Title: Associations of physical exercise as a lifestyle habit with lean and fat body mass and handgrip strength and age in Asian men

Running Title: Exercise as a lifestyle habit, body composition and aging in Asian men

Key Words: Asian men, exercise, grip strength, lean muscle mass, Aging men

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ABSTRACT

Background: We evaluated how the intensity of physical exercise as a lifestyle habit is associated with age, body composition and handgrip strength. **Methods:** Total body composition was analyzed using DEXA. Exercise scores were derived from an administered questionnaire and the scoring was calculated using the Metabolic Equvalent of Task (MET). Handgrip strength was measured using a dynamometer. **Results:** Age, independent of exercise intensity, was associated with declining lean mass, and handgrip strength and with increasing total body fat. A regular physical exercise regime of intensity greater than 1230 MET-min/week was associated with higher total lean mass and lean mass in the limbs, and handgrip strength and lower fat mass in the limbs. **Discussion:** We have shown that age was associated with lower lean mass especially in the limbs and higher total fat mass and handgrip strength. Regular physical exercise as a lifestyle habit of any type and of sufficient intensity could help improve muscle strength in the limbs. (158 words)

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INTRODUCTION

The term sarcopenia refers to the loss of skeletal muscle mass and strength associated with aging [1-3]. It has been unequivocally shown is that low muscle mass is associated with older age [4-8]. Muscles, especially those in the legs, are crucial for mobility and their loss or dysfunction, whether due to aging or other pathologies, has serious consequence on mobility [8,9]. Loss of mobility in turn poses a severe risk of poor health and low quality of life.

Various treatment modalities, including physical exercise have been explored for the treatment of sarcopenia [10-14]. The importance of physical exercise in mitigating the association of low muscle mass with aging has been amply shown. Physical exercise has been found to be associated with increasing muscle mass and muscle strength and improved capacity to perform physical activity and possibly reduced risk of disability later in life [15-17]. The protective potential of physical exercise may be related to the type, frequency and intensity of the exercise [8,18]. It is however, impractical to prescribe a single exercise regime for everyone. The young and the old can cope with different exercise regimes. Therefore, exercise will need to be age-appropriate. Many people do engage in regular physical exercise as a lifestyle habit. The type, duration and intensity vary widely. There are very few studies have evaluated the association of body mass and strength with physical exercise as a lifestyle habit. The question is, is there an optimal intensity of exercise, regardless of the type of exercise that would be beneficial for improving muscle mass and strength?

The present cross-sectional study is a first to evaluate how physical exercise as a lifestyle habit, instead of a programed physical exercise regime in research setting as in earlier studies, was associated with age, age-related changes in lean and fat body mass, especially in the limbs, and handgrip strength.. Since this sample of community living men were engaged in a different types and duration of physical exercise programme, we normalized the different exercise regimes by scoring the intensity based on the Metabolic Equivalent of Task (MET). We hypothesize that although there were different exercise regimes, it is possible to find the cut-off level of intensity of exercise that might be associated with beneficial effects on body mass and strength.

SUBJECTS, MATERIALS AND METHODS

Subjects

This study was approved by the Institutional Review Board of the National University Hospital of Singapore and each volunteer gave his written informed consent. The method was previously reported [19]. Five hundred and twenty-nine Singaporean Chinese men, aged between 29y and 72y, were included in the analyses. As the primary objective of the study was to evaluate the determinants of the natural aging process, only men without a history of medical illnesses such as cancer, hypertension, thyroid dysfunction, diabetes, osteoporotic fracture, cardiovascular events, major sleep disorders, major joint surgery, or bone fracture were included in the study. Subjects were not paid for their participation. The cohort of men represented the diverse spectrum of Chinese in Singapore, ranging from those with low to high levels of education, working and non-working men (retirees), and those in various types of vocation[25]. Their profiles were typical of Singapore, which is a highly urbanized city-state with no rural population. Each subject answered a self-administered and investigator-guided questionnaire. Questions asked covered their medical, dietary, social, sex, exercise regime, and family histories and other relevant histories regarding consumption of hormones, supplements and medication, types of beverages, smoking and alcohol consumption.

