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REGULAR ARTICLE

A cross-sectional assessment of oxidative DNA damage and muscle strength among elderly people living in the community

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Abstract

Objectives The mechanism by which muscle weakness leads to an increased risk of death remains a subject of interest. In this context, the aim of this study is to assess the relationship between urinary 8-hydroxy-2′-deoxyguanosine (8-OHdG) and muscle strength, and other risk factors contributing to poor muscle strength in older persons.

Methods This was a cross-sectional study in which a total of 86 participants, both men and women, aged 65 years or above were screened for urinary 8-OHdG, and muscle strength as measured by handgrip strength.

Results Handgrip strength was lower in participants who had history of acute or chronic disease. Urinary 8-OHdG level was negatively associated with muscle strength, and the association remained after adjusting for confounding factors.

Conclusions Urinary 8-OHdG is associated with muscle strength. These findings may be clinically relevant as there is a possibility of controlling oxidative DNA damage by healthy behaviors related to lifestyle.

Keywords Oxidative stress · Handgrip strength · Cross-sectional study · Older persons · Lifestyle

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Introduction

Japan's demographic is currently an issue of public health concern. The aging population of individuals aged 65 years and above is on the increase (23.3 % of the population in 2011) [1], while there is a shortage of working population who could potentially support dependent older persons in their daily activities. In both developed and developing countries, increasing longevity and its logical outcomes (frailty, physical disability or chronic diseases) have led to a social and economic burden for dependent older persons, relatives, healthcare professionals, and/or governments [2]. This observation has motivated research in gerontology and geriatrics.

A great number of acute and chronic age-related diseases have an underlying mechanism of oxidative stress [3]. It is widely accepted that oxidative stress may play a pivotal role in aging, disease onset and progression, and mortality among older persons [2, 4]. Oxidative stress is defined as an imbalance between pro-oxidants released and antioxidant defenses in favor of pro-oxidants, which can damage cell structures including proteins, lipids, carbohydrates, and deoxyribonucleic acid (DNA), leading to health problems [5, 6]. Measurement of reactive oxygen species (ROS) is difficult because their half-lives are usually very short; therefore, evaluation of oxidative stress in biological fluids is realized by quantification of oxidative stress biomarkers.

Several biomarkers of oxidative stress are known, including 8-hydroxy-2′-deoxyguanosine (8-OHdG). The biomarker 8-OHdG is the oxidized form of nucleoside in DNA; it is the most representative and detected product of oxidative DNA damage excreted in urine upon DNA reparation [5]. In humans, urinary 8-OHdG has been associated with various health conditions including cancer, heart failure, and diabetes [7]. Higher levels of 8-OHdG have also been found in biopsied skeletal muscle of older persons and probably contribute to age-dependent poor muscle strength. ROS have been known to play an important role in the aging process of human skeletal muscle [8].

Poor skeletal muscle strength is both a common condition and serious health problem among older persons, even those who are healthy. For humans, skeletal muscle weakness appears to be unavoidable with aging, starting from the fourth or fifth decade of life, leading to a decline in physical function, frailty [9, 10] or dependency [11]. Moreover, in old age, muscle weakness has been linked with several poor outcomes including increased risk of falling [12], disabilities and death [10, 13, 14]. In this regard, controlling oxidative stress through healthy behaviors related to lifestyle (such as physical activities, smoking cessation) and nutritional factors (diet-derived antioxidants) is thought to be vital in promoting geriatric health.

The mechanism by which poor skeletal muscle strength leads to poor outcomes remains a subject of interest in the biology of aging. Studies regarding urinary 8-OHdG and muscle strength among older persons are scarce. The purpose of this study is to examine whether urinary 8-OHdG is associated with muscle strength in a group of older persons living in the community.

