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SHORT COMMUNICATION

Comparison of handgrip strength between young female kendo athletes and sex-matched non-athlete controls

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Objective: This study aimed to compare young female kendo athletes and sex-matched non-athlete controls to determine if there are differences in handgrip strength between the groups, and if so, at what age these differences appear.

Methods: Thirty-three female kendo athletes (mean age [SD]: 9.5 [1.8] years) and 33 sex-matched female non-athlete controls (mean age [SD]: 9.3 [1.8] years) between the ages of 6 and 12 years participated in this study. Handgrip strength was measured using a Smedley dynamometer, and the average value of both hands was used for analysis. The kendo experience was determined when they started practice. Handgrip strength was compared between groups. Statistical moderation was used to determine if the relationship between group and handgrip strength depended upon the age of the participant.

Results: Female kendo athletes exhibited significantly higher handgrip strength compared to female non-athlete controls both before (4.5 kg [95% CI: 1.9, 7.03]) and after (2.4 kg [95% CI: 0.7, 3.9]) adjusting for body mass. Adjusting for body mass, we observed that the relationship between group and handgrip strength depended on the child's age (group × age, $t = 2.75$, $p = 0.007$). Using the Johnson-Neyman procedure, we identified statistically significant differences between groups starting from 8.3 years old and above. Without adjusting for body mass, significant differences appeared from 8.0 years old and above. Below that age, differences between groups were minimal and not statistically different.

Conclusion: Our findings suggest that sports (e.g., kendo) requiring grasping equipment with the hands may help improve handgrip strength in adulthood.

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Keywords: ■ biomarker ■ grip strength ■ sports ■ young children

INTRODUCTION

Numerous studies consistently demonstrate that handgrip strength, a part of physical fitness, predicts both current and future health outcomes in children and adolescents. For example, younger people with higher handgrip strength tend to have lower rates of future psychiatric disorders,[1] suicide,[2] premature cardiovascular events, all-cause mortality,[3,4] physical disabilities,[5] and work limitation[6]. These findings suggest that acquiring high handgrip strength by adulthood may contribute to future healthy life expectancy.[7,8] However, individual differences in handgrip strength can already be observed in preschool children.[9] A follow-up study found that children with low handgrip strength were approximately five times more likely to have low handgrip strength as young adults compared to those with high handgrip strength.[10] Therefore, it is necessary to identify potential interventions that can help children with low handgrip strength develop into adults with high handgrip strength.

Some sports involve the use of tools, and such activities can help improve handgrip strength.[11] Therefore, we examined the handgrip strength of young male athletes in sports that use tools (kendo) versus those that do not (soccer). The results from the previous study showed that young male kendo athletes had stronger handgrip strength than male soccer players, with a significant difference starting at an age of 8.5 years.[12] Cross-sectional studies have shown that prepubertal boys and girls have roughly similar average handgrip strength;[13] however, it is unclear whether sport has an impact on handgrip strength in young female athletes. The goal of this study was to compare young female kendo athletes and non-athlete controls to see if there are differences in handgrip strength between the groups, and if so, at what age these differences show up.

METHODS

Participants

A sample of 33 female kendo athletes and 33 sex-matched female non-athlete controls was recruited from the Fukuoka City area with the assistance of their parents and coaches. Participants were initially recruited from kendo athletes, and then non-athletes were recruited to match the number of kendo athletes in each school grade. The number of partici-

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pants in each grade in the kendo and non-athlete control groups was 1st grade (6 vs. 6), 2nd grade (3 vs. 5), 3rd grade (4 vs. 4), 4th grade (9 vs. 7), 5th grade (4 vs. 3), and 6th grade (7 vs. 8), respectively. The inclusion criteria were: 1) overtly healthy athletes needed to be between 6 and 12 years old and have more than 6 months of kendo practice at the start of the study; 2) the non-athlete control group included participants from the same age range who engaged in recreational activities (such as swimming) but did not participate in competitive sports training or practice, and 3) written consent was obtained from the parents or legal guardians for both groups. The exclusion criteria consisted of healthy participants who were unable to use their arms due to injury. The participants and their parents were fully informed about the purpose of the study and its safety, and written informed consent was obtained from the parents of each participant. Data collection was conducted in the evening at a training facility for each kendo athlete and in the morning at a school for each of the non-athlete controls. This study received approval from the University's Institutional Review Board (SG #2021-2-2 and HSS-2024-142).