Methodologies

Exercise scores (MET-min)

The scoring for physical exercise was based on metabolic equivalents for task (MET) and cut-off values for light (<3 METS), moderate (3-6 METS) and vigorous (>6 METS) were used to compute the exercise scores expressed as metabolic equivalent for task-minutes per week (MET-min) as reported earlier [20,21]. For example, if a man jogs (jogging has a MET of 10.5) 4 times a week and each time for 30 min, his exercise score will be 1260 MET-min (10.5 x 30 x 4). On the other hand, if he brisk walks (brisk walk has a MET of 8.0) 4 time a week and each time for 45 min, his exercise score will be 1440 MET-min (8 x 45 x 4). Subjects were categorized into 3 MET groups based on the MET-min scores: MET1 (no habitual exercise, MET-min = 0), MET2 (MET-min = 52-1230), and MET3 [(MET-min= 1260-4324), where 1260 MET-min is the 75^{th} percentile cut off of all MET-min score]. Only when exercise carried out regularly for at least six months was considered as a lifestyle habit.

Body composition

Each subject underwent a whole body scan using DEXA (DPX-L, Lunar Radiation, Madison, WI, USA; software version 1.3z). Total lean body mass (TLM), total fat mass (TFM) and regional distributions of lean and fat mass in the arms (ArmL, ArmF) and legs (LegL, LegF) were computed from data from the DEXA whole body scan.

Handgrip strength

A handgrip dynamometer (Takei Scientific Instruments, Japan) was used for the handgrip strength test as reported earlier [22]. The purpose of this test was to measure the maximum isometric strength of the hand and forearm muscles. Handgrip strength is important for any sport in which the hands are used for catching, throwing or lifting. Also, as a general rule people with strong hands tend to be strong elsewhere, so this test is often used as a general test of strength [23,24]. Each subject performed the handgrip test three times and the maximum score (Grip) of the three was used for the analysis. The handgrip strength was expressed as kilogram force.

Statistical analysis

Statistical analyses were performed using SPSS for windows version 21.0. Basic descriptive statistics as well as comparison of means using the Multivariate analyses of the General Linear Model coupled with the Bonferroni as the Post-Hoc test for multiple means were used on continuous measurements. Linear regression analyses were used between handgrip strength and total lean and fat body mass and lean and fat mass in the arms and legs.

Comparisons of means of lean and fat body mass and handgrip strength were carried out on 4 age groups, AgeGp1 (<40y), AgeGp2 (41-50y), AgeGp3 (51-60y) and AgeGp4 (>60y) and; the analyses were weighted for bodyweight. Since the intensity of exercise has very significant associations with age and body mass the association with age was adjusted for it by analyzing with MET-min as the covariate. The associations of the three exercise groups with body mass, and handgrip strength were carried with adjustment for bodyweight and age.

Linear regression between handgrip strength was carried out with total and appendicular body mass.

RESULTS

On an average, 67.7% of men aged between 4th to 6th decade and 77.8% of men in their 7th decade were engaged in regular physical exercise. In addition, older men in their 7th decade had significantly higher intensity of physical exercise as compared to men in their 4th to 6th decade (Table 1). Following adjustment for the intensity of exercise (MET-min), it was noted that TLM, ArmL LegL, and TFM, but not ArmF and LegF were significantly associated with age. Significantly lower TLM and ArmL were associated with men in the 5th through to the 7th decade when compared with men in the 4th decade (Table 1). Total lean mass was lower by 3.1% and ArmL between 4.9% and 7.2% in men in from the 5th and 7th decade, than corresponding levels in men in their 4th decade (Table 1). The association of LegL with age was noticeably different from those of TLM and ArmL. Lean mass in the legs was progressively lower from 6th and 7th decade 5.6% and 7.8% when compared to levels in men in their 4th decade (Table 1). In contrast to lean mass, age was associated with significantly higher TFM and the quantum of increase was more than the quantum of decrease in lean mass (Table 1). From the 5th to the 7th decade TFM was higher by 8.0% to 13.0% when compared to the levels in men in the 4th decade (Table 1). Fat mass in the arms and legs were not significantly associated with age.

