Trends in Measures of Handgrip Strength from 2014 to 2017 Among Korean Adolescents using the Korean National Health and Nutrition Examination Survey Data

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Abstract

Background: The incidence of obesity, metabolic syndrome, and nonalcoholic fatty liver disease among adolescents is increasing worldwide. Adolescents are also known to have sarcopenia along with these diseases. Measuring handgrip strength is a useful method to evaluate sarcopenia. No study has shown the trends of muscle quality (handgrip-to-weight) among Korean adolescents by year. This study aimed to determine the trends of handgrip strength among Korean adolescents using data from the Korea National Health and Nutrition Examination Survey (KNHANES).

Methods: Data of 2,304 adolescents (1,227 boys; 1,077 girls; age, 10–18 years) who participated in the KNHANES between 2014 and 2017 were obtained. Muscle quality was estimated by dividing handgrip strength by body weight (handgrip-to-weight ratio). The handgrip-to-weight ratios were categorized by age, sex, and year.

Results: Handgrip strength in adolescents decreased from 28.67kg in 2014 to 27kg in 2017. (P for trend<0.05) The handgrip-to-weight ratio also decreased from 51.48 in 2014 to 48.18 in 2017 (P for trend<0.05). The handgrip strength and handgrip-to-weight ratio also decreased significantly among boys and girls over the years 2014–2017 (P for trend<0.05).

Conclusions: The results of the present study indicate that the handgrip-to-weight ratio decreased in Korean adolescents from the years 2014 to 2017, and a declining overall ratio indicates a decrease in the quality of muscles among Korean adolescents. Hence, there is a need to review the health of Korean adolescents, and measures should be taken to prevent its deterioration.

Introduction

Anthropometric measurements, such as height and weight are basic but important examinations for children and adolescents. They can be evaluated as short or tall, obese or underweight using these measurements; moreover, these simple parameters may help in screening them for several other diseases. These non-invasive methods of obtaining information can be a good test for patients as well as pediatricians, especially for adolescents in whom we need to minimize invasive screening.

Sarcopenia is defined as the degenerative loss of skeletal muscle mass, quality, and strength with advancing age. Furthermore, sarcopenia is known to be associated not only with aging but also with other systemic diseases, such as metabolic syndrome and nonalcoholic fatty liver disease (NAFLD) in adults.[1, 2] Thus, evaluating sarcopenia is important, for which there are many measurement tools available. Computed tomography, magnetic resonance imaging, and dual-energy X-ray absorptiometry can measure muscle mass. Additionally, handgrip strength and knee flexion/extension strength can be used to assess muscle strength.[3, 4] Handgrip strength assessment is a very simple and reliable method because it is correlated with several medical conditions.[5] even in adolescents. Thus, handgrip strength has been used to identify sarcopenic obesity in children.[6] Many studies have reported the association between adult obesity and sarcopenia. A recent study reported a strong relationship between handgrip strength and obesity and metabolic syndrome in adults and adolescents.[7–11] Steffl et al. showed that handgrip strength can help identify children at risk for sarcopenic obesity.[6] However, no study has shown the trends of muscle quality (handgrip-to-weight) among Korean adolescents by year. This study aimed to evaluate the trends of muscle quality and estimate the overall health condition among Korean adolescents.

Methods

Data

The present study evaluated data from the 2014–2017 Korea National Health and Nutrition Examination Survey (KNHANES). These annual cross-sectional surveys are performed using multi-stage probability samples that are representative of the general Korean population. All participants provided written informed consent, and the KNHANES is approved by the Korean Center for Disease Control (<http://knhanes.cdc.go.kr/>). The Yonsei Severance Hospital Institutional Review Board approved the study protocol (No. 4–2018–1143)

Subject selection

During 2014–2017, a total of 2,988 individuals participated in the KNHANES. The present study included participants aged 10–18 years; participants with missing data were excluded. Thus, 2,304 participants (1,227 boys and 1,077 girls) were included in the analysis. The participants were categorized by age and sex. The subjects were categorized into 9 age groups by each year, from ages 10 to 18 years (Fig. 1).

Handgrip strength measurement

The Takei digital grip strength dynamometer (Model T. K. K.5401, Takei Co., Ltd., Ishioka, Japan) was used to measure handgrip strength. Measurement of handgrip strength can be influenced by other tests. Therefore, measurement of handgrip strength was performed before it could be influenced by any other test. All participants, except those with a history of wrist surgery within 3 months or any wrist discomfort, underwent the handgrip strength test. Handgrip strength was measured in a standing position with the arm and wrist in the anatomical position. Participants were asked to exhale and apply a maximal grip for 3 seconds, for a total of 3 repetitions each, starting with the dominant hand. The left and right hands were alternated. Sixty seconds of rest was allowed between each measurement. The highest handgrip strength value (in kg) between both hands was recorded and included in the analysis.[6] (<http://knhanes.cdc.go.kr/>) Handgrip strength was also calculated as a ratio of weight and body mass index (BMI), and this ratio (handgrip-to-weight, HGtW, (hand grip, HG / weight) × 100) was used in the analysis.[6, 9]

Statistical analysis

The SPSS software (version 23.0; IBM Inc., Armonk, NY) was used for statistical analyses of all data. Data were adjusted with sampling weight factors because of the complex survey design of the KNHANES. Continuous data were analyzed and expressed as mean ± standard error, applying weight factors. P for trend was analyzed by linear regression with applying weight factors of survey design.

