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

Yunkoo Kang
Yonsei University Wonju College of Medicine
Jieun Kim
Kyung Hee University
Seung Kim
Yonsei University College of Medicine
Sowon Park
Yonsei University College of Medicine
Hyunjung Lim
Kyung Hee University
Hong Koh (khong@yuhs.ac)
Yonsei University College of Medicine https://orcid.org/0000-0002-3660-7483

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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 conditions. 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 status of Korean adolescents, and measures should be taken to prevent its deterioration.

Background

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 diseases such as nonalcoholic fatty liver disease (NAFLD), metabolic syndrome. These non-invasive methods of obtaining information can be a good evaluation method 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 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, 6] even in adolescents and children.[7–10] Thus, handgrip strength has been used to identify sarcopenic obesity in children.[11] 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.[12–16] Steffl et al. showed that handgrip strength can help identify children at risk for sarcopenic obesity.[11] The handgrip strength represents the strength of the simple muscle force, however, it can also represent something more important. The decreases in grip strength can be attributed to problems with several medical conditions, such as children's mental health, obesity and metabolic syndrome as mentioned above. Based on this, if we can figure out the trends of handgrip strength, medical condition of children can be evaluated easily. 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). The different participants were selected every year. These annual cross-sectional surveys are performed using multi-stage probability samples that are representative of the noninstitutionalized civilian Korean population. The data of selected participants has specific sampling weights factors because each data does not have equal probability of being selected. The data were analyzed after adjusting with specific sampling weights factors for each participants. All participants provided written informed consent, and the KNHANES is conducted 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).

Measurement of anthropometric and laboratory variables

Systolic blood pressure (SBP, mmHg) and diastolic blood pressure (DBP, mmHg) were measured to the nearest 2 mmHg using a mercury sphygmomanometer (Baumanometer Wall Unit 33(0850)). Height was measured to the nearest 0.1 cm using a stadiometer (SECA 225, Seca GmbH & KG.), and weight was measured to the nearest 0.1 kg using a balance beam scale (GL-600-20, G-tech). Waist circumference was measured to the nearest 0.1 cm using a measuring tape (SECA 200, Seca GmbH & KG.). The body mass index (BMI) and waist-to-height ratio (WtHR) were calculated from the measured height and weight of participants (kg/m2 and waist (cm)/height (cm) × 100, respectively). Levels of fasting glucose (mg/dL), aspartate aminotransferase (AST, U/L), and alanine aminotransferase (ALT, U/L), triglyceride

(TG, mg/dL), cholesterol(mg/dL), high-density lipoprotein (HDL, mg/dL), were measured using a Hitachi Automatic Analyzer 7600.[17]

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. The dynamometer were calibrated according to standardized protocol and well trained special investigator checked the measurement whether it was done properly. Measurement of handgrip strength can be influenced by other tests such as blood test. Therefore, measurement of handgrip strength was performed after rest and light exercise which could helped performing maximum strength of handgrip. All participants, except those with a history of wrist surgery within 3 months or any wrist discomfort, underwent the handgrip strength test. The handgrip strength testing procedures has been done according to muscle strength procedures manual by Centers for Disease Control and Prevention.[18, 19] 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.[11] (http://knhanes.cdc.go.kr/) Handgrip strength was calculated as a ratio (handgrip-to-weight, HGtW, (hand grip, HG / weight) × 100) and it was used in the analysis.[11, 14]

Statistical analysis

The SPSS software (version 23.0; IBM Inc., Armonk, NY) was used for statistical analyses of all data. Data was adjusted with sampling weight factors because of the complex survey design of the KNHANES which small number of participants are representative of the general Korean population. Continuous data was 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), 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 (WtHR) increased and total cholesterol level decreased significantly between the years 2014 and 2017. (P for trend < 0.05) (Table 1)

Table 1

Participants characteristics in KNHANES 2014 to 2017

	Total (n = 2304)	2014 (n = 483)	2015 (n = 574)	2016 (n = 634)	2017 (n = 613)	B coefficient	P 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 ± 0.32	0.10 ± 0.06	0.30 ± 0.68	0.01 ± 0.06	0.05 ± 0.06	0.117	0.115
WtHR	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; WtHR, Waist to Height Ratio(waist(cm)/height(cm)x100); TG; triglyceride; AST, aspartate aminotransferase; ALT, Alanine aminotransferase. Data presented as mean ± standard error with weighting of survey design.