Handgrip strength was significantly lower in men in the 7th decade as compared to men in 5th to 6th decade and was 11.3% lower than those in men in the 4th decade (Table 1)

Linear regression analyses of handgrip strength weighted for bodyweight and adjusted for age and MET-min showed significant positive correlation with ArmL to a greater extent than with LegL and negative correlation with ArmF (Table 2).

Table 3 shows that high intensity of physical exercise, >1230 MET-min (MET3) is associated with significantly higher TLM, and LegL but not ArmL. The exercise-associated lower TFM, by 7.6%, was of greater magnitude than the exercise-associated higher TLM and LegL, by 2.4%, and 3.6% respectively (Table 3). Only the higher intensity of physical exercise group (MET3) was associated with significantly higher Grip (5.7%) when compared to the non-exercise group (MET1, Table 3). Moderately intense exercise (MET2) was not associated with significant difference in body mass (Table 3).

DISCUSSION

The present study showed that more men in their 7th decade were engaged in regular physical exercise and that the intensity of their exercise was significantly higher than younger men in their 4th to 6th decade. This observation is possibly specific to the cohort of Singaporean men and is in contrast to Caucasian groups where older men tended to exercise less and less intensely [25-28]. It is, therefore, important that in the evaluation of the association of body composition, and handgrip strength, with age, adjustment for the exercise intensity be carried, as was done in the present study. Failure to do so might distort an actual association with age.

It was shown clearly that, independent of exercise intensity, lower TLM, ArmL, LegL, and Grip, and higher TFM were associated with older aged men. The results showed that age-associated increase in TFM was proportionately more than the age-associated decrease in TLM, implying that as men age the risk for obesity may be higher than the risk for sarcopenia.

Lean mass in legs was progressively lower from the 6th through the 7th decade, suggesting that the age-related lowering of LegL was slower than those for ArmL and TLM. The differences may, in part, be due to the constant weight-bearing beneficial effect of the bodyweight on muscle mass and strength. The results also highlighted differences in the association of body mass in the arms and legs with age and strength. The large leg muscles are responsible for supporting the whole body weight and are important for integrity of gait, balance and mobility. Therefore, the loss of lean body mass, especially in the legs, may contribute to increased risk of osteoarthritis, frailty and disabilities leading to loss of mobility in older men.

Similarly to earlier studies, the decline in muscle strength, by 11.3% in men in their 7th decade, appeared to be greater than the decline in muscle mass [29-33], with ArmL and LegL in the 7th decade lower by 7.2% and 7.8%. This partial dissociation between muscle mass and strength may be influenced by other factors [34,35]. Data from the present study showed that Grip was positively correlated to ArmL and, to a lesser extent, to LegL and negatively to ArmF. Therefore, the increase in ArmF, with its negative association with Grip concurrent with the decrease in ArmL may account for a greater decrease in Grip. The effect of fat on muscle quality may be the cause of the observed lower muscle strength [36,37].

Engagement in regular physical exercise as a lifestyle habit was not the norm among this sample of Asian men. 25.5% percent of men were not engaged in a regular regime of physical exercise. Another 55.4% had moderately intense while 19.1% had intense physical exercise as a lifestyle habit. Possibly specific to Singapore, more older men had a regular and more intense exercise regime as a lifestyle habit than younger men. A regular physical exercise regime as a lifestyle habit is associated with higher lean mass, lower fat mass and higher handgrip strength as was shown in an earlier study [38]. The levels attained in the group with the high exercise intensity were comparable to those in the young age group, men <40y old. Therefore a program of regular physical exercise may help to reduce the risk of sarcopenia and loss of mobility associated with aging. However, to achieve these beneficial effects on lean and fat mass and strength, the exercise intensity has to be sufficiently high. According to the present study the intensity is equivalent to jogging 30 min, 4 times per week or brisk walking for 45 min, 4 times per week. In contrast, an earlier study has shown that the exercise intensities associated with beneficial effects on total body fat, testosterone, bioavailable testosterone, and SHBG were lower [21], implying that the threshold values of the intensity of exercise for different parameters are different.

