

# Relationship between occlusal force and endothelial function in community-dwelling elderly

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## Research Article

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# Abstract

**Background:** Prolonged healthy life expectancy, which is duration without the requirement of any kind of help for activities of daily living (ADL), is essential to ensure a long life with a good quality of living in the community. Further, local residents should understand their health conditions and live consciously to prolong healthy life expectancy. The development of a simple general health indicator is necessary. Both occlusal force and flow-mediated dilation (FMD) which reflects endothelial function are useful tools for understanding the general condition of the elderly. However, few studies have investigated the relationship between occlusal force and endothelial function. In the present study we examined this relationship, occlusal force measurement can be a good indicator of the general condition of the elderly.

**Methods:** In 38 community-dwelling women (aged  $76.7 \pm 5.7$  years), we measured occlusal force, grip strength, endothelial function evaluated by FMD, advanced glycation end products (AGEs). In this study we investigated the relationship between occlusal force, measurement items, and factors independently related to endothelial function.

**Results:** There were significant correlation between occlusal force and grip strength ( $r = 0.54, p < 0.01$ ). Degree of FMD significantly associated with occlusal force ( $r = 0.60, p < 0.01$ ) and grip strength ( $r = 0.35, p < 0.05$ ) or amount of increased AGEs ( $r = -0.37, p < 0.05$ ). Multiple regression analysis revealed occlusal force as factors with significant association with degree of FMD ( $p < 0.01$ ).

**Conclusion:** There was a significant relationship between occlusal force and FMD. Occlusal force can be an important indicator of endothelial function in community-dwelling elderly. This study may help understanding general health of elderly in community.

## Background

For long life in a community, it is important to prolong the healthy life expectancy, the duration of living without the requirement of any kind of help for activities of daily living (ADL). Accordingly, it is essential to maintain and improve the physical strength and quality of life (QOL) of the elderly by preventative care in the

community.

“Eating” is a crucial part of ADL; it plays an important role in determining the QOL, especially in the elderly, and oral function [1, 2]. Previous studies have shown that occlusal force is associated with physical function [3-5], cognitive function [6], nutritional status [7], and all-cause mortality in the elderly [8, 9].

Endothelial function is also related to lifestyle habits [10] such as diets and exercise [11], and is assessed by flow-mediated dilation (FMD). Decreased FMD increases the risk of arteriosclerosis, cerebrovascular disease, and myocardial infarction [12, 13]. These diseases may have residual sequelae even after

recovery and can be considered as risk factors for shortening health life expectancy. FMD can be improved by reviewing lifestyle habits. Appropriate evaluation and understanding of FMD can provide elderly countermeasures against the associated disease that

shorten healthy life expectancy.

Both occlusal force and FMD can be important indicators for understanding the general condition of elderly for appropriate preventative care measures in the community. However, to measure FMD, a specialized medicated institution must be visited, which is time consuming; further, the procedure require technique. In contrast, measuring occlusal force is very simple and requires no special technique. Moreover, the measuring equipment is portable, and therefore, occlusal force can be measured at various places in the community. If there is a relationship between occlusal force and FMD, occlusal force evaluation can be an important indicator of the general condition for elderly and help determine risk of related disease that shorten healthy life expectancy. However, few studies have investigated the relationship between occlusal force and FMD. To the best of our knowledge, this is the first study evaluating the relationship between these two factors.

In this study, age, endothelial function as FMD, occlusal force, grip strength, and advanced glycation end products (AGEs) were obtained. AGEs were measured as indicators of aging, and grip strength was measured as in indicator of muscle strength. We aimed to explain the relationship between occlusal fore and endothelial function and determine whether occlusal force can be a new indicator in community preventative care projects.

## **Methods**

### **Participants**

We enrolled 38 elderly women ( $76.7 \pm 5.7$  years) in this study. Participants were aged > 65 years during the investigation, living in their own homes, walking independently, and participating in their community salon programs or preventative care more than once a week.