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. (Fig. 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 33.3 kg to 31.6 kg and from 56.5 to 52.8, respectively. (P for trend < 0.05) (Fig. 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. (Fig. 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 23.38 kg to 21.92 kg and HGtW ratio decreased from 45.7 to 43.1. (Fig. 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 28.7 kg to 27.0 kg and from 51.5 to 48.2, respectively. (P for trend < 0.05) (Fig. 5) (Supplementary Table 5)

Conclusion

This study showed a significant decrease in WtHR and increase in total cholesterol from year 2014 to 2017. The other variables such as SBP, DBP, AST, ALT, TG, BMI did not show any trends from year 2014 to 2017. However, 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 indicate more than just muscle strength is decreasing in adolescents over the years. Some studies have demonstrated a relationship between muscle mass and current health status.[1, 14] Cohen et al. showed the importance of muscle strength being associated with metabolic risk factors in children.[20] Moreover, Grontved et al. showed that adolescents' muscle strength is associated with cardiovascular risk in young adulthood.[21] Some studies argue that muscle mass alone cannot explain the patients' overall health status.[22] Therefore, Meng Ge et al. suggested that assessing muscle strength may be more valuable than measuring muscle mass.[14] 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.[11, 12, 16, 23] The decrease in HG and HGtW indicates that there is overall health problem in Korean adolescents, more than just decrease in the force of simple muscle strength.

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.[24] 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.

Other variables except WtHR and cholesterol does not show significant trends over years, but HG and HGrW are decreasing over years and it can be affected by various variables as mentioned above. We cannot be satisfied for Korean adolescents are safe even the variables such as SBP, DBP, AST, ALT, TG, BMI did not change over years. The socioeconomic status, dietary intake, physical activity, and mental status, many other variables can be affected health of Korean adolescents. Currently, the situation in Korea does not seem to be irrelevant. The health status can be easily inferred by HG and HGtW, and this study implies the risk of health problems of Korean adolescents have begun to develop.

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. Third, missing data were present that could affect the result. Further effort is needed to minimize the missing data because it represents the whole Korean adolescent. Fourth, puberty can affect the result of handgrip strength, however, tanner staging data is missing in KNHANES data. Fifth, physical activity, dietary intake or socioeconomic status can affect handgrip strength, but these variables were excluded in analysis.[27] Further study is needed to evaluate cause of decrease in HG and HGtW in Korean adolescents. 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 a problem in overall health status among Korean adolescents. Decrease in HGtW might be caused by such as increase in metabolic risk or mental health problem, decrease in physical activity or having dietary intake problem. 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

Abbreviations

KNHANES: Korean adolescents using data from the Korea National Health and Nutrition Examination Survey; NAFLD: nonalcoholic fatty liver disease; SBP: Systolic blood pressure; DBP: diastolic blood pressure; BMI: body mass index; WtHR: waist-to-height ratio; AST: aspartate aminotransferase; ALT: alanine aminotransferase; TG: triglyceride; HDL: high-density lipoprotein; HG: handgrip strength; HGtW: handgrip-to-weight.

Ethics approval and consent to participate

All participants provided written informed consent, and the KNHANES is conducted 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)

Consent for publication

Not applicable

Availability of data and material

The KNHANES data used in this study is available in http://knhanes.cdc.go.kr

Competing interests

The authors declare no competing interest associated with this report.

