

# Relationships Between Eating Behaviors and Hand Grip Strength Among Chinese Adults: A Population-Based Cross-Sectional Study

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Liang Ding<sup>1</sup>  
Jianjun Yin<sup>2</sup>  
Wenbo Zhang<sup>3</sup>  
Ziqiang Wu<sup>4</sup>  
Shulei Chen<sup>4</sup>

<sup>1</sup>Department of Physical Education, Southeast University, Nanjing, People's Republic of China; <sup>2</sup>Department of Physical Education, Guangdong University of Finance and Economics, Guangzhou, People's Republic of China; <sup>3</sup>Department of Physical Education, Changchun Institute of Education, Changchun, People's Republic of China; <sup>4</sup>Department of Physical Education, Dalian Institute of Science and Technology, Dalian, People's Republic of China

**Purpose:** Poor eating behaviors are associated with imbalances in energy and food intake, which may directly or indirectly contribute to muscle strength loss. This study aimed to investigate the association between eating behaviors and hand grip strength in Chinese adults.

**Materials and Methods:** We designed and conducted a cross-sectional study of 2009 Chinese individuals aged 25–65 years in 2017. Eating behaviors, including breakfast consumption, snacking after dinner, and eating rate, were assessed using a self-administered questionnaire. Hand grip strength was assessed using a digital grip dynamometer. Age, sex, BMI, physical activity, educational level, occupation, living status, sleep duration, smoking and drinking status, hypertension, diabetes, and depressive symptoms were used as confounding factors.

**Results:** After final adjustments for confounding factors, grip strength was measured as 35.2 (95% confidence interval [CI]: 34.7–35.8), 36.0 (95% CI: 35.6–36.4), and 36.9 (95% CI: 36.6–37.3) for those who skipped, occasionally ate, and regularly ate breakfast, respectively ( $p$  for trend  $<0.001$ ). Those who always, sometimes, and seldom snacked after dinner ( $p$  for trend  $<0.001$ ) reported the following grip strength: 34.7 (95% CI: 34.0–35.3), 36.2 (95% CI: 35.8–36.6), and 36.9 (95% CI: 36.6–37.2), respectively. Significant associations were not found between eating rate and grip strength.

**Conclusion:** This study showed that higher frequency of breakfast consumption and lower frequency of snacking after dinner were associated with higher grip strength in Chinese adults. Therefore, eating behaviors may be involved in muscle function.

**Keywords:** breakfast consumption, eating rate, snacking after dinner, grip strength, adult population

## Introduction

Muscle strength loss has been found to be associated with functional impairment,<sup>1</sup> disability,<sup>2</sup> falls,<sup>3</sup> and loss of independence.<sup>4</sup> Thus, it is well known that muscle strength is a strong predictor of human health. Meanwhile, grip strength is an assessment technique recommended for the measurement of muscle strength and is the simplest method for assessing muscle function in clinical practice.<sup>5</sup> Low grip strength was also indicated to be associated with the presence of chronic diseases,<sup>6</sup> falls,<sup>7</sup> and disability.<sup>8</sup> In addition, a six-year follow-up study has demonstrated that, even in middle-aged individuals, the risk of mortality in those with lower grip strength is more than twice that of those with higher grip strength.<sup>9</sup> Therefore, preventing grip strength decline is important for well-being.