Anthropometric measurements

Standing height and body mass were measured using a height scale and an electronic weight scale (WB-260A, Tanita, Tokyo, Japan) before the handgrip strength measurements. Body mass index (BMI) was calculated as body mass divided by the square of height in kilograms per square meter. The circumference of the right forearm was measured at its widest part using a tape measure. The length of the right hand was measured as the straight-line distance between the distal wrist crease and the tip of the middle finger.

Handgrip strength measurements

Maximum handgrip strength was measured with both the right and left hands using a digital handgrip dynamometer (Grip-D, Takei Kiki, Niigata, Japan).[12] The grip span (distance between the grip bars) of the dynamometer was initially adjusted to 30% of the participant's hand length. Each participant used a handgrip dynamometer to verify that the grip span was suitable before measurement and adjusted it if necessary. All participants were instructed to stand upright with their arms at their sides and hold the dynamometer in their hand with their elbow extended downward without squeezing. Participants performed two maximal trials for each hand, with a one-minute break between trials for the right and left hands (alternating between right and left). The data analysis used the highest value in each hand and the average value of both hands. The absolute values of test–retest reliability for handgrip strength measurements have been previously reported for each age group.[14]

Sports practice history

Kendo athletes typically belong to a dojo (kendo school) and practice there. We asked each athlete how old (or what grade, such as kindergarten or elementary school) they were when they started practicing in a dojo. Parents were consulted if necessary for younger children.

Statistical analysis

In alignment with our previous analysis,[12] we implemented an independent sample t-test to determine whether there were handgrip strength differences between groups. An ANCOVA was used to compare handgrip strength after adjusting for body mass. Statistical moderation (PROCESS macro) was then used to determine whether the relationship between group and handgrip strength depended upon the age (in years) of the child. For all models, we provide results with and without adjustment for body mass. If there was evidence of moderation, we probed the interaction using the Johnson-Neyman procedure. Statistical significance was set at $p < 0.05$. All statistics were run using IBM SPSS. Because the Johnson-Neyman results cannot be visualized well within SPSS, we reran the analysis with R-studio (2025.09.1) and utilized the "interactions" package (v. 1.2.0) in order to illustrate the interaction between group*age for handgrip strength.

RESULTS

For the overall sample, there was a statistically significant difference between groups ($t = 3.48$, $p < 0.001$) with kendo having 4.5 kg (95% CI: 1.9, 7.03) greater handgrip strength than control. Following adjustment for body mass, kendo still had 2.4 kg (95% CI: 0.7, 3.9) greater handgrip strength than the control.

Following adjustment for body mass, we found that the relationship between group and handgrip strength depended upon the age of the child (group*age $t = 2.75$, $p = 0.007$). Using the Johnson-Neyman procedure, we found statistically significant differences between groups from 8.3 years and older. Before that age, the differences between groups were minimal and not statistically different (Figure 1).

When running the same model without adjusting for body mass, the relationship between group and handgrip strength still depended upon age (group*age $t = 2.65$, $p = 0.009$). Using the Johnson-Neyman procedure, we found statistically significant differences between groups from 8.0 years and older. Before that age, the differences between groups were minimal and not statistically different.

DISCUSSION

Our findings from this cross-sectional comparison indicated that young female kendo athletes who use bamboo swords during practice had significantly greater handgrip strength than sex-matched young non-athlete controls. This strength effect depended upon age, with differences in strength becoming significant between groups (Kendo > Control) after 8 years of age.