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Not applicable

Authors' contributions

KH and LH were the group leader. Conceptualization was done by KY, LH and KH. Formal analysis performed by KY. KS and PS worked with software. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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Not applicable

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Figures

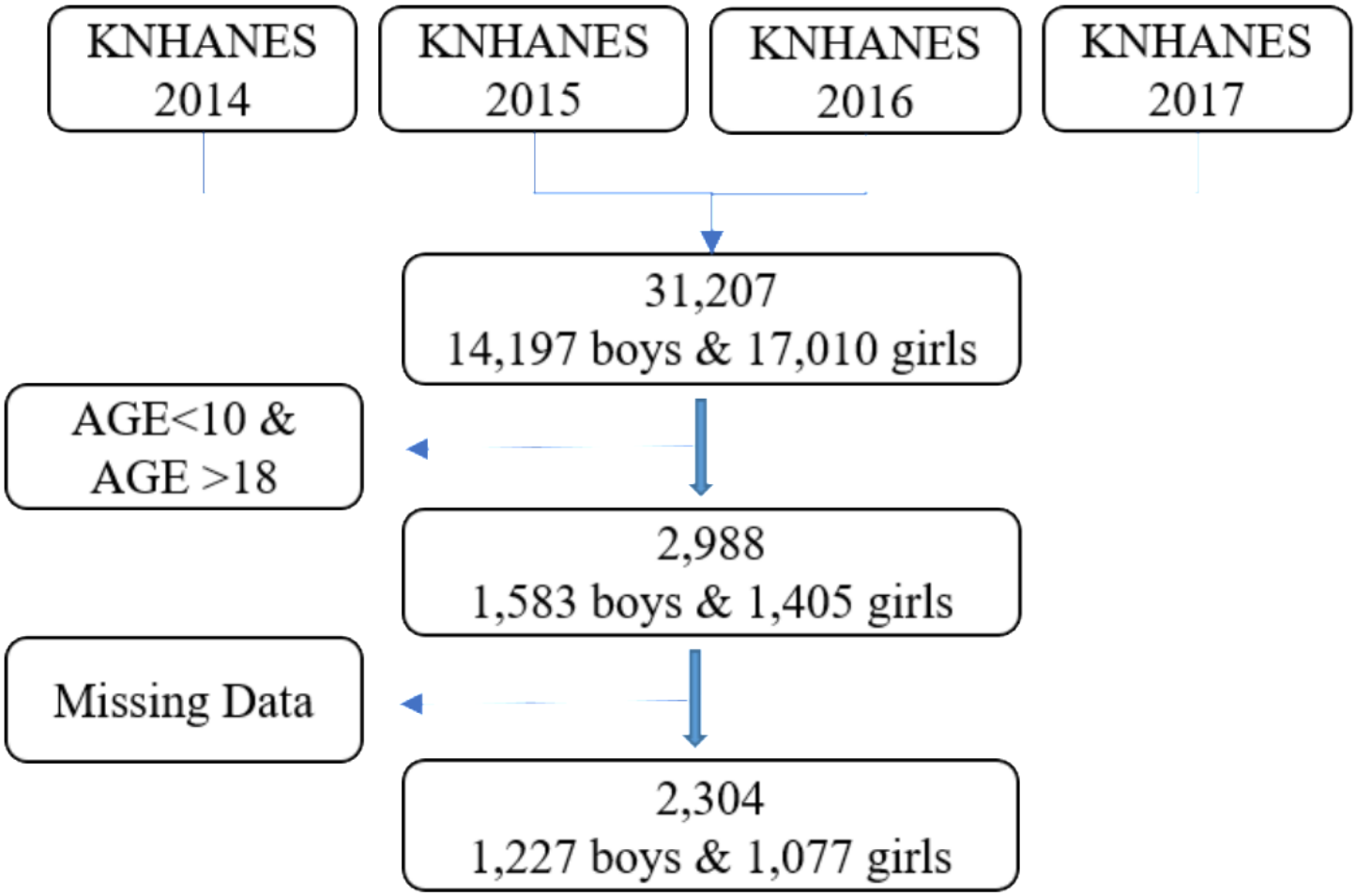

Figure 1

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

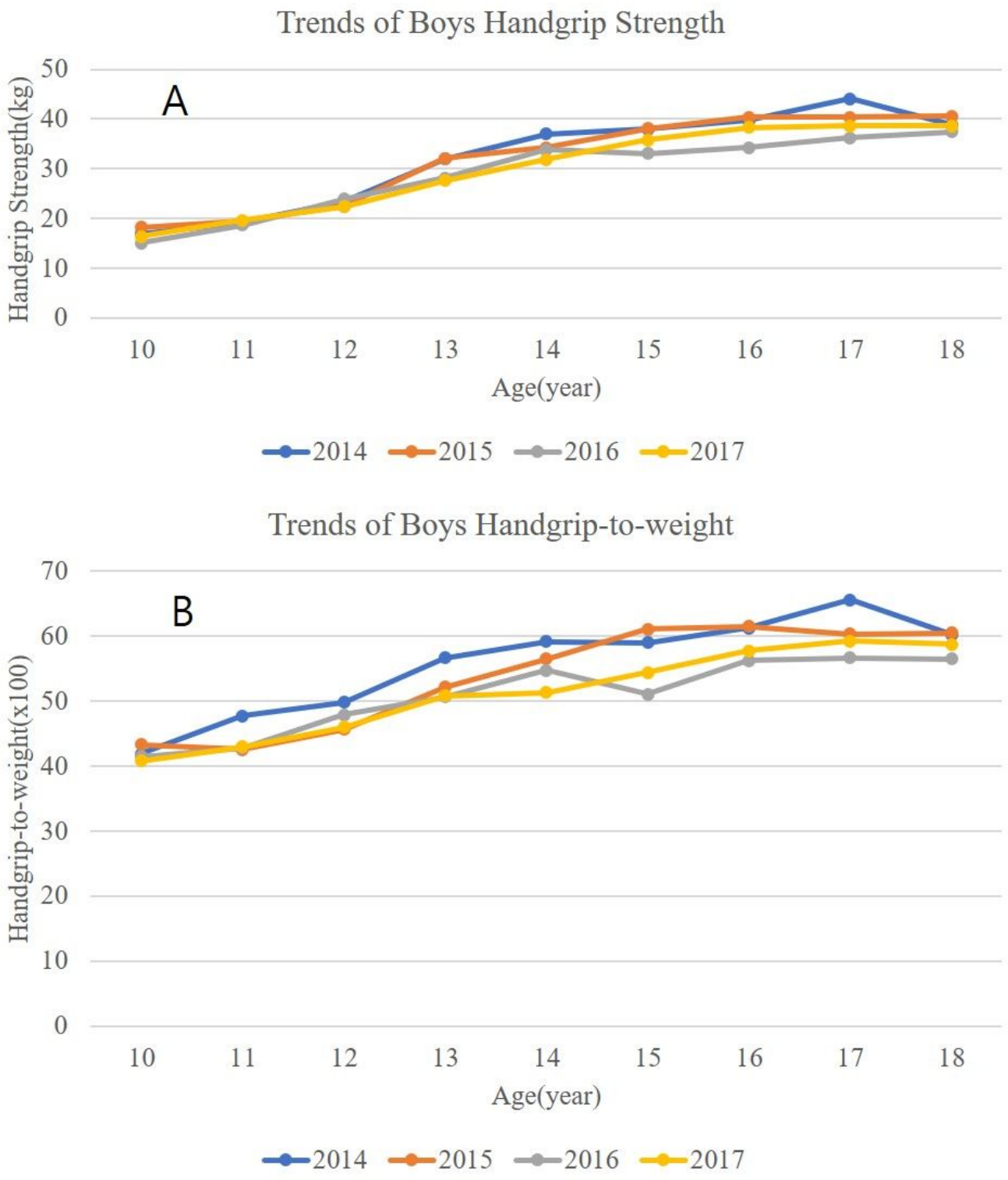

Figure 2

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