Correspondence: Liang Ding  
Department of Physical Education,  
Southeast University, 2 Sipailou, Nanjing  
210009, People's Republic of China  
Email dlseu1980@163.com

Meanwhile, eating behaviors are critical for human health and are associated with many health outcomes. In a Japanese study, people with more than two unhealthy eating behaviors showed a higher incidence of depressive symptoms compared with those with fewer than two unhealthy eating behaviors.<sup>10</sup> In a different study, self-reported eating rate was positively associated with the presence of metabolic syndrome in Japanese men and women.<sup>11</sup> Other studies have also shown that night eating can cause nutritional imbalance,<sup>12</sup> and compared with irregular breakfast consumption, regular breakfast consumption contributes to higher nutrient intake, such as dietary fiber, iron, calcium, and folate.<sup>13</sup> As such, night eating and irregular breakfast consumption may contribute to grip strength decrease owing to nutrient imbalance; indeed, nutrition deficiency is a well-known predictor of low muscle function and muscle strength loss.<sup>14,15</sup> A high frequency of breakfast consumption is also associated with high physical activity (PA),<sup>16,17</sup> which can improve grip strength and prevent strength loss. Based on these findings, it is possible that eating behaviors may affect grip strength. However, few studies have directly examined the relation between eating behaviors and grip strength. A population-based study has indicated that an increase in the components of unhealthy eating habits is associated with poor aerobic fitness and lower limb muscle power in primary school children.<sup>18</sup> In addition, breakfast consumption frequency has been associated with grip strength and physical fitness in Japanese adults<sup>19</sup> and Chinese university students.<sup>20</sup> However, the association between snacking after dinner, eating rate, frequency of breakfast (three representative eating behaviors), and grip strength in Chinese adults is unclear. Therefore, we designed a cross-sectional study to investigate whether eating behaviors are associated with hand grip strength in Chinese adults.

## Methods

### Participants

This study used 2017 data from an annual health examination for adults conducted with self-report questionnaires in Pingfang District, Haerbin, China. In this study, 2323 participants provided their written informed consent for the analysis of their data. This study was conducted according to the guidelines of the Declaration of Helsinki. The protocol for the study was approved by the Human Investigation Ethics Committee of Dalian Institute of Science and Technology on September 14, 2016 (approval number: DLHR0106).

The sample selection process is described in Figure 1. Responses were excluded if the data for grip strength ( $n = 98$ ), eating behaviors ( $n = 30$ ), depressive symptoms ( $n = 156$ ), and PA ( $n = 3$ ) were missing. Participants aged  $>65$  years were also excluded ( $n = 27$ ). The final study population consisted of 2009 participants (men = 1171, women = 838).

### Eating Behaviors

Eating behaviors were measured using a self-administered questionnaire that included items on breakfast consumption, snacking after dinner, and eating rate. Frequency of breakfast consumption was determined by the question, “In the past month, how many times did you eat breakfast per week?”<sup>21</sup> Snacking after dinner was determined by the question, “In the past month, how many days did you snack after dinner per week?”<sup>10</sup> Participants were asked to report the frequency of their breakfast consumption and snacking after dinner by responding with “never,” “once per week,” to “7 times per week.” Regarding breakfast consumption, the participants were categorized as regular consumers (6–7 times per week), occasional consumers (2–5 times per week), and skippers (less than two times per week). Regarding snacking after dinner, participants were categorized as “always” (6–7 times per week), “sometimes” (2–5 times per week), and “seldom” (less than two times per week). Eating rate was examined using the following question: Compared to others, how

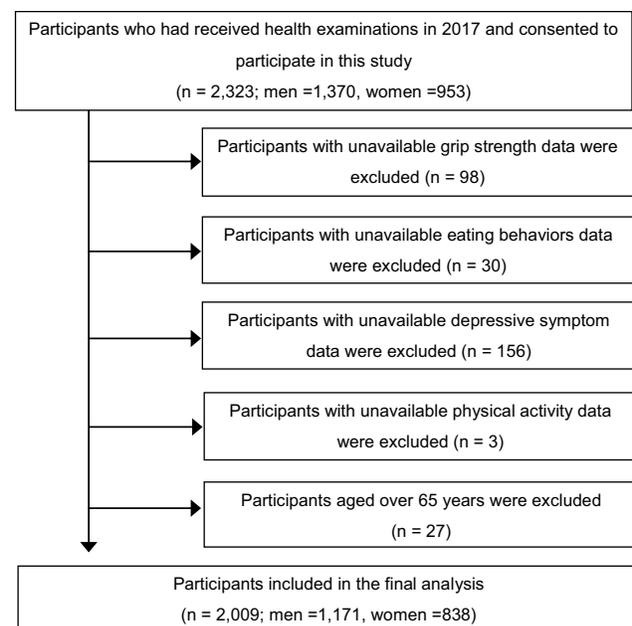


Figure 1 Flow chart of the sample selection process.