First, we visited the community salons in each area to explain the outline of our research and requested participation in our study. Following this, dental hygienist conducted a survey wherein the numbers of teeth of individuals who agreed to participate in the study were determined (primary survey). After that participants who agreed to participate in secondary survey underwent a second survey, parameters other than the number of teeth were measured at the Yamagata

Prefectural University of Health Sciences.

### **Variables**

#### **Endothelial function**

FMD was measured as an endothelial function using an instrument equipped with software for monitoring the brachial artery diameter (UNEX38G, Unex Co. Ltd., Japan) (Figure1-a). Measurements were taken in 15-20 min. The subjects were placed in supine position with a blood pressure cuff placed around the forearm (Figure1-b, c). The brachial artery was scanned longitudinally 5-10 cm above the elbow by ultrasonic echo. When the clearest B-mode image of the anterior and posterior intimal interfaces between the lumen and vessel wall was obtained, both the tracking gates were placed on the intima, the artery diameter was automatically tracked, and the waveform of diameter changes over a cardiac cycle was displayed in real time using the FMD mode of the tracking system. After measuring the blood pressure, the blood pressure cuff was inflated to 50 mmHg above systolic pressure for 5 min and released. Changes in the blood vessel diameter were measured for 2 min after the 5 min inflation. The baseline diameter was defined by measuring the minimum blood vessel diameter for 20 s after releasing the blood pressure cuff. FMD was automatically calculated as a percentage change in the peak vessel diameter from the baseline value. Endothelial dysfunction is suspected in less than 4% of cause [14]. The measurements were taken by one researcher. Figure1-a, b, c shows the measuring tool and subjects position.

### **Occlusal force**

Occlusal force was measured using an occlusal force meter (GM10, Nagano Keiki, Japan) (Figure1-d, e). Measurements were taken twice on the left side, and the larger value was considered as the final value. The subjects were instructed to bite as hard as possible to take measurements during contraction [15].

**Advanced glycation end products** An increasing in the levels of AGEs is thought to affect aging. In this study, AGEs as indicators of aging, were measured using the AGE Reader (AGE Reader SU 4, Dignoptics, Netherlands) [16, 17]. The subjects were seated, with their forearm on the AGE Reader in pronation position [18]. Measurements were taken three times on the same side of the forearm, and the average value was

considered as the final values.

### **Grip strength**

Grip strength was measured using a Jamar hand dynamometer (SH-5001, SAKAI med, Japan). The subjects were seated; with elbow joint flexed at 90° and both their feet shoulder-width apart. Measurements of the dominate hand were taken twice, and the largest value was considered as the final value.

### **Statistical analysis**

The normality of the data was confirmed using the Shapiro-Wilk test. Correlations between parameters were assessed by bivariate simple correlation analysis. For age, occlusal force, grip strength, FMD, and AGEs spearman`s rank correlation coefficient was used for analysis. Multiple regression analysis was performed with degree of FMD as dependent variables, and occlusal force, grip strength, AGEs, and age

as independent variables. IBM SPSS version 24 (IBM Japan, Tokyo, Japan) was used for all analyses, and  $p < 0.05$  was considered statistically significant.

## Results

The participant's characteristics are shown in Table 1. Mean age of the subject was  $76.5 \pm 5.7$ . Table 2 shows that Characteristics of grip strength, occlusal force, AGEs, and FMD measured in subjects. Table 3 shows the correlation coefficient for age, occlusal force, grip strength, FMD, and AGEs. There was significant correlation between occlusal force and grip strength ( $r = 0.54$ ,  $p < 0.01$ ). Degree of FMD significantly associated with occlusal force ( $r = 0.60$ ,  $p < 0.01$ ) and grip strength ( $r = 0.35$ ,  $p < 0.05$ ) or amount of increased AGEs ( $r = -0.37$ ,  $p < 0.05$ ). Table 4 shows that result of multiple regression analysis with degree of FMD as dependent variables. Occlusal force ( $p < 0.01$ ) was identified as significant factors.  $R$  was 0.61 and the adjusted  $R^2$  was 0.3. The standard partial regression coefficient was 0.59 in occlusal force.

