

# The Association Between Handgrip Strength and Type 2 Diabetes Mellitus in Community Dwelling Older Adults in Nanjing, China

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## Abstract

**OBJECTIVE:** The objective of this study was to examine the relationship between handgrip strength (HGS) and the prevalence of type 2 diabetes mellitus (T2DM) among older adults residing in community settings in Nanjing, China.

**METHODS:** In this cross-sectional study, 279 participants aged 60 years and older were assessed using a questionnaire, and T2DM diagnosis was confirmed through a review of medical records, defined as a documented physician diagnosis of type 2 diabetes and/or current use of antidiabetic medication. Participants were categorized into three groups based on HGS tertiles: low HGS group (<12.0 kg, n = 92), middle HGS group (12.0–26.5 kg, n = 94), and high HGS group (>26.5 kg, n = 93). Data analysis was conducted using analysis of variance, the  $\chi^2$  test, and multivariable logistic regression.

**RESULTS:** The mean age of participants was  $72.43 \pm 6.38$  years, and 38.0% were male (n = 106). The average body mass index (BMI) was  $23.40 \pm 3.14$  kg/m<sup>2</sup>, and the prevalence of T2DM, hypertension, and heart disease was 15.1%, 44.8%, and 19.8%, respectively. No significant differences were observed among the three groups in BMI, systolic blood pressure, diastolic blood pressure, or the prevalence of hypertension and heart disease, whereas the prevalence of T2DM was highest in the low HGS group (21.7%) and lowest in the high HGS group (8.6%). In the fully adjusted model, each 1 kg increase in HGS was associated with a 3.3% lower odds of T2DM (odds ratio 0.967, 95% confidence interval 0.944–0.989).

**CONCLUSIONS:** Higher HGS was associated with a lower prevalence of T2DM among community dwelling older adults in Nanjing. These findings indicate that HGS may serve as a potential target for intervention and as a simple indicator for identifying older individuals at increased risk of T2DM in community settings. In Chinese community health centers, incorporating HGS into routine check ups for older adults could help prioritize individuals for further glucose testing and counseling about strength building physical activity.

**Abbreviations:**

HGS	- handgrip strength
T2DM	- type 2 diabetes Mellitus
BMI	- body mass index
IDF	- The International Diabetes Federation
SBP	- Systolic Blood Pressure
DBP	- Diastolic Blood Pressure

## INTRODUCTION

Decreased muscle strength and reduced muscle mass are common physiological changes associated with aging in older adults and are linked to adverse outcomes, including functional decline and reduced quality of life (Ukegbu *et al.* 2014). In older adults, reduced muscle strength is a stronger predictor of morbidity and mortality than loss of muscle mass, and higher strength appears protective for cardiovascular and metabolic health, including diabetes risk (Newman *et al.* 2006; Lauretani *et al.* 2003; Evans 1997; Dominguez & Barbagallo 2007; Baumgartner *et al.* 2004)

Handgrip strength (HGS), a widely used measure of muscle strength, may therefore provide a practical marker for identifying individuals at risk of developing type 2 diabetes mellitus (T2DM) in clinical and public health settings (van der Kooi *et al.* 2015).

Diabetes has emerged as a critical public health concern globally (Chen *et al.* 2011; Roglic & Unwin 2010; Wild *et al.* 2004; Shaw *et al.* 2010). According to the International Diabetes Federation (IDF), the number of individuals with diabetes is projected to reach 380 million by 2025 (International Diabetes Federation, 2006). In China, the prevalence of T2DM among adults aged 20 years and older has already reached approximately 10% (Yang *et al.* 2010). With China accounting for nearly 20% of the global population, the number of older adults aged 60 years and above surpassed 200 million in 2013 and this number is expected to exceed 300 million by 2025 (Wang *et al.* 2016). Furthermore, older adults with diabetes are anticipated to constitute over 10% of the total Chinese population. These trends underscore the urgent need for healthcare professionals to identify high-risk diabetic populations. However, few studies have examined whether handgrip strength can help identify older Chinese adults at increased risk of T2DM in routine community health settings, and no data are available from Nanjing.

