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Original Article

Appendicular Skeletal Muscle Mass Index Level (ASMI) and Its Influencing Factors in Healthy Adult Males

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Abstract

Background: We aimed to retrospectively analyze the level of appendicular skeletal muscle mass index (ASMI) in adult males and its influencing factors for early screening and intervention of sarcopenia.

Methods: From January 2020 to December 2021, adult male medical examiners from the Health Management Center of the Affiliated Hospital of North Sichuan Medical College, Chengdu City, China were selected as the research subjects. The ASMI level was measured by bioelectrical impedance (BIA) method. The subjects were divided into four groups according to the quartiles of ASMI level, the levels of related indicators between the groups were compared, and the related factors affecting the ASMI level were analyzed.

Results: The detection rate of sarcopenia was about 1.09% (78/7187). One-way ANOVA or nonparametric test results showed that age, BMI, WHR, SBP, DBP, FPG, HbA1c, AST, ALT, GGT, Cr, UA, TG, TC, HDL-C, LDL-C and FT3 levels were significantly different among the four ASMI groups (P<0.05). ASMI was positively correlated with BMI, WHR, SBP, DBP, FPG, HbA1c, AST, ALT, GGT, Cr, UA, TG, TC, LDL-C, FT3, and TSH (all P<0.05); negatively correlated with age and HDL-C (all P<0.05). Age, WHR and TG were independent risk factors for ASMI level, and BMI was an independent protective factor for ASMI level.

Conclusion: The ASMI level in healthy adult males is related to age, obesity, blood pressure, glucose and lipid metabolism disorder, inflammation and thyroid hormone, among which age, BMI, WHR and TG are independent influencing factors of ASMI level.

Keywords: Appendicular skeletal muscle mass index; Sarcopenia; Healthy population; Bioelectrical impedance method

Introduction

Sarcopenia is a syndrome characterized by progressive reduction in skeletal muscle mass, strength, and function, leading to risks of physical disability, poor quality of life, and death (1). With the intensification of population aging in my country, the prevalence of sarcopenia has risen sharply. At present, the number of people with sarcopenia in the world is as high as 50 million,

and it is expected to reach 500 million by 2050, while the prevalence of sarcopenia in the elderly in Asia is about 4.1% to 11.5% (2). Sarcopenia is closely related to a variety of metabolic diseases and organic diseases (3), the prevalence in patients with chronic diseases such as cardiovascular disease, type 2 diabetes and dementia is higher than that in patients with non-chronic diseases (4), and sarcopenia is also closely related to osteoporosis (5). Therefore, it is of great significance to clarify the relevant influencing factors of sarcopenia for the prevention and treatment of sarcopenia.

According to the diagnostic criteria for sarcopenia developed by the Asian Working Group for Sarcopenia, the criteria include: 1) decreased muscle strength; 2) decreased quality or quantity of muscle; 3) decreased physical fitness; when only 1) occurs, sarcopenia should be suspected; when 1) and 2) are satisfied, it can be diagnosed as sarcopenia; when all three conditions are satisfied, and it was diagnosed as severe sarcopenia (6). Among them, muscle mass is recommended to be measured by dual-energy X-ray (DXA), computed tomography (CT), magnetic resonance imaging (MRI), and bioelectrical impedance (BIA).

Therefore, in this study, the BIA method was used to measure the appendicular skeletal muscle mass index (ASMI) to evaluate the muscle mass of healthy people in Nanchong City. The retrospective analysis of ASMI levels and related influencing factors in healthy adult males are expected to provide clues for early screening and intervention of skeletal muscle diseases such as sarcopenia.

Materials and Methods

Research subjects

A total of 7187 adult male medical examiners from the Health Management Center of the Affiliated Hospital of Sichuan North Medical College from January 2020 to December 2021 were selected as the research subjects, of whom 521 were <30 years old, 771 were 30-34 years old, and 746 were 35-39 years old, 826 were 40-44 years old, 1292 were 45-49 years old, 1163 were 50-54 years old, 1020 were 55-59 years old, and 848 were ≥60 years old. Inclusion criteria: age ≥ 18 years old with complete research data; exclusion criteria: lack of research data, liver and kidney insufficiency, endocrine and metabolic system diseases, malignant tumors, etc.