Subjects and methods

Study design and recruitment

The present study was approved by the Research Ethics Committee of Kochi Medical School, and was carried out in accordance with the Declaration of Helsinki. Informed consent was obtained from all participants in written form. This was a cross-sectional study designed to assess the health status of older persons living in one of the cities in Kochi Prefecture, Japan, for a healthy aging goal. Participation was on a voluntary basis; postal invitations containing an explanation of the purpose of the study and the health check-up schedule were mailed by the local welfare committee to 1103 potential participants, who were targeted based on the following inclusion criteria: being aged 65 years or above, and being able to answer a survey questionnaire. Of the 1103 postal invitations sent to potential participants, a total of 100 older persons attended local community centers for medical examination.

Health assessment and measurements

The participants were assessed for lifestyle, past medical history, functional status, and anthropometric measurements. Information gathered on their lifestyle included physical activities, smoking habits, alcohol consumption, social life, and dietary habits. The medical history-taking emphasized past chronic disease, acute disease within the last 3 months, and current medication.

Functional status was evaluated using activities of daily living (ADL) [15] and instrumental activities of daily living (IADL) [16]. Anthropometric parameters evaluated were height, weight, and body mass index (BMI). The participants' height was measured using a stadiometer, and body weight using a mechanical medical scale. BMI was calculated by dividing weight in kg by height in meters squared, and was categorized based on guidelines of the National Heart, Lung, and Blood Institute [17].

In addition, blood pressure was measured. Blood pressure (BP) was evaluated with a mercury sphygmomanometer after the participants had had a 10-min rest. Blood pressure was classified into the following four categories according to the seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure [18]: normal (systolic BP <120 mmHg and diastolic BP <80 mmHg), pre-hypertension (systolic BP = 120–139 mmHg or diastolic BP = 80–89 mmHg), hypertension stage I (systolic BP = 140–159 mmHg or diastolic BP = 90–99 mmHg), and hypertension stage II (systolic BP ≥160 mmHg or diastolic BP ≥100 mmHg).

Muscle strength evaluation

Handgrip strength was used for muscle strength testing. Handgrip strength measurements were assessed using a handled dynamometer (T.K.K. 5401 GRIP-D; Takei Scientific Instruments Co. Ltd., Tokyo, Japan) with each participant in standing position and being encouraged to exert maximum force during the test. The measurement was performed in both hands and was expressed in kilograms. Three trials were performed for each handgrip strength measurement in each hand, and then the mean of both hands was used for analysis. Prior to the handgrip test, participants' blood pressure was measured to exclude those with blood pressure of 180/110 mmHg and above.

The cut-off values for handgrip strength (<30 kg for men and <20 kg for women) recommended by the European Working Group on Sarcopenia in Older People (EWGSOP) to recognize a person with mobility limitation were used as a reference [19, 20].

Laboratory assays

Biological assays included levels of 8-OHdG and creatinine. Spot urine samples were collected using paper cups. The samples were centrifuged at 2000 rpm for 5 min, and stored at −80 °C until measurements.

Urinary 8-OHdG levels (new 8-OHdG Check; the Japan Institute for the Control of Aging, Fukuroi, Japan) were determined using enzyme-linked immunosorbent assay kits, and were adjusted with creatinine and expressed in ng/mg creatinine. Urinary creatinine was measured by a method based on the reaction of creatinine and alkaline picrate in conformity with the manufacturer's instructions (creatinine test kit; R&D Systems, Minneapolis, MN).

There were 86 participants who had both urinary 8-OHdG levels and muscle strength data measurements available for analysis.

Statistical analysis

The results of quantitative variables are summarized as mean ± standard deviation of the mean, or as frequency and percentage. The chi-squared test and Student's t test were used to assess differences in categorical and continuous variables, respectively. The correlation between urinary 8-OHdG and muscle strength was examined using Pearson's correlation test. Multiple regression analysis was performed to evaluate the relationship between muscle strength and urinary 8-OHdG, and other studied parameters. Data were analyzed using the Stata software package version 10 (StataCorp LP; TX 77845, USA), and $p < 0.05$ was regarded as significant.