Prior studies have established an association between HGS and the prevalence of T2DM (Peterson *et al.* 2016a; Mainous *et al.* 2015; Peterson *et al.* 2016b). Reduced HGS has been identified as a risk factor for mortality from various chronic conditions, including hyperglycemia and T2DM (Timpka *et al.* 2014; Kalyani *et al.* 2015; Moore *et al.* 2014). As a non-invasive, cost-effective, and reliable measure of muscle strength, HGS has been proposed by international studies as a potential tool for the early screening of T2DM (Eckman *et al.* 2016; Kunutsor *et al.* 2020). Few studies have examined

the association between HGS and T2DM in community dwelling older adults in China, and no data are available from Nanjing. Therefore, we investigated whether higher HGS is independently associated with lower T2DM prevalence in community dwelling older adults in Nanjing after adjustment for age, sex, BMI, smoking, and drinking. We hypothesized that higher HGS would be associated with lower odds of T2DM and that HGS could serve as a simple, feasible screening marker in community health practice.

## METHODS

### Study design and participants

The present study was conducted using a cross-sectional design. Participants residing in the Gulin community of Nanjing, Jiangsu Province, China, were recruited by convenience sampling through a local community health service center. Nanjing, the capital of Jiangsu Province, serves as a significant political, economic, and cultural hub in eastern China, covering an area of 6,587 km<sup>2</sup>. The sample size was calculated based on the estimated population proportion, with a 95% confidence interval ( $\alpha = 0.05$ ) and a margin of error set at 5%. To account for potential losses and refusals, an additional 10% was added to the sample size. Ultimately, 279 residents aged 60 years or older were consecutively enrolled.

Exclusion criteria were: (1) patients with impaired communication abilities; (2) patients with acute diseases or recent trauma; and (3) patients with neurological disorders, such as Parkinson's disease, or other conditions that would hinder grip strength measurements. The study was approved by the Medical Ethics Committee of the Jiangsu Province Official Hospital and was conducted in accordance with applicable guidelines and regulations. Informed consent was obtained from all participants prior to their inclusion in the study.

### Data collection

Data were collected by trained researchers and included information on sex, weight, height, smoking status, drinking habits, SBP, DBP, disease history, and HGS. Height, weight, and blood pressure measurements were obtained following standard protocols. Height and weight were recorded to the nearest 0.1 cm and 0.1 kg, respectively, and BMI was calculated using these measurements. Smoking status was classified as current smoking or non-smoking, while drinking habits were categorized as current drinking or non-drinking.

Sitting blood pressure was measured using a standardized mercury sphygmomanometer. Handgrip strength was assessed using a handheld dynamometer according to the National Constitutional Measurement Standards Manual (Older Part). Participants stood with feet shoulder-width apart and arms relaxed at the sides, then were instructed to squeeze with maximal effort while avoiding arm swinging, squatting, or contact

**Tab. 1.** Descriptive Characteristics of the Participants Stratified by HGS (n=279)

	Low HGS group (HGS<12kg) (n = 92)	Middle HGS group (12kg ≤HGS ≤26.5kg) (n = 94)	High HGS group (HGS >26.5kg) (n = 93)	F/ $\chi^2$	p
Age(years)	73.95 ± 6.52	71.35 ± 6.99	72.03 ± 5.28	4.22	0.016
Male (n/%)	6/6.5	21/22.3	79/84.9	120.57	<0.001
BMI (kg/m <sup>2</sup> )	23.53±3.05	23.53±3.04	23.14±3.33	0.47	0.627
Smoking (n/%)	10/10.9	10/10.6	37/39.8	23.85	<0.001
Drinking (n/%)	4/4.3	4/4.3	22/23.7	18.05	<0.001
Hypertension (n/%)	41/44.6	49/52.1	35/37.6	0.91	0.341
Heart disease(n/%)	1/1.1	0/0	0/0	0.79	0.373
T2DM(n/%)	20/21.7	14/14.9	8/8.6	6.22	0.013
SBP (mmHg)	130.53 ± 19.0	130.70 ± 15.70	134.84 ± 19.63	1.67	0.190
DBP (mmHg)	71.68 ± 9.24	73.78 ± 9.25	74.86 ± 10.23	2.62	0.074

Descriptive characteristics of 279 community dwelling older adults in Nanjing, China, stratified by handgrip strength (HGS) tertiles: low HGS (<12.0 kg, n = 92), middle HGS (12.0–26.5 kg, n = 94), and high HGS (>26.5 kg, n = 93). Continuous variables are presented as mean ± standard deviation and categorical variables as number (percentage). *p* values are from analysis of variance (continuous variables) and  $\chi^2$  tests (categorical variables). BMI, body mass index; HGS, handgrip strength; SBP, systolic blood pressure; DBP, diastolic blood pressure; T2DM, type 2 diabetes mellitus.

between the device and the body. HGS was measured twice on the dominant hand to the nearest 1 kg, and the higher of the two values was used in the analysis.