This study was reviewed and approved by the Medical Ethics Committee of Affiliated Hospital of Sichuan North Medical College (2021ER132-1), and all subjects gave informed consent.

Research methods

Collection of basic data: age, gender, systolic pressure (SBP), diastolic pressure (DBP), waist hip ratio (WHR) and body mass index (BMI) were collected.

Determination of clinical indicators: All study subjects fasted for 10-12 hours overnight, and cubital venous blood was collected at 8:00 am the next morning and sent to the laboratory and nuclear medicine department of our hospital. The fasting plasma glucose (FPG), glycosylated hemoglobin(HbA1c), triglyceride (triglyceride, TG), total cholesterol (TC), high density lipoprotein cholesterol (HDL-C), low density lipoprotein cholesterol (LDL-C), alanine aminotransferase (ALT), aspartic acid amino transferase (AST), alkaline phosphatase (ALP), glutamyl transpeptidase (GGT), urea (Ur), creatinine (Cr), uric acid (UA), cystatin C, homocysteine (HCY), free triiodothyronine(FT3), free thyroxine (FT4), and thyroid-stimulating hormone (TSH) were measured.

ASMI measurement and grouping: BIA body composition analyzer was used to measure ASMI level, and subjects were grouped according to the quartile of ASMI level: A1 group (ASMI<8.35 kg/m^2), A2 group (8.35 kg/m^2 ≤ASMI<8.81 kg/m^2), A3 group (8.81 kg/m^2 ≤ASMI<9.28 kg/m^2) and A4 group (ASMI≥9.28 kg/m^2). In this study, ASMI was used to diagnose sarcopenia, that is, ASMI of male <7.0 kg/m^2.

Statistical methods

SPSS 25.0 software (IBM Corp., Armonk, NY, USA) was used to process data. Counting data

was expressed as rate, and measurement data was expressed by $\bar{x} \pm s$ or *M* (*P25, P75*). The comparison between multiple groups was by one-way analysis of variance or non- parametric rank sum test. The relationship between ASMI level and other indicators was analyzed by Pearson or Spearman correlation analysis and multiple linear stepwise regression analysis. $P<0.05$ was considered to be statistically significant.

Results

ASMI level and sarcopenia detection rate among different age groups

Among 7187 adult males, 78 had sarcopenia, accounting for about 1.09%. The average ASMI level of 7187 adult males was (8.84±0.78) kg/m^2. There was a statistically significant difference between the different age groups ($F = 53.617$, $P < 0.05$) (Table 1).

Table 1: ASMI levels in different age groups (kg/m^2, $\bar{x} \pm s$)

Age/years	*Number*	*ASMI (x ± s)*	*F value*	*P*
<30	521	9.06±0.98		
30-34	771	8.92±0.83		
35-39	746	8.95±0.77		
40-44	826	8.93±0.74	53.617	<0.001
45-49	1292	8.89±0.69		
50-54	1163	8.84±0.73		
55-59	1020	8.85±0.66		
≥60	848	8.40±0.80		
Total	7187	8.84±0.78		

Comparison of basic data and clinical indicators among the four groups

Subjects were classified into four groups according to the quartile of ASMI level, and one-way ANOVA or nonparametric test were performed. Age, BMI, WHR, SBP, DBP, FPG, $HbA1_C$, AST, ALT, GGT, Cr, UA, TG, TC, HDL-C, LDL-C, and FT3 levels were significantly different among the four groups ($P < 0.05$). Compared with A1 group, the levels of BMI, WHR, SBP, DBP, ALT, GGT, Cr, UA, TG, and LDL-C in A2, A3 and A4 groups were significantly increased, while the levels of age and HDL-C were significantly decreased. Compared with the A1 groups, the AST levels in the A3 and A4 groups were significantly increased, while the differences in the TC levels in the A2 and A4 groups were statistically significant. (All $P<0.05$) Compared with the A2 group, the age and HDL-C levels of the A3 and A4 groups were significantly decreased, while the levels of BMI, WHR, SBP, DBP, ALT, UA, and TG were significantly increased. Compared with groups A1 and A2, the levels of FPG, HbA_{1C}, AST, GGT, and FT3 in group A4 were significantly increased. Compared with the A3 group, the age and HDL-C levels of the A4 group were significantly decreased, while the levels of BMI, WHR, SBP, DBP, AST, ALT, GGT, Cr, UA, TG, and FT3 were significantly increased ($P<0.05$) (Table 2).