quickly do you eat?<sup>22</sup> The participants responded by choosing from the following five categories: very slowly, relatively slowly, at a moderate speed, relatively quickly, and very quickly. Because the number of participants was too small in the very slowly and very quickly categories, we combined the very slow and relatively slow categories to form one slow category, and the relatively quickly and very quickly categories to form one fast category.

## Hand Grip Strength

Hand grip strength was measured using a digital grip dynamometer (WCS-100 Qishu Co., Shanghai, China), with participants in the standing position. The dynamometer was adjusted to fit participants' individual hand sizes. The participants were encouraged to exert maximal grip effort. Grip strength was measured four times: twice for each hand on an alternating basis, with brief intervals between trials. The average value of the highest power recorded for both hands was included in the analysis.<sup>23,24</sup>

## Confounding Variables

Blood pressure (BP) was measured twice using an automatic device, which was applied to the upper-left arm (KENTAROU HBP-9021; OMRON Co., Ltd., Japan) subsequent to rest periods of five minutes in the sitting position. The mean of two measurements was used as the BP value. Hypertension was determined based on a systolic BP of  $\geq 130$  mmHg, diastolic BP of  $\geq 80$  mmHg, or use of antihypertensive medication.<sup>25</sup> Fasting glucose was measured from the blood sample, and diabetes was determined based on a fasting blood glucose concentration of  $\geq 7.0$  mmol/L (126 mg/dL) or the use of antidiabetic medication.<sup>26</sup> Depressive symptoms were assessed using the Chinese version of the Self-Rating Depression Scale (SDS).<sup>27</sup> An SDS score of  $\geq 45$  was adopted as the cutoff point indicating relatively mild or severe depressive symptoms.<sup>28</sup> Body mass index (BMI) was calculated as  $\text{weight/height}^2$  ( $\text{kg/m}^2$ ). Educational level was assessed by determining the highest school grade completed, and classified into two categories: < college and  $\geq$  college. Occupation was classified into two categories: desk work and other. Information regarding age, sex, smoking status, drinking status, occupation, and living status was obtained via a questionnaire survey. Levels of daily PA were estimated using the International Physical Activity Questionnaire (IPAQ).<sup>29</sup> Total daily PA (metabolic equivalents [METs] in h/week) was calculated as follows: 1) walking MET-minutes/week =  $3.3 \times$  walking minutes  $\times$  walking days at work; 2) moderate MET-minutes/week =  $4.0 \times$  moderate-

intensity minutes  $\times$  moderate days at work; 3) vigorous MET-minutes/week =  $8.0 \times$  vigorous intensity minutes  $\times$  vigorous days at work. Subsequently, the total MET hour/week was calculated as the sum of walking MET minutes/week, moderate MET minutes/week, and vigorous MET minutes/week divided by 60. PA was categorized into high and low categories.