Results

Characteristics of the participants from 2014 to 2017

The characteristics of the study participants from 2014 to 2017 are shown in Table 1. All values including age, systolic blood pressure (SBP), diastolic blood pressure (DBP), aspartate aminotransferase (AST), alanine aminotransferase (ALT), triglycerides (TG), cholesterol, glucose, handgrip strength (HG), handgrip-to-weight (HGtW), waist circumferences, and body mass index (BMI) did not show any trends over the years 2014, 2015, 2016, and 2017. However, waist to height ratio (WHtR) increased and total cholesterol level decreased significantly between the years 2014 and 2017. (P for trend<0.05) (Table 1)

Trends of handgrip strength among boys from 2014 to 2017

The trends in HG and HGtW among the boys are shown by year and age. (Figure 2A, 2B) The overall (age 10 to 18) trends of boy's HG and HGtW ratio is decreasing over 2014 to 2017. HG and HGtW ratio decreased from 33.32kg to 31.60kg and from 56.54 to 52.82, respectively. (P for trend<0.05) (Figure 4A, 4B) The HG significantly decreased among 13-, 14-, 15-, and 17-year-old boys. Furthermore, HGtW ratio decreased in 13-, 14-, 15-, 16-, and 17-year-old boys. (P for trend<0.05) (Supplementary Table. 1,2)

Trends of handgrip strength among girls from 2014 to 2017

The trends of HG and HGtW ratio among the girls are shown by year and age. (Figure 3A, 3B) The results showed a similar trend for HG and HGtW ratio among the girls as with the boys over the years. (P for trend<0.05) The HG decreased from 23.38kg to 21.92kg and HGtW ratio decreased from 45.73 to 43.05. (Figure 4A, 4B) The HG decreased significantly in 13-, 14-, 15-, 16-, and 17-year-old girls. Furthermore, HGtW ratio decreased in 13-, and 16-year-old girls. (P for trend<0.05) (Supplementary Table 3, 4)

Trends of handgrip strength among adolescents from 2014 to 2017

The trends of HG and HGtW ratio among the overall adolescents (boys and girls) decreased over the years significantly, from 28.67kg to 27kg and from 51.48 to 48.18, respectively. (P for trend<0.05) (Figure 5) (Supplementary Table 5)

Discussion

This study showed a significant decrease in HG and HGtW ratio among adolescent participants over the years from 2014 to 2017. The results of this study do not simply indicate that muscle strength is decreasing in adolescents over the years. Some studies have demonstrated a relationship between muscle mass and current health status.[1, 9] Cohen et al. showed the importance of muscle strength being associated with metabolic risk factors in children.[12] Moreover, Grontved et al. showed that adolescents' muscle strength is associated with cardiovascular risk in young adulthood.[13] Some studies argue that muscle mass alone cannot explain the patients' overall health status.[14] Therefore, Meng Ge et al. suggested that assessing muscle strength may be more valuable than measuring muscle mass.[9] Thus, HGtW represents muscle quality and is more important than HG alone. However, HGtW is decreasing in adolescents in Korea along with a decrease in HG. This indicates that Korean adolescents' muscle strength and quality are both decreasing over the years. In addition to the above-mentioned metabolic syndrome-related diseases, many studies have demonstrated HG's relationship with functional and psychological health as well as quality of life.[6, 7, 11, 15] The decrease in HG and HGtW indicates that there is reduction in more than just the force of simple muscle strength. Based on this retrospective data, we cannot know the exact cause of decrease in HG and HGtW; however, it indicates that in Korean adolescents it is not only the metabolic syndrome but also their overall health that might be concerning.

A recent study of handgrip cutoffs performed in children and adolescents in Colombia reported that the lower the HGtW ratio, the higher the likelihood of cardiometabolic risk.[16] Compared with the HG cut-off presented in a previous study, the HGtW ratio among boys and girls aged 10–12 years are higher (0.376 for boys and 0.359 for girls). In the present study, from 2014 to 2017, boys over 13 years of age showed an HGtW higher than the cut-off value (0.447 for boys) in a previous study. Girls' HGtW, however, was higher than the cut-off value (0.440 for girls) in year 2014, but the HGtW was found to be low in 2017. HGtW of Korean adolescents are higher than the cut-off value seen in the Colombia study, but it is declining over the years. Specifically, in 2017, HGtW of girls over 13 years of age were lower than the cut-off value. Further evaluation and management of Korean adolescents' overall health is necessary.