Correlation analysis between ASMI and various indicators

Pearson or *Spearman* correlation analysis found that ASMI was positively correlated with BMI, WHR, SBP, DBP, FPG, HbA1c, AST, ALT, GGT, Cr, UA, TG, TC, LDL-C, FT3, and TSH (r =0.869, 0.569, 0.119, 0.184, 0.033, 0.043, 0.110, 0.259, 0.114, 0.039, 0.271, 0.196, 0.047, 0.060, 0.061, and 0.033; all $P < 0.05$), and negatively correlated with age and HDL-C (r =- 0.190 and -0.176; both $P < 0.05$). Further ASMI was used as the dependent variable, and age, BMI, WHR, SBP, DBP, FPG, HbA1c, AST, ALT, GGT, Cr, UA, TG, TC, HDL-C, LDL-C, FT3, and TSH were used as independent variables. Age, WHR and TG were independent risk factors for ASMI level, and BMI was an independent protective factor for ASMI level, as shown in Table 3.

Table 2: Comparison of basic data and clinical indicators among the four groups [$\bar{x} \pm s$, M (P 25, P 75)]

Groups	*Number*	*Age (yr)*	*BMI (kg/m²)*	*WHR*	*SBP(mmHg)*	*DBP(mmHg)*
A1	1779	49.25±13.99	21.82±1.87	0.90±0.04	124.64±17.19	76.33±11.04
A2	1817	48.12± 11.43[a]	24.41± 1.27[a]	0.92± 0.04[a]	126.83± 28.33[a]	79.06±11.41 [a]
A3	1799	47.07±10.67 [ab]	26.14± 1.27[ab]	0.93± 0.03[ab]	128.14±15.51 [ab]	80.18±11.31 [ab]
A4	1792	43.68±10.77 [abc]	29.05±2.44 [abc]	0.97±0.05 [abc]	131.40±15.31 [abc]	82.43±11.81 [abc]
F/H	-	74.588	5214.908	943.735	35.954	87.78
P	-	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Groups	FPG(mmol/L)	HbA1c (%)	AST(U/L)	ALT(U/L)	ALP(U/L)	GGT(U/L)*
A1	5.25±1.98	6.01±1.22	24.17±12.07	23.31±19.06	77.23±20.21	21.00 (15.00, 35.00)
A2	5.21±1.56	5.98±0.95	24.58±11.80	27.34± 19.96[a]	75.98±20.07	27.00(18.00,49.00) [a]
A3	5.32±1.59	6.04±0.98	25.09± 11.46[a]	30.16±19.70 [ab]	75.58±18.79	29.00(20.00,49.00) [a]
A4	5.37± 1.54[ab]	6.10± 0.95[ab]	27.89±14.62 [abc]	38.53±28.83 [abc]	75.75±18.96	38.00(24.00,61.00) [abc]
F/H	3.23	3.844	31.928	149.039	1.701	309.388
P	0.021	0.009	<0.0001	<0.0001	0.165	<0.0001
Groups	Urea (mmol/L)	Cr(umol/L)	UA(mmol/L)	Cystatin C (mg/mL)	TG(mmol/L)	TC(mmol/L)
A1	4.91±1.42	74.24±14.06	368.91±74.76	0.99±0.19	1.53±1.22	4.95±1.01
A2	4.86±1.29	76.80±24.62 [a]	396.08± 83.24[a]	1.01±0.31	1.96± 1.56[a]	5.03± 0.93[a]
A3	4.86±1.30	77.49± 24.16[a]	413.28±83.88 [ab]	0.99±0.32	2.10± 1.57[ab]	5.00±0.93
A4	4.82±1.21	77.00±12.52 [a]	433.86±93.61 [abc]	0.99±0.15	2.42±1.89 [abc]	5.05±0.90 [a]
F/H	1.347	9.726	191.316	1.458	98.228	4.038
P	0.257	<0.0001	<0.0001	0.224	<0.0001	0.007
Groups	HDL-C (mmol/L)	LDL-C (mmol/L)	HCY(umol/L)	FT3(pg/mL)	FT4(ng/dL)	TSH(uIU/mL)*
A1	1.37±0.42	2.79±0.85	14.22±6.12	3.26±0.57	1.36±0.23	1.88 (1.26, 2.82)
A2	1.24±0.43 [a]	2.90± 0.82[a]	14.56±6.25	3.26±0.48	1.35±0.21	1.98 (1.35, 2.93)
A3	1.20± 0.45[ab]	2.86± 0.86[a]	14.89±7.34	3.27±0.42	1.34±0.20	1.92 (1.37, 2.78)
A4	1.15±0.48 [abc]	2.91± 0.84[a]	14.56±6.53	3.32±0.42 [abc]	1.36±0.39	2.04 (1.40, 2.88)
F/H	77.604	7.142	1.976	4.610	1.525	6.160
P	<0.0001	<0.0001	0.115	0.003	0.206	0.104