Results

Participants' characteristics

As shown in Table 1, out of the 86 participants, 68 (79 %) were women. The average age of the participants was 76.5 years. Compared with women, men were significantly older (78.9 versus 75.8 years; $p = 0.027$) and had significantly higher weight (57.4 versus 48.8 kg; $p < 0.001$); however, men and women had similar BMI (23.2 versus 22.4 kg/m^2). The mean blood pressure was 136/71 mmHg; the minimum value of systolic blood pressure was 90 mmHg and the maximum was 178 mmHg, while the minimum value of diastolic blood pressure was 61 mmHg and the maximum 90 mmHg. Thirty-seven (43 %) participants had pre-hypertension, 26 (30.2 %) hypertension stage I, and 14 (16.2 %) hypertension stage II. The chronic diseases most reported were hypertension (37.6 %), diabetes mellitus (19.0 %), arthritis (13.0 %), and coronary heart disease (4.7 %). Comorbidity was found in 12 (13.9 %) participants, whereas 36 (41.8 %) did not report any history of chronic disease.

The evaluation of ADL items revealed that 19 (22.0 %) of the 86 participants had dependence in at least one ADL item while 25 (29.0 %) participants had limitation in at least one IADL item. Shopping and house-keeping were the tasks reported as most difficult by participants. Only a few participants declared a loss of interest in social life: 8 (9.3 %) were not visiting any friend or relative, while 12 (14.1 %) were not attending any social events.

Findings in urine and muscle strength testing

The mean values of urinary 8-OHdG level and muscle strength are presented in Table 2. The average urinary 8-OHdG level was 10.1 ± 4.8 ng/mg creatinine, and did not differ between men and women. Participants who "occasionally" consumed alcohol had significantly lower urinary 8-OHdG level (7.9 ± 2.7 ng/mg creatinine) than those who did not consume alcohol (10.4 ± 5.0 ng/mg creatinine, $p = 0.022$) or those who consumed alcohol daily (10.4 ± 4.7 ng/mg creatinine, $p = 0.016$).

The mean handgrip strength was 30.4 kg for men and 20.4 kg for women; seven (38.8 %) men had handgrip strength lower than 30 kg, and 27 (39.7 %) women had handgrip strength lower than 20 kg, meaning that in this study 34 (39.5 %) participants had poor handgrip strength. In both sexes, levels of 8-OHdG were significantly higher in participants with poor handgrip strength compared with those with normal handgrip strength (Table 3).

The mean handgrip strength did not differ between right and left hands, or between nonsmokers and ex-smokers. The mean handgrip strength was significantly higher ($p = 0.033$) in participants in the group ranging between 65 and 74 years (24.2 ± 7.3 kg) compared with those who were over 75 years of age (21.5 ± 5.8 kg). When muscle strength was analyzed in relation to the history of acute disease during the last 3 months, we found that muscle strength was significantly lower in participants who had history of acute disease compared with those without (18.8 ± 9.0 versus 23.0 ± 6.2 kg, $p = 0.035$). Conversely, when muscle strength was assessed in regard to chronic diseases, we found that muscle strength decreased with the presence of chronic diseases (21.6 ± 6.1 versus 23.6 ± 7.0 kg, $p = 0.083$). Moreover, comparing participants who engaged in regular physical exercise versus those who did not, the former had significantly higher handgrip strength (21.0 ± 5.5 versus 24.0 ± 7.0, $p = 0.017$).