## Statistical Analyses

Descriptive data are presented as means (with 95% confidence intervals [95% CIs]) and percentages. Grip strength was used as a dependent variable, whereas categories of eating behaviors (all in tertiles) were used as independent variables. Differences between eating behavior categories were examined using analysis of variance for continuous variables and logistic regression analysis for proportional variables. An analysis of covariance was performed to examine the correlation between eating behaviors and grip strength in the crude and adjusted models. Model 1 was adjusted for age, sex, and BMI, whereas Model 2 was adjusted for the items in Model 1, as well as hypertension, diabetes, and depressive symptoms. Model 3 was adjusted for the items in Models 1 and 2, as well as PA, education level, occupation, living status, smoking, and drinking habits. These confounding factors were considered because they have direct or indirect effects on eating behaviors or grip strength and have been used in a previous study.<sup>30</sup> Bonferroni-corrected p-values were used to compare differences between groups. All statistical analyses were performed using SPSS Statistics version 24.0 for Windows (SPSS, Inc., Chicago, IL, USA). Means and 95% CIs were reported throughout. All p-values for linear trends were calculated using the categories described above; a p-value of  $< 0.05$  was considered statistically significant.

## Results

The study participants' characteristics according to eating behaviors are presented in [Table 1](#). Results in this table were obtained using bivariate analysis, by not controlling for confounding factors. Participants with a faster eating rate were more likely to have higher BMI and lower educational level. Participants with a higher frequency of breakfast consumption were older and more likely to be women, smoker, and have high physical activity, higher prevalence of hypertension, and lower prevalence of depressive symptoms. Participants with a high frequency of snacking after dinner were younger and more likely to have higher BMI, lower

**Table 1** Participant Characteristics According to Eating Behaviors<sup>a</sup>

	Eating Rate		Breakfast Consumption		Snacking After Dinner	
	Slow	Fast	Skipper	Consumer	Seldom	Always
N	687	298	370	1031	1047	284
Sex (men; %)	59.7	63.1	68.9	57.1**	59.5	56.3
Age (years)						
<40	40.8	46	48.4	35.8***	37.0	57.7***
40–49	27.2	25.5	28.1	26.1	30.6	20.8***
>50	32.0	28.5	23.5	38.1***	32.4	21.5
BMI (kg/m <sup>2</sup> ) <sup>b</sup>						
≤18.5	8.2	10.1	7.8	7.9	7.4	9.9
18.6–24.0	57.1	50.3	60.8	59.3	59.4	47.5*
24.1–28.0	26.5	25.2	24.6	23.5	24	25.7
>28	8.3	14.4*	6.8	9.4	9.2	16.9*
PA high (%)	48.3	48.7	43.5	52.4**	49	47.9
Education level ≥12 years (%)	27.8	22.1**	22.7	22.0	25.8	22.2*
Occupation (desk work; %)	42.2	41.9	47	42.8	44	37.7*
Living alone (%)	22.6	26.2	26.5	20.2*	23.2	26.4
Smoking status (%)						
Smoker	47.2	41.6	34.6	51.5***	48.1	47.2
Drinking status (%)						
Drinking everyday	21.5	24.5	26.8	23.2	21.8	19
Drink occasionally	53.3	47.0*	50	48.4	50.2	56
No drinking	25.2	28.5	23.2	28.4	28	25
Hypertension (%)	52.8	52.3	49.2	56.4**	54.8	44.0**
Diabetes (%)	5.4	4.7	5.1	5.9	5.9	2.5*
Depressive symptom (%)	30.7	33.9	36.8	28.2***	31.6	30.3

**Notes:** <sup>a</sup>Obtained using  $\chi^2$  test for proportional variables. <sup>b</sup>BMI: body mass index; PA: physical activity. \*: p for trend < 0.05, \*\*: < 0.01, \*\*\*: < 0.001.

educational level, lower percentage of desk work, lower prevalence of hypertension and diabetes.

Table 2 shows correlations between the three eating behaviors. There is a positive association between the frequency of snacking after dinner and the eating rate. No significant association was found between other variables.

**Table 2** Correlations Between Three Eating Behaviors<sup>a</sup>

	Breakfast Frequency	Snacking After Dinner	Eating Rate
Breakfast frequency	I		
Snacking after dinner	0.020 <sup>b</sup>	I	
Eating rate	-0.029	0.476***	I

**Notes:** <sup>a</sup>Obtained using correlation analysis. <sup>b</sup>Variables are expressed as Spearman correlation coefficient. \*\*\*p < 0.001.