Note: *: nonparametric test, the rest are analysis of variance; a: compared with group A1, b: compared with group A2, c: compared with group A3, all $P < 0.05$

Table 3: Multiple linear stepwise regression analysis of ASMI and other indicators (R^2=0.873)

Variable	*B*	*SE*	*B′*	*t*	*P*	*95% CI*
Constant	9.066	0.127	-	71.421	<0.0001	8.818-9.315
BMI	0.318	0.003	1.309	110.190	<0.0001	0.312-0.324
WHR	-8.556	0.198	-0.514	-43.312	<0.0001	-8.943--8.168
Age	-0.007	0.000	-0.102	-15.636	<0.0001	-0.008--0.006
TG	-0.006	0.003	-0.014	-2.118	0.034	-0.012--0.0001

Discussion

As a progressive and widespread skeletal muscle disease involving loss of muscle mass and function, sarcopenia is not only considered an age-related problem, but is also associated with a range of long-term diseases with complex and interacting etiologies (7). Skeletal muscle can be

closely related to other organs through the production and secretion of various myokines, thereby participating in cognitive regulation, glucose and lipid metabolism, white fat browning, endothelial function. However, skeletal muscle mass and related strength begin to decline after age of 40 years (8,9), and about 20% of skeletal muscle mass may be lost between the ages of 40 and 80 years (10). In this study, it was found that the ASMI level gradually increased with age, reaching a peak at the age of 35-39 years, and then the ASMI level gradually decreased. At the same time, compared with the A1 group, there were significant differences in the age of the A2, A3 and A4 groups. The correlation analysis found that the age was negatively correlated with the ASMI level, and the regression analysis showed that the age was an independent risk factor for the ASMI level. In agreement with the above studies, strategies to promote or protect skeletal muscle mass in the middle-aged and elderly are necessary to help maintain the functional independence of skeletal muscle and the metabolic balance of various systems in the body in later life. In this study, 78 patients with sarcopenia were screened, accounting for about 1.09%, which was lower than the detection rate of previous studies (11,12), which may be related to the younger age of the study population selected in this study.

Sarcopenia and obesity are both independent diseases and risk factors for a variety of chronic diseases and their severity. WHR and BMI are commonly used clinical indicators of obesity. Increased visceral fat area and BMI are independent risk factors for sarcopenia in elderly obese patients (12,13). However, too low BMI is a risk factor for sarcopenia (14-16). Our study found that the BMI and WHR levels of A4 group were significantly higher than those of A1, A2, and A3 groups, and ASMI was positively correlated with BMI and WHR. Multiple linear stepwise regression analysis found that WHR was an independent risk factor for ASMI level, while ASMI was positively correlated with BMI and WHR. However, BMI is an independent protective factor for ASMI level, which is consistent with the previous results (14-16). It was speculated that this may be related to the selection of men as the research subjects in this study, and the BMI index cannot accurately reflect the changes in body composition of the research subjects. The increased BMI level may be skeletal muscle mass rather than fat content, but the specific situation needs further study.