Correlation of muscle strength with urinary 8-OHdG and other health parameters

The correlation between handgrip strength and urinary 8-OHdG, and other health factors, is presented in Table 4. A negative correlation was noted between handgrip strength and urinary 8-OHdG ($r = -0.318$; $p = 0.002$); handgrip strength was correlated negatively with history of acute disease in the last 3 months in women, a correlation

Table 1 Participants' characteristics by gender

Variable	Total *n* (%)	Men *n* (%)	Women *n* (%)	*p* Value
Total	86 (100.0)	18 (100.0)	68 (100.0)	
Age group (%)				
65–74 years	33 (38.3)	6 (33.3)	27 (39.7)	
75–84 years	42 (48.8)	7 (39.0)	35 (51.5)	
≥85 years	11 (12.7)	5 (27.7)	6 (8.8)	
Mean age (years)	76.5 ± 6.1	78.9 ± 6.7	75.8 ± 5.8	0.027*
Systolic blood pressure (mmHg)	135.8 ± 18.1	130.1 ± 21.1	137.2 ± 17.0	0.069
Diastolic blood pressure (mmHg)	71.0 ± 11.0	70.2 ± 9.1	71.2 ± 11.4	0.364
Height (m)	1.49 ± 7.4	1.56 ± 7.3	1.47 ± 6.1	<0.001*
Weight (kg)	50.6 ± 9.0	57.4 ± 11.0	48.8 ± 7.4	<0.001*
Body mass index (kg/m^2)				
<18.5	5 (5.8)	1 (5.6)	4 (5.9)	
18.5–24.9	58 (67.5)	10 (55.6)	48 (70.6)	
25.0–29.9	22 (25.6)	7 (38.8)	15 (22.0)	
≥30	1 (1.1)	–	1 (1.5)	
Mean body mass index (kg/m^2)	22.6 ± 3.1	23.2 ± 3.2	22.4 ± 3.1	0.168
Smoking				
Nonsmoker	76 (88.4)	10 (55.6)	66 (97.0)	
Ex-smoker	9 (10.5)	7 (38.8)	2 (3.0)	
Smoker	1 (1.1)	1 (5.6)	–	
Alcohol consumption				
Every day	12 (14.1)	9 (50.0)	3 (4.4)	
Occasionally	10 (11.8)	2 (11.1)	8 (12.0)	
No alcohol	63 (74.1)	7 (38.9)	56 (83.6)	
Physical exercise				
Regular	48 (55.8)	13 (72.2)	35 (51.4)	
No exercise	36 (41.8)	5 (27.8)	31 (45.6)	
No answer	2 (2.4)	–	2 (3.0)	
Number of chronic diseases				
None	36 (42.4)	11 (64.7)	25 (36.7)	
One	37 (43.5)	4 (23.5)	33 (48.5)	
Two	7 (8.2)	2 (11.8)	5 (7.4)	
Three	3 (3.5)	–	3 (4.4)	
Four	2 (2.4)	–	2 (3.0)	
Acute disease in the last 3 months				
Yes	10 (12.1)	1 (5.6)	9 (13.9)	
No	73 (87.9)	17 (94.4)	56 (86.1)	

* $p < 0.05$ (by unpaired *t* test)

Table 2 Urinary 8-OHdG levels and muscle strength by gender

Variable	All ($n = 86$)	Men ($n = 18$)	Women ($n = 68$)	*p* Value
8-OHdG (ng/mg cr.)	10.1 ± 4.8	10.0 ± 5.7	10.1 ± 4.6	0.415
Right-handgrip strength (kg)	23.0 ± 6.8	31.1 ± 8.4	21.0 ± 4.3	<0.001*
Left-handgrip strength (kg)	22.0 ± 6.7	29.8 ± 8.1	20.0 ± 4.3	<0.001*
Mean handgrip strength (kg)	22.6 ± 6.5	30.4 ± 8.0	20.4 ± 6.5	<0.001*

8-OHdG 8-hydroxy-2′-deoxyguanosine

* $p < 0.05$ (by Student's *t*-test)

