBJECTS AND METHODS

2.1. Subjects

We used data for 48 men and 189 women, aged 15 - 19 years, who met the following criteria: 1) received a

health check-up including health guidance, 2) received anthropometric and body composition measurements, and muscle strength measurements as part of the annual health check-up, 3) received no medications for diabetes, hypertension, and/or dyslipidemia, and 4) provided written informed consent (**Table 1**).

Ethical approval for the study was obtained from the Ethical Committee of Okayama Health Foundation.

2.2. Anthropometric and Body Composition Measurements

Their anthropometric and body composition were evaluated by using the following respective parameters such as, height, body weight, body mass index (BMI), abdominal circumference, hip circumference and body fat percentage. BMI was calculated by $\text{weight}/[\text{height}]^2$ (kg/m^2). Abdominal circumference was measured at the umbilical level in standing subjects after normal expiration [7] and the hip was measured at the widest circumferences over the trochanter in standing subjects after normal expiration. Body fat percentage was measured by an air displacement plethysmograph called the BOD POD Body Composition System (Life Measurement Instruments, Concord, CA) [8,9]. Body fat mass was calculated as follows: $\text{body weight} \times \text{body fat percentage} \times 100$. Lean body mass was also calculated as follows: $\text{body weight} - \text{body fat mass}$.

2.3. Muscle Strength

To assess muscle strength, grip and leg strength were measured [6,10]. Grip strength was measured using THP-10 (SAKAI, Tokyo, Japan), while leg strength was measured by COMBIT CB-1 (MINATO, Osaka, Japan).

Isometric leg strength was measured as follows: the subject sat in a chair, grasping the armrest in order to fix the body position. A dynamometer was then attached to the subject's one ankle joint by a strap. The subject extended his or her leg to 60 degrees as described in previous reports [6,10,11] which have also demonstrated good accuracy for this measurement [11]. All muscle strength measurements were recorded in 2 trials, and the better one was employed for analysis. In addition, to standardize the influence of body weight, we calculated the ratio of leg strength to body weight; a 1.0 in leg strength per body weight has been a standard in past studies [11].

2.4. Statistical Analysis

Data are expressed as means \pm standard deviation (SD). Pearson's correlation coefficients were calculated and used to test the significance of the linear relationship among continuous variables; stepwise multiple regression analysis was also used.

3. RESULTS

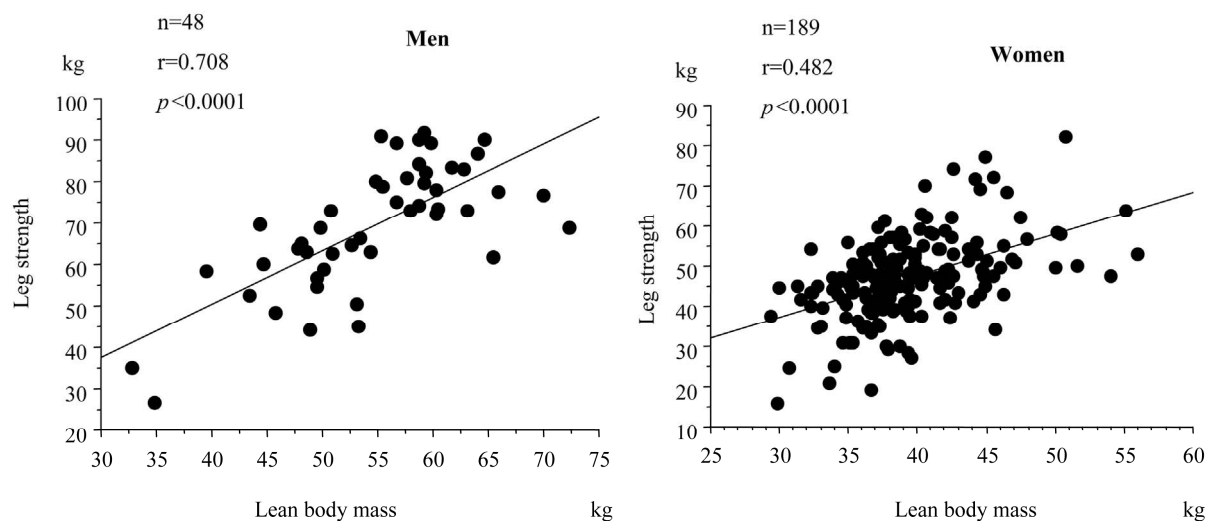
Clinical profiles of enrolled subjects are summarized in **Table 1**. In addition, we evaluated the relationship between anthropometric, body composition parameters and muscle strength (**Table 2**). In men, grip strength was positively correlated with height and lean body mass. Leg strength was significantly correlated with height, body weight, hip circumference and lean body mass ($r = 0.708$, $p < 0.0001$) (**Figure 1**). However, leg strength per body weight was negatively correlated with BMI, abdominal circumference, hip circumference, body fat percentage ($r = -0.719$, $p < 0.0001$) (**Figure 2**) and body fat mass ($r = -0.623$, $p < 0.0001$). In women, grip strength

Table 1. Clinical profiles of enrolled subjects.