Table 3 shows the adjusted association between eating behaviors and grip strength. In the unadjusted model, grip strength (kg) was measured as 37.1 (36.4–37.7), 35.8 (35.1–36.6), and 34.9 (33.7–36.1) for the seldom, sometimes, and always snacking after dinner categories, respectively (p for trend = 0.001). However, no significant association was observed between breakfast consumption, eating rate, and grip strength. In the model 1, a significantly positive association was found between breakfast consumption and grip strength. Grip strength was higher across the categories of breakfast consumption: 35.2 (34.7, 35.8), 36.0 (35.5, 36.4), and 3.70 (36.6, 37.3) for the skipper, occasional consumer, and regular consumer categories, respectively (p for trend <0.001). Grip strength was higher in the regular consumer category relative to the occasional consumer and skipper categories (Bonferroni-corrected p < 0.05). This significant association did not change in Models 2 and 3. The inverse association between snacking after dinner and grip strength

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**Table 3** Adjusted Relationship Between Eating Behaviors and Grip Strength (kg)<sup>a</sup>

		Unadjusted	Model 1 <sup>b</sup>	Model 2 <sup>c</sup>	Model 3 <sup>d</sup>
Breakfast consumption					
Skipper	(n = 370)	37.2 (36.1, 38.2)	35.2 (34.7, 35.8)	35.3 (34.7, 35.8)	35.2 (34.7, 35.8)
Occasional consumer	(n = 608)	35.3 (34.5, 36.1) <sup>f</sup>	36.0 (35.5, 36.4)	36.0 (35.5, 36.4)	36.0 (35.6, 36.4)
Consumer	(n = 1031)	36.7 (36.0, 37.3) <sup>g</sup>	37.0 (36.6, 37.3) <sup>f,g</sup>	37.0 (36.6, 37.3) <sup>f,g</sup>	36.9 (36.6, 37.3) <sup>f,g</sup>
p for trend <sup>e</sup>		0.414	<0.001	<0.001	<0.001
Snacking after dinner					
Seldom	(n = 1047)	37.1 (36.4, 37.7)	36.9 (36.5, 37.2)	36.9 (36.5, 37.2)	36.9 (36.6, 37.2)
Sometimes	(n = 678)	35.8 (35.1, 36.6) <sup>f</sup>	36.2 (35.8, 36.7)	36.2 (35.8, 36.7)	36.2 (35.8, 36.6) <sup>f</sup>
Always	(n = 284)	34.9 (33.7, 36.1) <sup>f</sup>	34.7 (34.0, 35.3) <sup>f,g</sup>	34.6 (34.0, 35.3) <sup>f,g</sup>	34.7 (34.0, 35.3) <sup>f,g</sup>
p for trend <sup>e</sup>		0.001	<0.001	<0.001	<0.001
Eating rate					
Slow	(n = 687)	36.7 (35.9, 37.4)	36.4 (36.0, 36.8)	36.4 (36.0, 36.8)	36.4 (36.0, 36.8)
Medium	(n = 1024)	36.0 (35.3, 36.6)	36.4 (36.1, 36.8)	36.4 (36.1, 36.8)	36.4 (36.1, 36.8)
Fast	(n = 298)	36.9 (35.8, 38.1)	35.9 (35.3, 36.6)	35.9 (35.3, 36.5)	35.9 (35.3, 36.6)
p for trend <sup>e</sup>		0.675	0.227	0.217	0.226

**Notes:** <sup>a</sup>Variables are expressed as estimated geometric means (95% CI). <sup>b</sup>Adjusted for age, sex, and body mass index. <sup>c</sup>Further adjusted for hypertension, diabetes, and depressive symptoms. <sup>d</sup>Further adjusted for physical activity, educational level, occupation, living status, smoking and drinking habits. <sup>e</sup>Obtained using ANCOVA. <sup>f</sup>Significantly different to the first category,  $p < 0.05$  (Bonferroni-corrected). <sup>g</sup>Significantly different to the second category,  $p < 0.05$  (Bonferroni-corrected).