Table 3 Levels of 8-OHdG according to handgrip strength and gender

	Handgrip strength (kg)		p Value
	Women ($n = 68$)		
	<20 ($n = 28$)	≥20 ($n = 39$)	
8-Hydroxy-2′-deoxyguanosine (ng/mg cr.)	11.5 ± 4.4	9.1 ± 4.6	0.017*
Men			
	<30 ($n = 7$)	≥30 ($n = 11$)	
8-Hydroxy-2′-deoxyguanosine (ng/mg cr.)	13.4 ± 6.0	7.6 ± 4.3	0.014*

The cut-off values for poor handgrip strength are <30 kg for males and <20 kg for females

* $p < 0.05$ (by Student's t-test)

Table 4 Correlation of handgrip strength and health parameters

Parameter	All ($n = 86$)		Men ($n = 18$)		Women ($n = 68$)	
	(r)	p Value	(r)	p Value	(r)	p Value
8-Hydroxy-2′-deoxyguanosine (ng/mg creatinine)	−0.318	0.002*	−0.635	0.004*	−0.254	0.037*
Alcohol consumption (yes or no)	−0.402	<0.001*	−0.117	0.642	−0.264	0.032*
Physical exercise (yes or no)	0.230	0.034*	0.253	0.310	0.125	0.312
Acute disease in the past 3 months (yes or no)	−0.202	0.070	0.202	0.435	−0.355	0.004*
Chronic diseases (yes or no)	−0.152	0.166	−0.015	0.953	−0.023	0.852
Age (years)	−0.160	0.141	−0.739	<0.001*	−0.191	0.121
Weight (kg)	0.619	<0.001*	0.791	<0.001*	0.335	0.005*
Body mass index (kg/m^2)	0.251	0.020*	0.621	0.005*	0.059	0.630
Systolic blood pressure (mmHg)	−0.141	0.200	−0.117	0.642	−0.008	0.945
Diastolic blood pressure (mmHg)	−0.116	0.286	0.043	0.862	0.262	0.031*

* $p < 0.05$ (by Pearson's correlation test)

not seen in men. Handgrip strength was negatively correlated with age in men, but not in women. In the combined group of all participants, handgrip strength was positively correlated with physical exercise, weight, and BMI.

Regression analysis for handgrip strength

The result of the univariate linear regression analysis in predicting low handgrip strength showed that having higher urinary 8-OHdG levels was significantly associated with low handgrip strength (Figs. 1, 2). Table 5 presents the results of multivariate linear regression analysis of the association between handgrip strength and urinary 8-OHdG levels in all participants. The first model used age, gender, weight, BMI, and urinary 8-OHdG levels as predictors. After adjusting for these factors, urinary 8-OHdG levels were significantly associated with handgrip strength; Urinary 8-OHdG levels, age, gender and weight accounted for 64 % of the variation of handgrip strength. This association remained significant in the second model after controlling for age, sex, weight, BMI, physical exercise, alcohol consumption, and diseases. This model showed that urinary 8-OHdG levels, age, gender, weight and acute disease explained about 65 % of the variance of handgrip strength.

Discussion

In the present study, we investigated the relationship between a biomarker of oxidative DNA damage and muscle strength, and other risk factors contributing to poor muscle strength such as disease and sedentary lifestyle, in a group of older persons living freely in the community.

Urinary 8-OHdG and handgrip strength

8-OHdG is an in vivo biomarker of oxidative DNA damage considered to be useful in predicting the risk of lifestyle-related disease [21]. In living cells, ROS are produced incessantly as by-products of biological reactions. ROS in moderate concentrations are essential signaling molecules that regulate physiological processes such as defense against infectious agents; however, ROS interact with lipids, proteins, and DNA, resulting in oxidative stress [22].