In summary, the study showed that independent of the intensity of exercise, age is associated with lower lean mass (especially in the limbs) and higher total fat mass, and lower handgrip strength. Furthermore, a regime of regular physical exercise could help mitigate the age-related lowering of lean mass and increase in fat mass. The new take home message**:** is any type of physical exercise as a lifestyle habit, as long as it is of sufficiently high intensity could help improve muscle strength in the limbs.

AUTHORS' CONTRIBUTIONS

This study was designed, conducted and data collected while Professor Victor H H Goh was at the Department of Obstetrics and Gynaecology, National University of Singapore. Professor William Hart was intimately involved in the interpretation, drafting of the manuscript and critical revision of the paper for submission.

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DECLARATION OF INTEREST

The authors report no declaration of interest

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Table 1: Mean (±SE) lean and fat body mass and handgrip strength, in men by age groups. (All parameters were analysed with adjustments for MET-min and weighted for bodyweight).

	AgeGp1 <40y (71)	AgeGp2 (41-50y) (200)	AgeGp3 (51-60y) (178)	AgeGp4 (>60y) (80)
TLM (kg)	*51.0±0.42*[a]	*49.9±0.22*	*49.4±0.23*	*49.4±0.35*
TFM (kg)	*13.8±0.42*[b]	*14.9±0.22*	*15.5±0.23*	*15.6±0.35*
ArmL (kg)	*6.07±0.096*[c]	*5.79±0.050*	*5.77±0.052*	*5.63±0.080*
LegL (kg)	*17.9±0.18*[d]	*17.4±0.093*[e]	*16.9±0.096*	*16.5±0.15*
Grip (kgf)	*39.9±0.75*[f]	*38.9±0.39*[f]	*37.8±0.0*[f]	*35.4±0.62*
MET-min	*516+103*[i]	*593+58*[i]	*650+62*[i]	*1022+92*

a=AgeGp1 is significantly higher than AgeGp3 & AgeGp4 (p = 0.003, 0.015)
b= AgeGp1 is significantly lower than AgeGp3 & AgeGp4 (p = 0.004, 0.007)
c= AgeGp1 is significantly higher than AgeGp3 & AgeGp4 (p = 0.031, 0.003)
d= AgeGp1 is significantly higher than AgeGp3 & AgeGp4 (p = <0.001, <0.001)
e= AgeGp2 is significantly higher than AgeGp3 & AgeGp4 (p = 0.003, <0.001)
f= AgeGp1, AgeGp2 & AgeGp3 are significantly higher than AgeGp4 (p <0.001, <0.001, 0.006)
g= AgeGp1, AgeGp2 & AgGp3 are significantly lower than AgeGp4 (p = 0.001, 0.001, 0.005)

Table 2: Linear regression of Grip with lean and fat body mass, weighted for bodyweight, and adjusted for age and MET-min.

Regression of Grip with	**Beta (Standardized Coefficients)**	**p-value**
Arm lean mass	0.412	<0.001
Leg lean mass	0.238	0.004
Arm fat mass	-0.102	0.021

Table 3: Mean (+SE) body mass and handgrip strength, SMI and LMI in men in different exercise groups with age and bodyweight as covariates

	MET1(n=122)	MET2 (n=266)	MET3 (n=92)
TLM (kg)	49.1+0.27[a]	49.5+0.25	50.3+0.21
TFM (kg)	15.8+0.27[b]	15.3+0.28	14.6+0.21
LegL (kg)	16.8+0.12[c]	17.0+0.10[c]	17.4+0.09
Grip (kgf)	37.0+0.48[d]	37.5+0.43[d]	39.1+0.37

a= MET1 is significantly lower than MET3 ($p = 0.004$)
b= MET1 is significantly higher than MET3 ($p = 0.004$)
c= MET1 & MET2 are significantly lower than MET3 ($p = 0.001, 0.008$)
d= MET1 & MET2 are significantly lower than MET3 ($p = 0.002, 0.015$)