Several cross-sectional studies have examined the impact of sports activity on handgrip strength in children and adolescents. One study compared the handgrip strength and other physical fitness tests of 596 boys and girls between the ages of 10 and 18, divided into athletes (n=231) and non-athletes (n=365).[15] Another study compared the physical fitness, including handgrip strength, of 4,126 boys and 3,958 girls

Table 1. Anthropometrical variable, sports experience, and handgrip strength in female kendo athletes and sex-matched non-athlete controls. This table is for descriptive purposes only. Values are expressed by mean and standard deviation (SD).

Variables	Kendo	Control
N	33	33
Age (year)	9.5 ± 1.8	9.3 ± 1.8
Height (cm)	134.8 ± 13.9	130.8 ± 12.4
Body Mass (kg)	32.2 ± 8.5	28.1 ± 7.7
Body Mass Index (kg/m2)	17.4 ± 2.3	16.1 ± 1.8
Forearm Girth right (cm)	20.1 ± 2.0	18.7 ± 1.6
Handgrip Strength right (kg)	19.1 ± 6.4	14.7 ± 4.1
Handgrip Strength left (kg)	18.6 ± 6.4	14.0 ± 3.8
Handgrip Strength average (kg)	18.8 ± 6.3	14.4 ± 3.9
Kendo Practice (year)	3.0 ± 1.8	

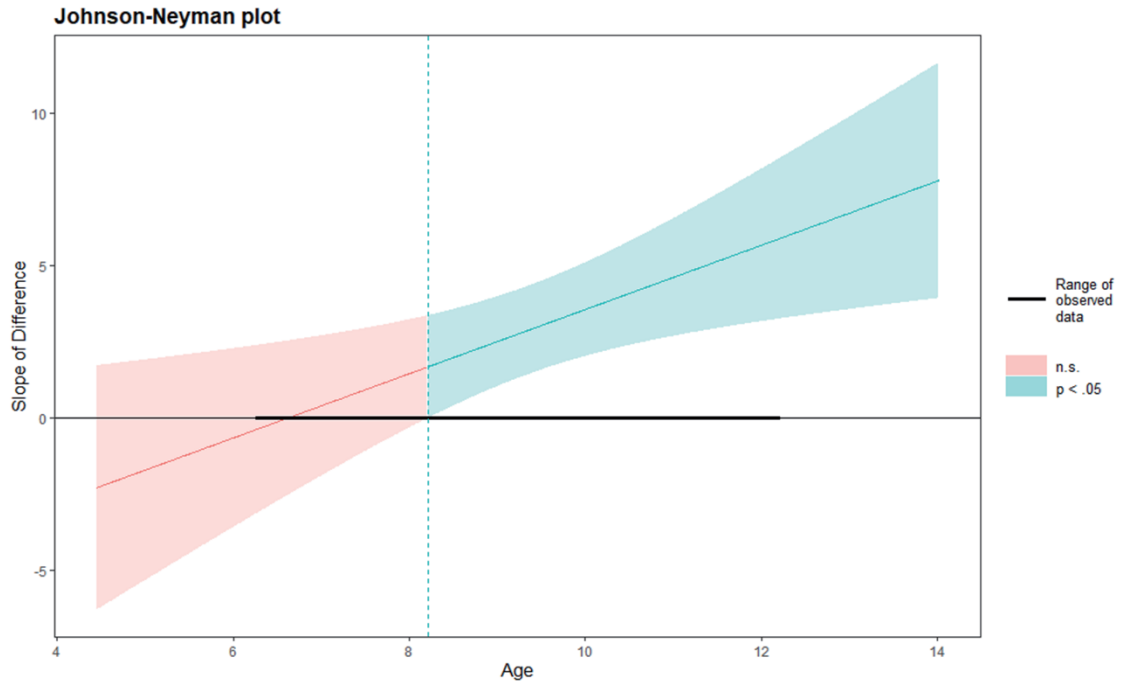

Figure 1. Johnson-Neyman plot created using the interactions package in R-studio. The difference between groups is on the y-axis (kg) and age in on the x-axis (yrs). Above 0 indicates that kendo athletes are stronger than sex-matched controls. The solid black line represents the range of observed data for the moderator. The dotted vertical blue line represents the point of transition from "non-significant' to "significant" differences.