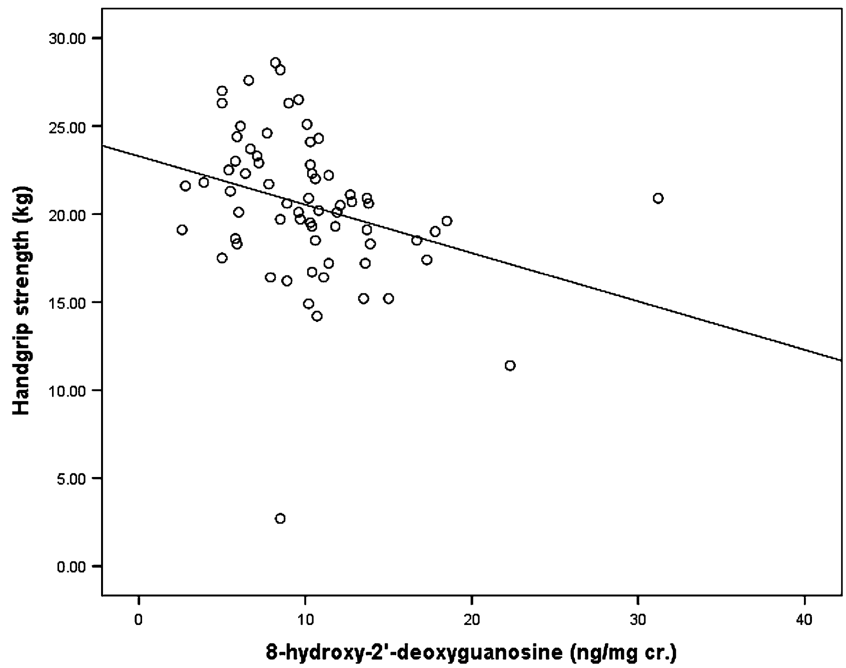

Fig. 1 Scatter diagram of handgrip strength and urinary 8-hydroxy-2′-deoxyguanosine levels in women ($n = 68$); this figure suggests that handgrip strength of women decreases as the urinary 8-hydroxy-2′-deoxyguanosine level increases

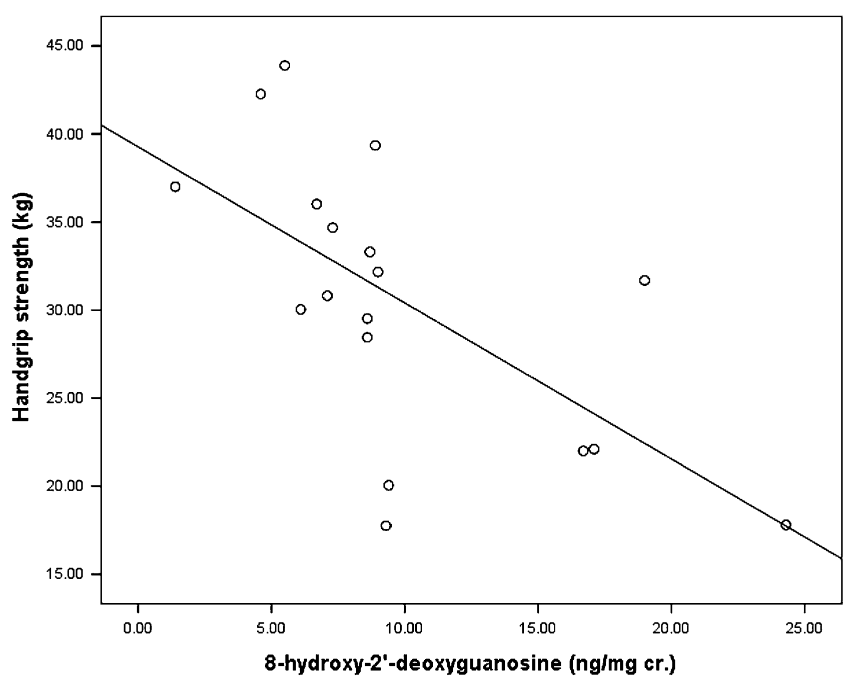

Fig. 2 Scatter diagram of handgrip strength and urinary 8-hydroxy-2′-deoxyguanosine levels in men ($n = 18$); this figure shows that handgrip strength of men decreases as the urinary 8-hydroxy-2′-deoxyguanosine level increases