According to the risk prediction model of sarcopenia, the important factors of sarcopenia included blood pressure, HDL-C, TG, liver, and kidney function, etc. (12). The detection rate of sarcopenia in hypertensive patients was much higher than that in non-hypertensive elderly (17) and healthy people (18). At the same time, TG was negatively correlated with the incidence of sarcopenia, and HDL-C was positively correlated with the incidence of sarcopenia (19). In addition, sarcopenia can affect up to 70% of patients with advanced liver disease, resulting in reduced quality of life and survival, increased incidence of liver disease complications and infections, and poor prognosis after liver transplantation (19,20). Sarcopenia was an important predictor of liver disease prognosis (21). The incidence of sarcopenia could also increase with the progression of chronic kidney disease (22). Chronic kidney disease promoted impairment of the muscle regeneration process by reducing the production of myogenic regulators and activation of cells, resulting in increased protein catabolism and decreased muscle synthesis (23). This study also found that with the increase of ASMI level, the levels for blood pressure (SBP and DBP), liver function (AST, ALT and GGT), renal function (Cr and UA), blood lipids (TG, TC, HDL-C, and LDL-C) were significantly different. At the same time, ASMI was positively correlated with SBP, DBP, AST, ALT, GGT, Cr, UA, TG, TC, and LDL-C, but negatively correlated with HDL-C. Regression analysis showed that TG was the independent risk factor of ASMI level. These results suggested that the reduction in muscle mass was not only affected by abnormal protein metabolism, but may also be related to abnormal carbohydrate, inflammation, and fat metabolism.

Sarcopenia is more common in patients with type 2 diabetes (24). The hyperglycemia, insulin resistance, chronic inflammation, oxidative stress, and advanced glycation end products in type 2 diabetes can all contribute to the development of sarcopenia (25,26). Conversely, sarcopenia was also a major risk factor for type 2 diabetes (27,28). These data suggested a bidirectional link between sarcopenia and type 2 diabetes (29). The results of this study showed that the levels of FPG and HbA_{1C} in A4 group were significantly higher than those in A1 and A2 groups. Correlation analysis found that ASMI levels were positively correlated with FPG and HbA1c. Further regression analysis found that FPG and HbA_{1C} were not independent influencing factors of ASMI level. This was similar to the conclusion of other studies that in people with near-normal HbA1c level, HbA1c was not associated with sarcopenia and related parameters such as skeletal muscle mass and strength (26, 30), suggesting that long-term chronic hyperglycemia was a risk factor for muscle mass loss.

Skeletal muscle is also a major target organ of thyroid hormones (especially FT3) and is critical for muscle growth, contraction-relaxation cycles, energy supply, glucose homeostasis, and repair of muscle damage (31). Studies have shown that FT3 was positively correlated with muscle mass and muscle function in Chinese elderly euthyroid subjects and diabetic patients, and sarcopenia patients had lower levels of FT3 (32,33). This study also found that the level of FT3 in A4 group was significantly higher than that in A1, A2 and A3 groups. Further correlation analysis found that ASMI was positively correlated with FT3 and TSH. However, the role of thyroid hormones in muscle mass and function is also controversial. Studies have shown that TSH had a U-shaped association with sarcopenia and low muscle strength in the elderly, while FT3 was negatively correlated with muscle mass in the middle-aged and elderly population (34). In a cross-sectional analysis of a prospective cohort of the elderly, subclinical hypothyroidism had little effect on muscle mass and strength, and may not be related to sarcopenia (35).

Conclusion

The ASMI level in healthy adult males was related to age, obesity, blood pressure, glucose and lipid metabolism disorder, inflammation and thyroid hormone, among which age, BMI, WHR, and TG were independent influencing factors of ASMI level. Therefore, we carry out health education on sarcopenia and other related diseases from time to time to improve the awareness rate of healthy people and help reduce the occurrence of diseases. In addition, the subjects of this study were limited to adult males, and there was a lack of questionnaires on other research parameters and risk factors for sarcopenia, which had certain limitations. Therefore, it is necessary to include more samples and research indicators for further longitudinal observational research.

Journalism Ethics considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

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Conflict of Interest

The authors declare that there is no conflict of interest.

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