was consistent in the final adjusted model (Model 3) ( $p$  for trend  $< 0.001$ ). Grip strength was lower in the always category relative to the sometimes and seldom categories (Bonferroni-corrected  $p < 0.05$ ). In addition, a significant difference was found between the sometimes and seldom categories (Bonferroni-corrected  $p < 0.05$ ). Finally, eating rate was not significantly associated with grip strength in Models 1, 2, and 3.

Previous studies indicated that healthy eating behaviors are associated with higher physical activity. Therefore, we also verified whether this association exists in this study, as shown in Table 4. However, in this study, there was no significant association between eating behaviors and physical activity in the unadjusted and adjusted models.

## Discussion

This study showed that a high frequency of breakfast consumption and low frequency of snacking after dinner were significantly associated with higher grip strength in Chinese adults aged 25–68 years. We considered various confounding factors, including age, sex, BMI, health status, and lifestyle. However, after adjusting for these confounding factors, the significant association between eating behaviors and grip strength remained, indicating that such a correlation was independent of these factors.

A Japanese study has shown a significant association between higher breakfast consumption and higher grip strength among 1415 Japanese adults aged 19–83 years.<sup>19</sup>

A Chinese study among 10,125 college students has also indicated that frequent breakfast consumption is significantly associated with higher grip strength and faster sprint times.<sup>20</sup> Despite the difference in samples, the findings of these previous studies are consistent with the present findings. By contrast, our results are inconsistent with a European study that reported that breakfast consumption is not significantly associated with muscular fitness and speed/agility, but is only associated with cardiorespiratory fitness, in 2148 European adolescents aged 12.5–17.5 years.<sup>31</sup> The different methods used to assess breakfast consumption and muscle strength or different ages may explain the contrast in the findings. Notably, many studies have focused on children and adolescents, whereas those on adults' eating behaviors and muscle function are scarce. We could not find any previous study that investigated the association between night eating, eating rate, and grip strength.

To the best of our knowledge, this study is the first to demonstrate an association between self-reported eating behaviors and hand grip strength in Chinese adults. There are several possible explanations for the observation of a relation between eating behaviors and grip strength. First, our primary hypothesis was that eating behaviors would exert a beneficial influence on grip strength, as regular breakfast consumption would lead to higher nutrient intake<sup>13</sup> and higher energy intake.<sup>17</sup> Nutrient and energy intake is positively associated with muscle strength.<sup>32–34</sup> As such, regular breakfast consumption could be associated with higher grip strength.

**Table 4** Adjusted Relationship Between Eating Behaviors and Physical Activity (METs Hour/Week)<sup>a</sup>

		Unadjusted	Adjusted Model <sup>b</sup>
Breakfast consumption			
Skipper	(n = 370)	34.9 (27.5, 42.2)	32.4 (25.1, 39.8)
Occasional consumer	(n = 608)	34.6 (28.9, 40.3)	36.4 (30.7, 42.0)
Consumer	(n = 1031)	37.6 (33.2, 42.0)	37.5 (33.1, 41.8)
p for trend <sup>c</sup>		0.527	0.249
Snacking after dinner			
Seldom	(n = 1047)	38.5 (34.1, 42.9)	38.7 (34.4, 43.0)
Sometimes	(n = 678)	34.6 (29.2, 40.0)	33.4 (28.0, 38.8)
Always	(n = 284)	31.5 (23.1, 39.9)	33.5 (25.1, 41.9)
p for trend <sup>c</sup>		0.144	0.278
Eating rate			
Slow	(n = 687)	35.1 (29.7, 40.5)	36.5 (31.2, 41.8)
Medium	(n = 1024)	36.6 (32.1, 41.0)	35.9 (31.6, 40.3)
Fast	(n = 298)	37.4 (29.2, 45.6)	36.6 (28.5, 44.7)
p for trend <sup>c</sup>		0.642	0.985

**Notes:** <sup>a</sup>Variables are expressed as estimated geometric means (95% CI). <sup>b</sup>Adjusted for age, sex, body mass index, hypertension, diabetes, depressive symptoms, educational level, occupation, living status, smoking and drinking habits. <sup>c</sup>Obtained using ANCOVA.