	Men			Women		
	Mean \pm SD	Minimum	Maximum	Mean \pm SD	Minimum	Maximum
Number of subjects	48			189		
Age	17.8 \pm 1.2	15	19	18.4 \pm 1.0	15	19
Height (cm)	170.3 \pm 6.2	154.6	181.6	157.8 \pm 5.5	135.1	175.5
Body weight (kg)	67.7 \pm 15.3	42.1	118.7	54.3 \pm 9.3	35.9	96.2
Body mass index (kg/m^2)	23.2 \pm 4.6	17.6	39.8	21.8 \pm 3.7	16.2	37.6
Abdominal circumference (cm)	76.9 \pm 12.8	58.5	122.2	67.2 \pm 7.6	54.5	106.4
Hip circumference	93.5 \pm 8.2	77.2	116.6	91.7 \pm 6.6	77.0	125.0
Body fat percentage (%)	18.0 \pm 7.8	8.7	39.0	27.1 \pm 6.0	12.4	46.1
Body fat mass (kg)	13.0 \pm 9.1	4.8	46.3	15.1 \pm 5.9	5.3	41.3
Lean body mass (kg)	54.7 \pm 8.3	32.8	72.4	39.2 \pm 4.7	29.4	56.0
Right grip strength (kg)	42.8 \pm 8.3	16.2	60.0	26.7 \pm 5.2	9.3	41.1
Left grip strength (kg)	40.7 \pm 9.0	14.3	61.4	24.9 \pm 4.5	8.9	37.5
Leg strength (kg)	69.4 \pm 15.1	26.8	91.5	46.9 \pm 10.1	15.8	82.0
Leg strength per body weight	1.04 \pm 0.22	0.58	1.44	0.87 \pm 0.18	0.38	1.42

Table 2. Relationship between muscle strength and anthropometric, body composition parameters.

	Right grip strength (kg)		Left grip strength (kg)		Leg strength (kg)		Legs strength per body weight	
	r	p	r	p	r	p	r	p
Men								
Height (cm)	0.417	0.0032	0.481	0.0005	0.534	<0.0001	0.065	0.6584
Body weight (kg)	0.203	0.1662	0.208	0.1554	0.459	0.0010	-0.394	0.0056
Body mass index (kg/m ²)	0.112	0.4476	0.090	0.5412	0.352	0.0140	-0.456	0.0011
Abdominal circumference (cm)	0.057	0.6984	0.030	0.8375	0.281	0.0534	-0.510	0.0002
Hip circumference (cm)	0.199	0.1750	0.157	0.2855	0.434	0.0021	-0.456	0.0042
Body fat percentage (%)	-0.264	0.0693	-0.324	0.0248	-0.081	0.5844	-0.719	<0.0001
Body fat mass (kg)	-0.094	0.5238	-0.109	0.4620	0.128	0.3876	-0.623	<0.0001
Lean body mass (kg)	0.478	0.0006	0.503	0.0003	0.708	<0.0001	-0.046	0.7538
Women								
Height (cm)	0.404	<0.0001	0.430	<0.0001	0.236	0.0011	0.022	0.7673
Body weight (kg)	0.102	0.1638	0.130	0.0736	0.368	<0.0001	-0.341	<0.0001
Body mass index (kg/m ²)	-0.073	0.3197	-0.052	0.4769	0.279	<0.0001	-0.360	<0.0001
Abdominal circumference (cm)	-0.097	0.1830	-0.074	0.3097	0.247	0.0006	-0.370	<0.0001
Hip circumference (cm)	0.077	0.2906	0.086	0.2406	0.319	<0.0001	-0.347	<0.0001
Body fat percentage (%)	-0.192	0.0083	-0.174	0.0164	0.042	0.5646	-0.457	<0.0001
Body fat mass (kg)	-0.077	0.2945	-0.054	0.4641	0.198	0.0064	-0.431	<0.0001
Lean body mass (kg)	0.300	<0.0001	0.328	<0.0001	0.482	<0.0001	-0.134	0.0662