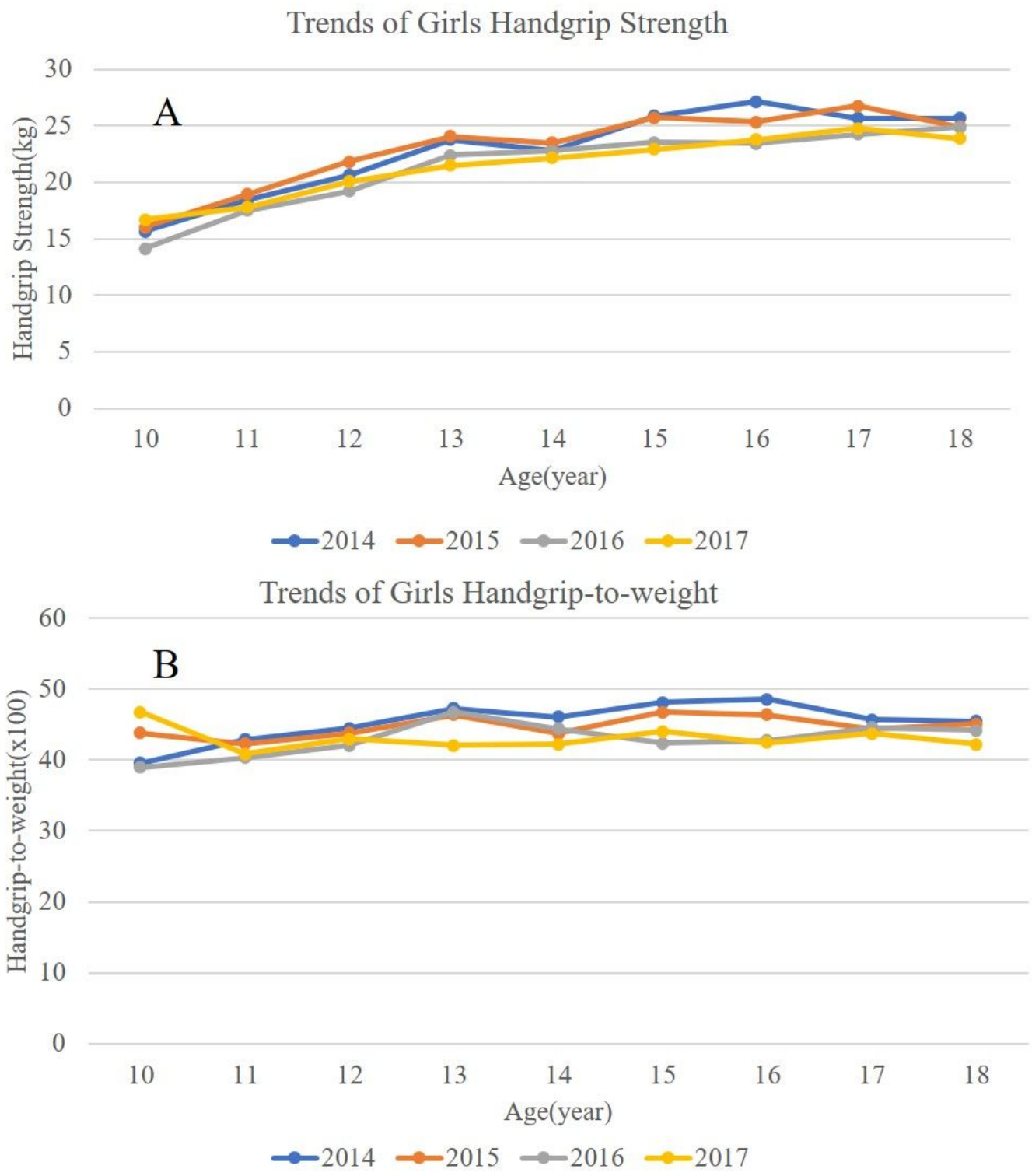

Figure 3

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

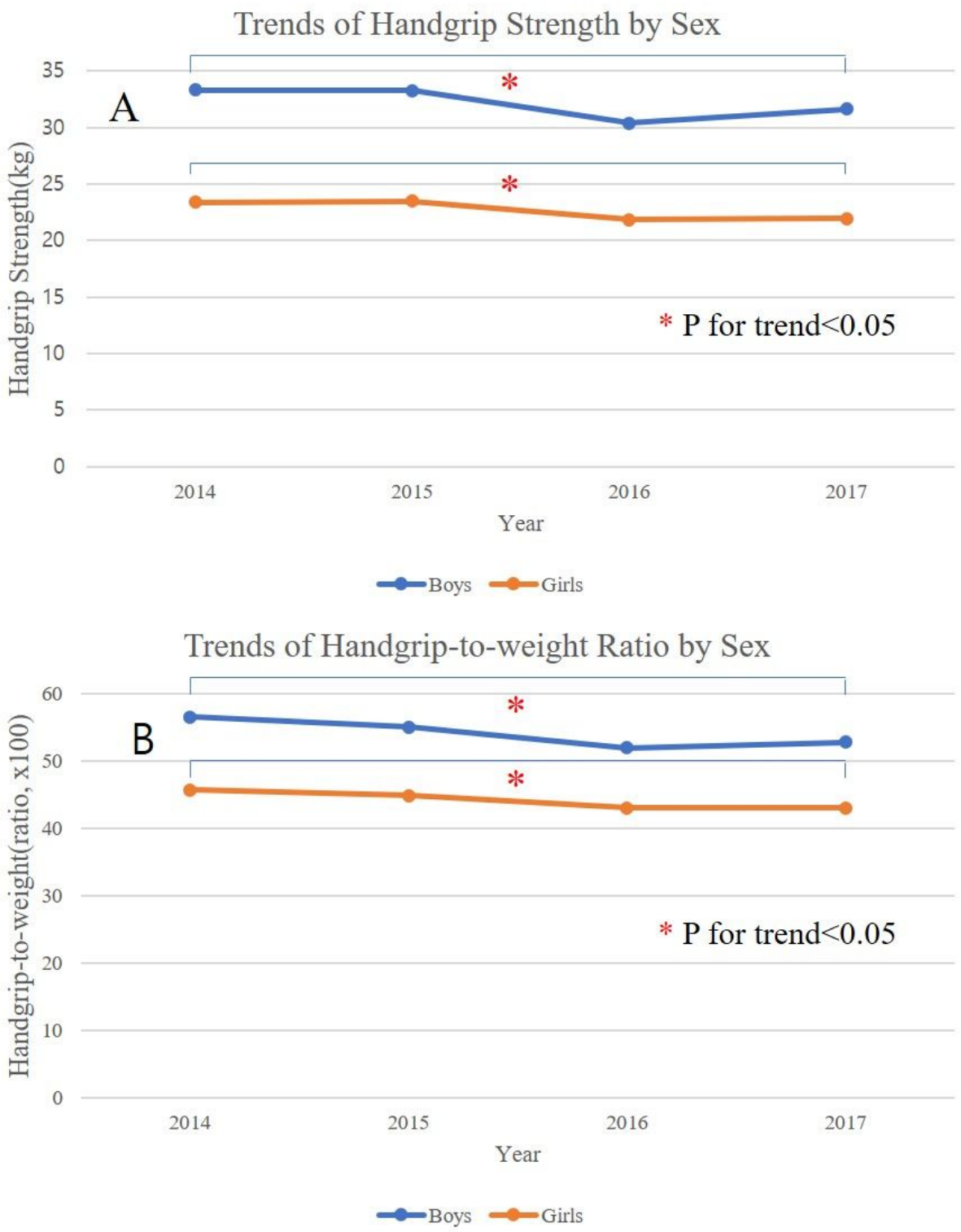

Figure 4

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.