Physiologically, there is a balance between ROS production and antioxidant defenses, enzymatic or nonenzymatic. In case of imbalance, ROS induce DNA lesions which play a crucial role in the initiation and promotion of cancer, aging, and other degenerative diseases [23]. In this study, urinary 8-OHdG was selected to assess levels of oxidative DNA damage because urinary 8-OHdG is considered to be the most representative and reliable biomarker of DNA injury induced by ROS [5]. The mean levels of urinary 8-OHdG in this study (10.1 ± 4.8 ng/mg creatinine) are similar to the value in normal human urine (8.4 ng/mg creatinine) reported by the Japan Institute for the Control of Aging (JaICA 2012) [24]. However, this value is significantly lower compared with the value reported by a previous study dealing with Japanese older persons living in temporary houses after natural disasters (12.1 ± 6.8 ng/mg creatinine, $n = 73$) [25].

Handgrip strength was used for the measurement of muscle strength. We decided to use handgrip strength because it is recommended by the EWGSOP [20] for

Table 5 Multiple regression analysis for handgrip strength

Predictor	Standardized coefficient (β)	p Value	Adjusted R^2
Model 1			0.64
8-Hydroxy-2′-deoxyguanosine (ng/mg creatinine)	−0.186	0.010*	
Age (years)	−0.181	0.015*	
Gender	−0.522	<0.001*	
Weight (kg)	0.35	<0.001*	
BMI (kg/m^2)	0.050	0.467	
Model 2			0.65
8-Hydroxy-2′-deoxyguanosine (ng/mg creatinine)	−0.171	0.034*	
Age (years)	−0.171	0.033*	
Gender	−0.355	<0.001*	
Weight (kg)	0.458	<0.001*	
BMI (kg/m^2)	0.069	0.347	
Chronic disease (yes or no)	−0.094	0.259	
Acute disease (yes or no)	−0.159	0.040*	
Physical exercise (yes or no)	0.136	0.086	
Alcohol consumption (yes or no)	−0.035	0.671	

* $p < 0.05$

muscle strength assessment, and also because, apart from the handgrip test being easy, reliable, and relatively low cost, screening for handgrip can help to identify older persons with high risk of health impairment [13]. The cut-off values for handgrip strength recommended by the EWGSOP to diagnose a person with low muscle strength are <30 kg for men and <20 kg for women [19, 20]. In the present study, the mean values of handgrip strength (30.4 kg for men and 20.4 kg for women) were above the mentioned thresholds. However, it should be mentioned that 39.5 % of the participants had low handgrip strength with high levels of urinary 8-OHdG, showing that urinary 8-OHdG may be a potential marker useful in predicting the risk of poor muscle strength in older persons. Therefore, early interventions to increase muscle strength are required for these participants with low handgrip strength to possibly improve their health.

The major findings of this study are that urinary 8-OHdG level was negatively associated with muscle strength, and that this association remained even after adjusting for confounding factors; these findings are supported by the mechanism whereby progressive mitochondrial oxidative DNA damage reduces muscle mitochondrial protein synthesis, which leads to poor muscle strength [10, 26, 27]. Increased inflammatory markers such as C-reactive protein and interleukin-6 have been shown to be associated with poor physical performance and muscle strength in older persons [28]. In addition, Schaap et al. [29] demonstrated that high levels of tumor necrosis factor-α were associated with a decline in grip strength. Taken together with the inverse association observed between urinary 8-OHdG levels and grip strength in this study, these results may raise awareness in routine clinical practice, and perhaps be an attractive target for clinical trials involving poor grip strength. However, it is important to note that neither urinary 8-OHdG nor the inflammatory markers (tumor necrosis factor-α, C-reactive protein, and interleukin-6) are muscle specific [30].