#### Statistical analysis

Statistical analyses were conducted using SPSS version 23.0. Continuous variables were expressed as means ± standard deviations, while categorical variables were presented as numbers (percentages). To examine the relationship between HGS and T2DM, participants were categorized into three groups based on overall HGS tertiles: low HGS group (<12.0 kg, n = 92), middle HGS group (12.0–26.5 kg, n = 94), and high HGS group (>26.5 kg, n = 93). We first used ANOVA to compare normally distributed continuous variables and the  $\chi^2$  test to compare categorical variables across HGS groups. We then fitted multiple logistic regression models with T2DM as the dependent variable and HGS entered as a continuous predictor. Model 1 adjusted for age, sex, and BMI, and Model 2 additionally adjusted for smoking and drinking, which were selected a priori as potential confounders based on prior evidence and biological plausibility.

## RESULTS

### Participant characteristics

A total of 279 participants were included, with a mean age of 72.43 ± 6.38 years. Among the participants, 106 (38%) were male, and 173 (62%) were female. The average BMI was 23.40 ± 3.14 kg/m<sup>2</sup>. The prevalence rates of T2DM, hypertension, and heart disease were 15.1%, 44.8%, and 19.8%.

### Participant characteristics by HGS tertile

No statistically significant differences were observed in BMI, SBP, DBP, or the prevalence of hypertension and heart disease across the three HGS groups. However, the prevalence of T2DM was highest in the low-HGS group (21.7%) and lowest in the high-HGS group (8.6%), indicating that lower HGS was associated with a higher prevalence of T2DM (Table 1).

### The relationship between HGS and T2DM

Lower HGS was associated with older age and a higher prevalence of T2DM (Table 2). In Model 1 (adjusted for age, sex, and BMI), each 1 kg increase in HGS was

**Tab. 2.** The Association of Handgrip Strength and Type 2 Diabetes Mellitus

	variable	B	Wald $\chi^2$	OR (95% CI)	p
Model 1	HGS (kg)	-0.028	6.62	0.972 (0.953-0.993)	0.010
Model 2	HGS (kg)	-0.033	8.05	0.967 (0.944-0.989)	0.005

Association between handgrip strength (HGS) and type 2 diabetes mellitus (T2DM) in 279 community dwelling older adults in Nanjing, China, based on multivariable logistic regression. HGS (kg) is included as a continuous predictor, and odds ratios (ORs) are expressed per 1 kg increase in HGS with T2DM as the outcome. Model 1: adjusted for age, sex, BMI; Model 2: additionally adjusted for smoking and drinking. B, regression coefficient; Wald  $\chi^2$ , Wald chi square statistic; OR, odds ratio; CI, confidence interval; HGS, handgrip strength; BMI, body mass index; T2DM, type 2 diabetes mellitus.

associated with a 2.8% lower odds of T2DM (odds ratio 0.972, 95% confidence interval 0.953–0.993). In Model 2 (additionally adjusted for smoking and drinking), each 1 kg increase in HGS was associated with a 3.3% lower odds of T2DM (odds ratio 0.967, 95% confidence interval 0.944–0.989) HGS was modeled as a linear continuous predictor on the log odds scale, and we did not formally assess interactions, including potential sex specific effects.

## DISCUSSION

Muscle mass and strength gradually decline with advancing age, contributing to reduced ability to perform daily activities, reduced quality of life, and an increased risk of chronic metabolic diseases. The objective of this study was to examine the relationship between HGS and T2DM among older adults in a community setting.

The findings indicated that lower HGS was associated with advancing age, consistent with the natural aging process. Additionally, the proportions of males, smokers, and individuals who consumed alcohol were higher in groups with greater HGS, which may be attributed to the generally better HGS performance observed in males compared to females.

Our primary finding is that higher HGS is independently associated with lower odds of T2DM among community dwelling older adults in Nanjing. In our fully adjusted model, each 1 kg increase in HGS corresponded to a 3.3% reduction in the odds of T2DM, and the prevalence of T2DM declined from 21.7% in the low HGS group to 8.6% in the high HGS group. This effect size is broadly consistent with previous studies from other populations, including Mexican, Japanese American, and multi-ethnic cohorts, which have also reported an inverse association between muscle strength and T2DM. (Peterson *et al.* 2016a; Peterson *et al.* 2016b; Mainous *et al.* 2015; Wu *et al.* 2023; McGrath *et al.* 2017; Wander *et al.* 2011).