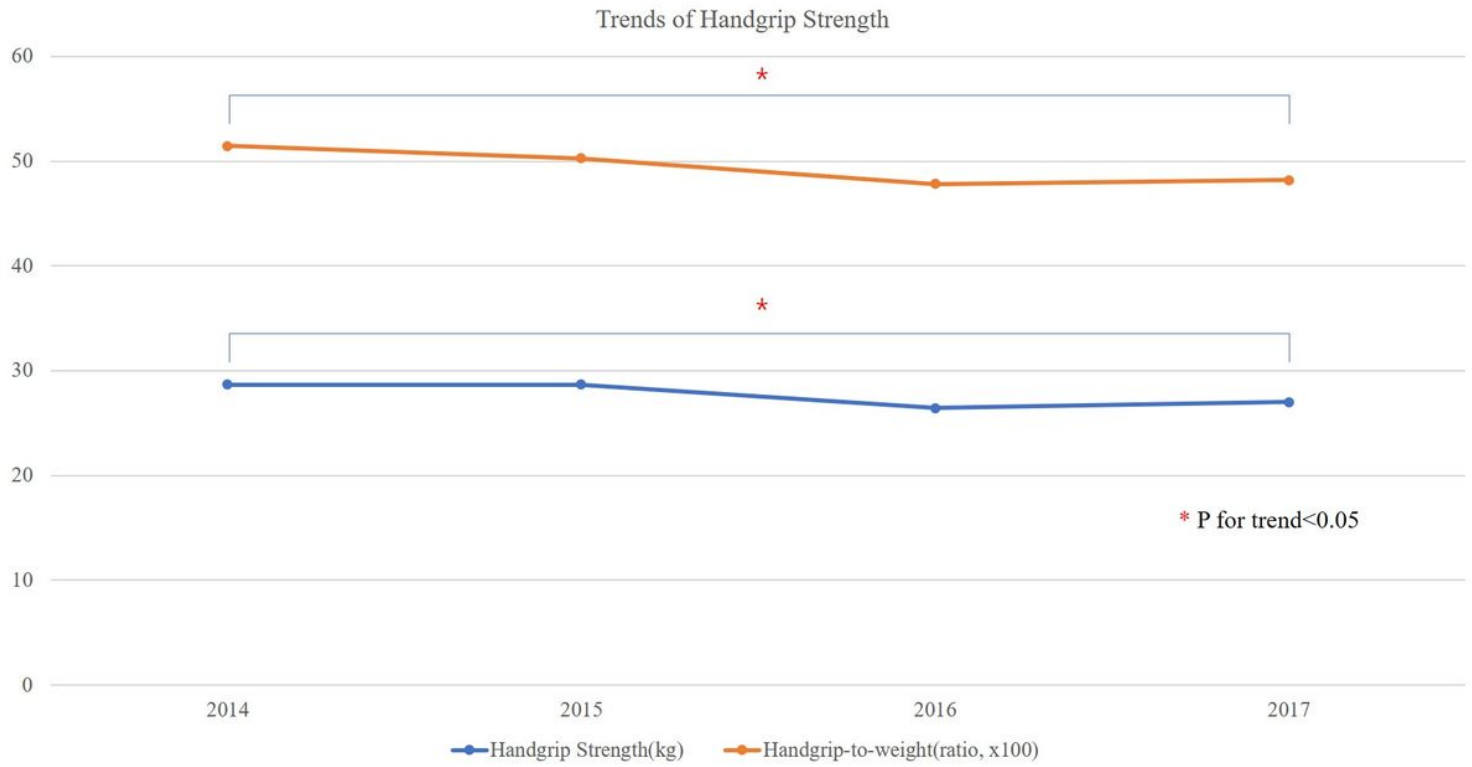

Figure 5

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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