Although the prevalence of metabolic syndrome in Korean adolescents varies from study to study, a recent study has reported a prevalence of 5.8% in boys and 5.5% in girls using the National Cholesterol Education Program, Adult Treatment Panel III.[17] The prevalence of metabolic syndrome in Korean adolescents is not yet high; however, it seems to increase since Park et al. mentioned that the prevalence of metabolic syndrome in Korean adolescents is 3.3% in both boys and girls using data from the 1998 KNHANES.[18] The prevalence of metabolic syndrome is increasing. Moreover, it does not seem to be irrelevant to the current findings.

This study has a few limitations. First, in the KNHANES, muscle mass was not measured using dual-energy X-ray absorptiometry or imaging studies, such as computed tomography. These data should be added for adolescents in the KNHANES in the future. Second, there is a lack of information on the cut-off value of HGtW in Korean adolescents. If additional data are collected or cohorts are built in the future, it may be possible to determine cut-off values. However, despite these limitations, this is the first large-scale study to evaluate trends of handgrip strength in Korean adolescents.

In conclusion, the results of the present study showed a decrease in HGtW in Korean adolescents, which might be indicative of an increase in metabolic risk among Korean adolescents. To our knowledge, this is first study to evaluate trends of HG and HGtW in adolescents and to show changes over the years. HGtW is a measure of muscle quality; the overall decrease suggests deterioration of the quality of muscles among Korean adolescents. Hence, there is a need to review the health of Korean adolescents, and measures should be taken to prevent its deterioration.

Declarations

Conflicts of Interest: The authors declare no conflicts of interest associated with this report.

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Disclosure

Financial Disclosures: None.

Author contributions

Conceptualization: Kang Y, Lim H, Kim D.

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Table

Table 1. Characteristic of Participants in KNHANES 2014 to 2017

	Total	2014	2015	2016	2017	<i>B</i> coefficient	<i>P</i> for trend*
Age(year)	14.41±0.06	14.28±0.14	14.41±0.13	14.47±0.10	14.49±0.14	0.067	0.272
SBP(mmHg)	108.54±0.26	108.06±0.61	108.90±0.49	109.14±0.53	108.05±0.49	0.008	0.975
DBP(mmHg)	66.41±0.22	65.70±0.50	66.31±0.40	66.94±0.41	66.67±0.47	0.349	0.098
Height(cm)	162.12±0.28	161.69±0.64	161.80±0.53	162.32±0.50	162.66±0.50	0.343	0.180
Weight(kg)	56.08±0.36	55.63±0.86	57.14±0.67	55.58±0.68	55.96±0.65	-0.069	0.838
Waist(cm)	71.05±0.26	70.47±0.55	72.73±0.49	70.91±0.49	70.09±0.51	-0.319	0.188
BMI(z-score)	0.12±0.03	0.10±0.06	0.30±0.06	0.01±0.06	0.05±0.06	0.117	0.115
WHtR	43.83±0.14	43.55±0.28	44.97±0.28	43.69±0.27	43.10±0.28	-0.280	0.028
Glucose(mg/dl)	91.85±0.23	92.33±0.67	91.88±0.34	91.82±0.36	91.37±0.41	-0.293	0.218
Cholesterol(mg/dl)	162.27±0.66	157.52±1.37	161.59±1.23	164.01±1.31	165.95±1.35	2.755	<0.001
TG(mg/dl)	86.08±1.29	85.52±2.95	88.29±2.69	84.89±2.26	85.61±2.41	-0.337	0.777
AST(U/L)	19.36±0.23	18.87±0.39	19.82±0.66	19.14±0.34	19.60±0.40	0.143	0.438
ALT(U/L)	15.73±0.46	14.87±0.74	16.36±1.22	15.55±0.70	16.12±0.94	0.284	0.465

SBP, systolic blood pressure; DBP, diastolic blood pressure; BMI, body mass index; WHtR, Waist-to-Height Ratio (waist(cm)/height(cm)×100); TG; triglyceride; AST, aspartate aminotransferase; ALT, alanine aminotransferase.

Data presented as mean ± standard error applying weight factors. * P for trend was analyzed by linear regression with applying weight factors of survey design.

Figures

Figure 1

Flow chart for participant selection (1,227 boys and 1,077 girls).

Figure 2

Trends of handgrip strength (A) and handgrip-to-weight ratio ($\times 100$) (B) of boy participants.

Figure 3

Trends of handgrip strength (A) and handgrip-to-weight ratio ($\times 100$) (B) among girl participants.

Figure 4

Trends of handgrip strength (A) and handgrip-to-weight ratio (x 100) (B) by sex. P for trend was analyzed by linear regression with applying weight factors of survey design.

Figure 5

Trends of handgrip strength and handgrip-to-weight ratio among adolescents (boys and girls) over the years 2014 to 2017. The HG and HGtW significantly decreased from 2014 to 2017 (*P for trend<0.05) P for trend was analyzed by linear regression with applying weight factors of survey design.

Supplementary Files

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