between the ages of 10 and 14, divided into school and/or club-based sports participants and non-participants.[16] In both studies, athletes had higher shuttle run test scores than non-athletes, but no difference was found in handgrip strength between the two groups. Unlike studies that treat different types of athletes as a single group, several studies,[7,11,12,17] including this one, have confirmed the effect of single-sport activity on handgrip strength. For example, Gerodimos and colleagues[17] divided male wrestlers between the ages of 9 and 28 into four age groups and examined how wrestling affected handgrip strength by comparing them with non-athletes of the same age. The authors reported no difference in handgrip strength in both the 9~11 and 13~15 year old groups, but noted that in the 16 and older age groups, the wrestlers had

higher handgrip strength than the non-athlete controls. We previously conducted cross-sectional research to examine how handgrip strength is affected in kendo athletes who practice by gripping the bamboo sword with both hands, compared to soccer players who do not.[7,11,12] In young college men[11] and women[7], the handgrip strength of kendo athletes was significantly higher than that of soccer players. In boys 6 years and older, kendo athletes showed greater handgrip strength than soccer players,[12] beginning around 8.5 years old. Similar results were seen in the girls in this study. The impact of sports on handgrip strength may vary depending on whether the activity involves gripping with the hands, as well as the force and frequency of gripping equipment during sports play. Kendo practice is generally similar at each dojo in frequency (3-4 times per week) and duration (1.5-2 hours) for elementary school kendo athletes.[12] Furthermore, the age when the benefits of sports begin to appear to the age when the sport is first introduced (duration of sports experience). One study has suggested a connection may exist between increased muscle strength and hormone secretion during development.[18]

The cross-sectional nature of this study limits the ability to determine whether the sport type could induce differential changes in handgrip strength. We recently followed young male kendo and soccer athletes for two years to observe changes in handgrip strength between the two groups,[19] and found that there was a difference in the change in handgrip strength between the two groups, with the kendo athletes showing a greater change. Additional evidence on the impacts of sports on handgrip strength can be obtained by conducting a follow-up study on the female participants in this study and comparing the changes in handgrip strength between the two groups.

Several criteria should be consistent in handgrip strength measurement protocols. In this study, the main protocols (i.e., instrument, testing position, grip span, number of trials, rest period between trials, etc.) remained the same, but the measurement times differed, with testing conducted in the morning for non-athlete controls and in the afternoon for kendo athletes. While not ideal, a study of young and middle-aged adults found no difference in handgrip strength measured in the morning (between 10:00 and 11:00 a.m.) and the afternoon (between 1:00 and 3:00 p.m.),[20] indicating that handgrip strength may not have been impacted by the time of day. Given that this finding was in alignment with what we have seen with boys,[12] it is likely that a meaningful part of the difference was due to the sport rather than the time measured.

In conclusion, this study showed that young female kendo athletes had significantly higher handgrip strength than sex-matched non-athlete controls. After adjusting for body mass, a significant difference was observed between the two groups after age 8.0 years. Our results suggest that sports requiring grasping equipment with the hands may help improve handgrip strength in adulthood. However, it is currently unknown whether the high handgrip strength gained through sports during growth has a positive effect on maintaining physical and mental health in the future. Future work can also consider investigating other sports with a gripping component (e.g., softball) to see if the results are similar to kendo.

CONFLICT OF INTEREST

The authors declared no potential conflicts of interest concerning this manuscript's research, authorship, and/or publication.

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