Furthermore, irregular breakfast consumption was indicated to be associated with higher inflammation levels.<sup>35</sup> Higher levels of inflammatory cytokine are associated with weaker grip strength.<sup>36</sup> Thus, this may also be an explanation. In addition, night eating is not only reported to cause nutritional imbalance but is also associated with poor sleep quality<sup>37</sup> and sleep disturbances,<sup>38</sup> which are related with poor muscle strength.<sup>39,40</sup> This link can also explain why snacking after dinner is associated with grip strength. Another study found that people who have a habit of night eating have lower level of circulating ghrelin,<sup>41</sup> a hunger hormone which stimulates appetite. Ghrelin enhanced muscle anabolism and exerted protective effects for muscle atrophy.<sup>42</sup> Thus, eating at night may lead to muscle mass loss and consequently decrease grip strength due to the strong positive relationship between muscle mass and muscle strength.<sup>43</sup>

We also hypothesized that eating behaviors may have a beneficial effect on the prevention of grip strength loss via high PA, because a previous study indicated that a higher frequency of breakfast consumption is associated with a higher PA, and high PA may directly improve muscle strength. Therefore, we examined whether eating behaviors are associated with PA (Table 4) and whether PA affects the association between eating behaviors and grip strength (Table 3) in this study. The results of our study showed a positive linear association between breakfast frequency and PA, and an inverse association between frequency of snacking after dinner and PA. However, these associations were not

statistically significant. These results may be inconsistent with those of a previous study.<sup>44</sup> In addition, the association between eating behaviors and grip strength did not change after adjusting for PA (as a confounding factor). This proved that PA cannot be attributable to the relationship between eating behaviors and grip strength in this study. Meanwhile, previous studies have indicated that the eating rate is associated with many health behaviors and health outcomes.<sup>45,46</sup> However, in this study, we did not find any significant association between eating rate and grip strength.

This study was subject to certain limitations. First, eating behaviors were self-reported—a method that is vulnerable to recall bias. Therefore, the eating rate needs to be measured experimentally in future studies. Second, the cross-sectional design prevented causal inference regarding whether healthy eating behaviors contributed to higher grip strength or participants with a higher grip strength simply tended to eat healthier relative to those with lower grip strength. Therefore, prospective or intervention studies are required to determine the causal relation between eating behaviors and grip strength. Third, the use of the term eating behavior only included breakfast consumption, snacking after dinner, and eating rate. Other aspects of eating behavior were not included. Fourth, participants in our study were only from an area of a city in China; thus, the results of this study may not represent all Chinese adult population. Finally, although we adjusted several confounding factors, we could not exclude the possibility that other covariates might have

mediated the association between eating behaviors and grip strength, such as sleep pattern, food, and nutrition intake.

## Conclusions

The results of this study indicated that grip strength was lower in Chinese adults who skipped breakfast or ate breakfast occasionally relative to those who regularly had breakfast and was also lower in those who always snacked after dinner relative to those who sometimes and seldom snacked after dinner. This finding suggests that eating behaviors may be correlated with muscular function in adults and provides important information in the field of preventive medicine and health education. Eating behaviors are indispensable in people's daily life. Maintaining positive eating behaviors is important for human health. In future, a prospective study or randomized trial may confirm these findings and clarify causality.

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## Disclosure

The authors report no conflicts of interest in this work.

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