**Figure 1.** Simple correlation analysis between leg strength and lean body mass.

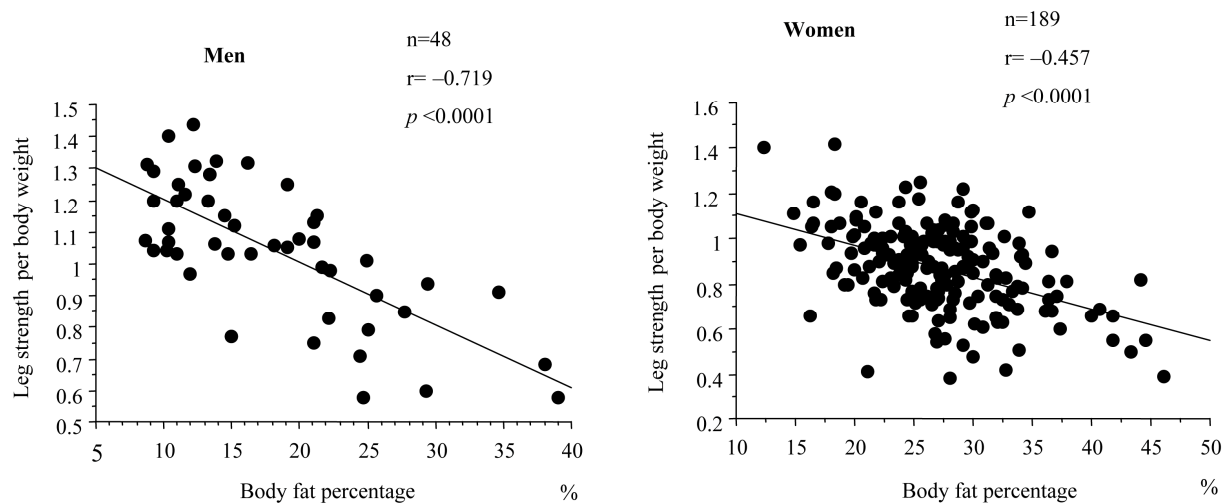


Figure 2. Simple correlation analysis between leg strength per body weight and body fat percentage.

was positively correlated with height. Leg strength was positively correlated lean body mass ($r = 0.482$, $p < 0.0001$) (**Figure 1**). Leg strength per body weight was negatively correlated with body fat percentage ($r = -0.457$, $p < 0.0001$) (**Figure 2**) and body fat mass ($r = -0.431$, $p < 0.0001$).

We also used stepwise multiple regression analysis to evaluate the effect of clinical parameters *i.e.* age, height, body weight, BMI, abdominal circumference, hip circumference, body fat percentage, body fat mass and lean body mass on leg strength per body weight, and found that age and body fat percentage were significant in men (leg strength per body weight = $0.750 + 0.036$ (age) – 0.020 (body fat percentage), $r^2 = 0.557$, $p < 0.0001$) and only body fat percentage was significant in women (leg strength per body weight = $1.255 - 0.014$ (body fat percentage), $r^2 = 0.208$, $p < 0.0001$).

4. DISCUSSION

The main finding of this study was that we explored that the relation between muscle strength and anthropometric, body composition parameters, and found that height and lean body mass were closely correlated with grip and leg strength, especially in men. However, leg strength per body weight was negatively correlated with body fat percentage in both sexes.

Jurimae *et al.* have reported that the most important predictive value for grip strength from the basic anthropometric variables was body height, and skin fold thicknesses was not related to grip strength in prepubertal children aged between 8 and 11 years [12]. They also reported that hand lean mass highly influenced hand grip strength in boys, and moderately but significantly in girls [12]. Koley *et al.* showed that hand dominance, especially of the right hand, has some close association with

the anthropometric variables related to upper extremities in 303 healthy students (height in men: $r = 0.275$, height in women: $r = 0.200$) [13]. Luna-Heredia *et al.* described that body height is directly correlated with hand grip strength, possibly because this factor is more closely related to the lean body mass [14].

In this study, we also found that height and lean body mass were important factors for grip and leg strength, especially men. However, leg strength per body weight was negatively correlated with body fat percentage. Taken together, it is difficult for Japanese adolescents with lower leg strength per body weight to support the entire body's weight; and also difficult for subjects with lower leg strength per body weight to carry out aerobic exercise *i.e.* walking and jogging. In addition, we have previously reported that changes in oxygen uptake at VT (per lean body mass) were also correlated with changes in leg strength per lean body mass in adults [15,16]. Although aerobic exercise has been advocated as most suitable for reducing fat mass and increasing aerobic exercise level, it is important for subjects with lower leg strength per body weight to maintain or maximize the muscle strength of their lower limbs as well as to carry out aerobic exercise for reducing fat mass and increasing aerobic exercise level in Japanese adolescents.

Potential limitations still remain in this study. First, our study was a cross-sectional and not a longitudinal study. Second, 48 men and 189 women in our study voluntarily underwent measurements: they were therefore more likely to be health-conscious compared with the average person. To show this, further prospective studies are needed to prove the link in the Japanese adolescents.

5. ACKNOWLEDGEMENTS

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