Anne-Lotte *et al.* further examined whether ethnic variations in HGS could contribute to ethnic disparities in T2DM prevalence, and their study similarly identified a consistent relationship between HGS and T2DM prevalence (van der Kooi *et al.* 2015).

HGS is a key indicator of overall muscle strength and is closely related to muscle cross sectional area. Declines in HGS typically reflect loss of muscle mass and quality, which may increase susceptibility to insulin resistance and T2DM through age related changes in body composition (reduced muscle mass and increased fat infiltration), impaired skeletal muscle glucose storage, and chronic low grade inflammation (McGrath *et al.* 2017; Park *et al.* 2006; Tonks *et al.* 2016; Srikanthan *et al.* 2010; Theuma & Fonseca 2004).

The findings from this and previous studies provide three practical recommendations for healthcare professionals: Healthcare providers should prioritize

assessment of HGS among older adults in community settings, as this non invasive and cost effective measure may help identify individuals at risk for T2DM (Chen *et al.* 2011). Recent studies have examined the relationship between muscle strength and diabetes in adults and have proposed low strength thresholds for risk detection, and future research should focus on defining these parameters for the Chinese population, where such thresholds have not yet been established (Chen *et al.* 2011). Monitoring glucose levels in older adults with low HGS is essential, as they may be at increased risk of T2DM. Prior research has also demonstrated that resistance exercises can enhance insulin sensitivity in skeletal muscle, improve glucose tolerance, and lower glycated hemoglobin levels, so older adults in community settings should be encouraged to engage in physical activities that preserve muscle mass and increase muscle strength (Tresierras & Balady 2009). Such interventions could improve glucose metabolism and reduce the risk of diabetes.

This study has several limitations that should be considered. First, the cross sectional design precludes causal inference, and we cannot determine whether low HGS leads to T2DM or whether T2DM contributes to reduced muscle strength. Complications such as neuropathy, vascular disease, or reduced physical activity associated with T2DM could also lower HGS, so longitudinal studies are needed to clarify the temporal relationship. Second, although we adjusted for age, sex, BMI, smoking, and drinking, we did not measure physical activity, dietary patterns, socioeconomic indicators, or medication use, so residual confounding may remain. Third, T2DM was identified from medical records, and undiagnosed cases may have been missed, potentially attenuating the observed association. Fourth, participants were recruited from a single community using convenient sampling, which may limit generalizability to other regions or to rural populations. Fifth, there was a marked imbalance in sex distribution across HGS tertiles, only 6.5% of participants in the low HGS group were men compared with 84.9% in the high HGS group, whereas most women were in the low and middle HGS groups, which may have influenced observed associations even after adjustment for sex. Finally, thresholds for using HGS as a predictive marker for diabetes in older Chinese adults have not yet been determined, and future studies should establish and validate such cut offs.

## CONCLUSION

In this cross sectional study of community dwelling older adults in Nanjing, higher HGS was associated with a lower prevalence of T2DM, suggesting that HGS may be a simple, noninvasive marker to identify older adults at increased diabetes risk in community settings. While longitudinal studies are needed to confirm causality and define optimal thresholds, incorporating HGS

measurement into routine assessments and promoting muscle strengthening activities may support strategies to prevent or delay T2DM in this population.

## DECLARATIONS

### Ethics approval and consent to participate

The study was approved by the Medical Ethics Committee of the Jiangsu Province Official Hospital (the Affiliated Geriatric Hospital of Nanjing Medical University) [No. (2021) Yuan Lun Shen Zi No. 002]. This study was conducted in accordance with the declaration of Helsinki. Informed consent was obtained from all participants prior to their inclusion in the study.

### Competing interests

The authors declare that they have no conflict of interest regarding this work.

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### Data Availability

The datasets used or analyzed during the current study are available from the corresponding author on reasonable request.

### Authors' Contributions

Conception and design of the research: Jie Wang, Yongzhen Mo

Acquisition of data: Yan Guo, Jie Wang

Analysis and interpretation of the data: Jie Wang, Yan Guo

Statistical analysis: Jie Wang

Obtaining financing: Jie Wang, Yongzhen Mo

Writing of the manuscript: Jie Wang

Critical revision of the manuscript for intellectual content: Jie Wang, Yongzhen Mo

All authors read and approved the final draft.

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