Our findings are in line with previous studies that demonstrated an inverse association between oxidative stress and muscle strength [31–33]. One study demonstrated that Chinese frail older persons had higher serum 8-OHdG levels than nonfrail older persons [31]. Another study found that high levels of serum reactive oxygen metabolites were inversely correlated with handgrip strength in Mongolians (20–70 years old) having higher levels of urinary 8-OHdG [32]. In addition, an association between oxidative stress and muscle strength among older women living in Baltimore, USA was previously described [33]. The latter study found that high serum protein carbonyl (a biomarker of protein oxidation) was independently associated with poor muscle strength, as measured by handgrip strength, among 672 older women living in the community. While our findings are consistent with these studies, there are primary differences that deserve a mention: the study conducted in Baltimore included both moderately and severely disabled older women, while only 14 % of the participants were nonfrail in the study conducted in China. The fact that these older persons were disabled or frail might have exposed them to high levels of oxidative stress, as higher levels of oxidative stress had been reported in older persons with physical disability [34]. In contrast to these two studies, our study included older persons without physical disability, 79 % of whom were women.

Disease and handgrip strength

Disability in older persons, either catastrophic or progressive, is a logical outcome of disease [35], with an underlying mechanism of oxidative stress [3]. A study by Cappola et al. [36] reported that diseases in association with poor nutrition and sedentary lifestyle reduce insulin-like growth factor (IGF-1) production, which leads to poor muscle strength. Muscle fatigability, in association with chronic diseases, leads to poor mobility, and therefore to frailty. In accordance with this fact, our findings revealed that about 57.6 % of the participants reported suffering from at least one chronic disease and 12.2 % had an acute disease in the last 3 months. Muscle strength was lower in participants with history of acute or chronic disease compared with those without. Our observation corroborates a previous 27-year follow-up study which demonstrated that chronic diseases were responsible for the rapid decline of muscle strength among men with Japanese ancestors [37]. However, the sexes in these studies are different, as ours included both men and women. In addition, this study does not allow us to affirm whether low grip strength was a consequence or a cause of disease process, because of its cross-sectional design. Disease leads to muscle fatigability directly or through sedentary lifestyle [38].

Physical exercise and handgrip strength

Studies about sedentary lifestyle or physical activities and muscle strength are controversial; as expected, in this study, the 48 (55.8 %) participants engaging in regular physical activity were found to have greater handgrip strength. Our findings are consistent with a 5-year follow-up study which showed that physical exercise in elderly people helps to maintain muscle strength [39], but inconsistent with a 10-year follow-up study which found no association between physical activity and muscle strength [40]. Another 22-year follow-up study did not find the expected benefits of regular physical activity, but only a decrease in muscle strength in participants who became physically inactive during follow-up [41].

Potential limitations

The participants in this study were likely to be health-oriented elderly people in relatively good health, even if some of them had chronic diseases. We do not know if the association observed between 8-OHdG and muscle strength will still hold in a population under the age of sixty. The participants in this study may not be completely representative of the older persons in the town; it should be mentioned that the response rate following the postal invitation was very low (9 %). According to the local welfare committee, the main reasons for the low response could be due to the participants' work schedules. Other reasons for nonparticipation may have been health related, such as lack of confidence in being healthy, walking disability, the fact that they are already going to hospital regularly, or an absence of disease among mobile older persons that could have led to a lack of interest in the medical check-up. Carrying out the medical check-up in the participant's home needs to be considered when planning future studies in this town.

In conclusion, the main finding of this study is that urinary 8-OHdG is independently associated with muscle strength. This finding may be clinically relevant as there is a possibility of controlling oxidative DNA damage by healthy behaviors related to lifestyle such as cigarette smoking cessation, regular physical exercise, and low-fat diet or calorie restriction.

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Conflict of interest There are no conflicts of interest regarding the content of this study.

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