## Discussion

A previous study found that occlusal force was associated with factors related to health status in the elderly, such as physical [3-5], cognitive functions [6], nutritional status [7], and all-cause mortality [8, 9]. In addition, many studies have shown that endothelial dysfunction was associated with cerebrovascular disease and myocardial infarction [12, 13] that may have residual sequelae even after recovery, and can be considered to be risk factors for shorted healthy life expectancy. Both occlusal force and FMD are useful understanding the general condition of the elderly in preventative care. However, to the best of our knowledge, this is the first study to investigate the relationship between occlusal force and FMD. In the present study we investigated the relationship between occlusal force and endothelial function in a community-dwelling sample of  $< 65$  years old individuals.

Many previous studies have focused on occlusal force and grip strength [4-6]. In this study we found a relationship between occlusal force and grip strength, consistent with the results reported in previous studies.

In this study, AGEs were measured as indicators of aging. Some previous studies have shown that AGEs accumulate with increasing age [16, 17]. However, in the present study, no relationship between AGEs and age was found. In our study, we selected elderly individuals who participated in their community salon programs or participated in preventative care more than once a week. Therefore, these individuals may be highly concerned for their health. Therefore, these may be no correlation between age and AGEs in this study. Accumulation of AGEs causes mutations in collagen crosslinks and reduces elastic force. A similar phenomenon has been considered to occur in collagen layer of the vascular endothelium; furthermore, we found a relationship between AGEs and FMD in this study.

To the best of our knowledge, few studies have investigated the relationship between occlusal force and endothelial function. This is a novel finding. From a functional and structural point of view, endothelial dysfunction may result in reduced flow through microcirculation, and reduced microcirculation may lead to muscle fiber atrophy. A previous study has reported a strong correlation between changes in blood flow volume and changes in muscle protein synthesis [19]. Furthermore, endothelial dysfunction also leads to decreased secretion of vascular endothelial growth factor (VEGF), facilitating functional muscle ischemia; moreover, decreased secretion of VEGF in association with endothelial dysfunction may lead to negative muscle protein balance [20]. Correlation among endothelial function, occlusal force, and grip strength was observed in this study.

It is important for local residents to understand their health condition and live consciously in preventative care. Therefore, a simple indicator is necessary. Both occlusal force and FMD are useful for understanding the general condition of the elderly. However, to measure FMD, a specialized medicated institution must be visited, which is time consuming. Occlusal force measurement can be easily performed without the requirement of difficult techniques or time for measurement, measuring equipment is portable, and can also be measured during weekly community salon visits. Multiple regression analysis shows that only occlusal force was independently associated with the presence of endothelial function. This study suggests that occlusal force can be a good indicator of the general condition of physical, and mental function, and nutritional status among the elderly, and can help determine early countermeasures against high risk diseases that shorten healthy life expectancy. This study has a few limitations. First, this study was designed as a cross-sectional study and could not evaluate the causal relationship between reduced occlusal force and decreased endothelial function. Second, we could not rule out the possible effects of medications and existing diseases on the outcomes. Third, elderly men were excluded. Further research is needed to improve overcome these limitations.

## **Conclusion**

In conclusion, in this study, we found a relationship between occlusal force and endothelial function in community-dwelling elderly women. Measuring occlusal force is easier than measuring FMD. Occlusal force can be an important indicator of general condition and high risk diseases that shorten healthy life expectancy among elderly.

## **Declarations**

### **Availability of data and material**

The datasets during and/or analysed during the current study available from the corresponding author on reasonable request.

## **Abbreviations**

ADL: Activities of daily living

AGEs: advanced glycation end products

BMI: Body mass index

CI: Confidence interval

FMD: Flow-mediated dilation

IQR: Interquartile range

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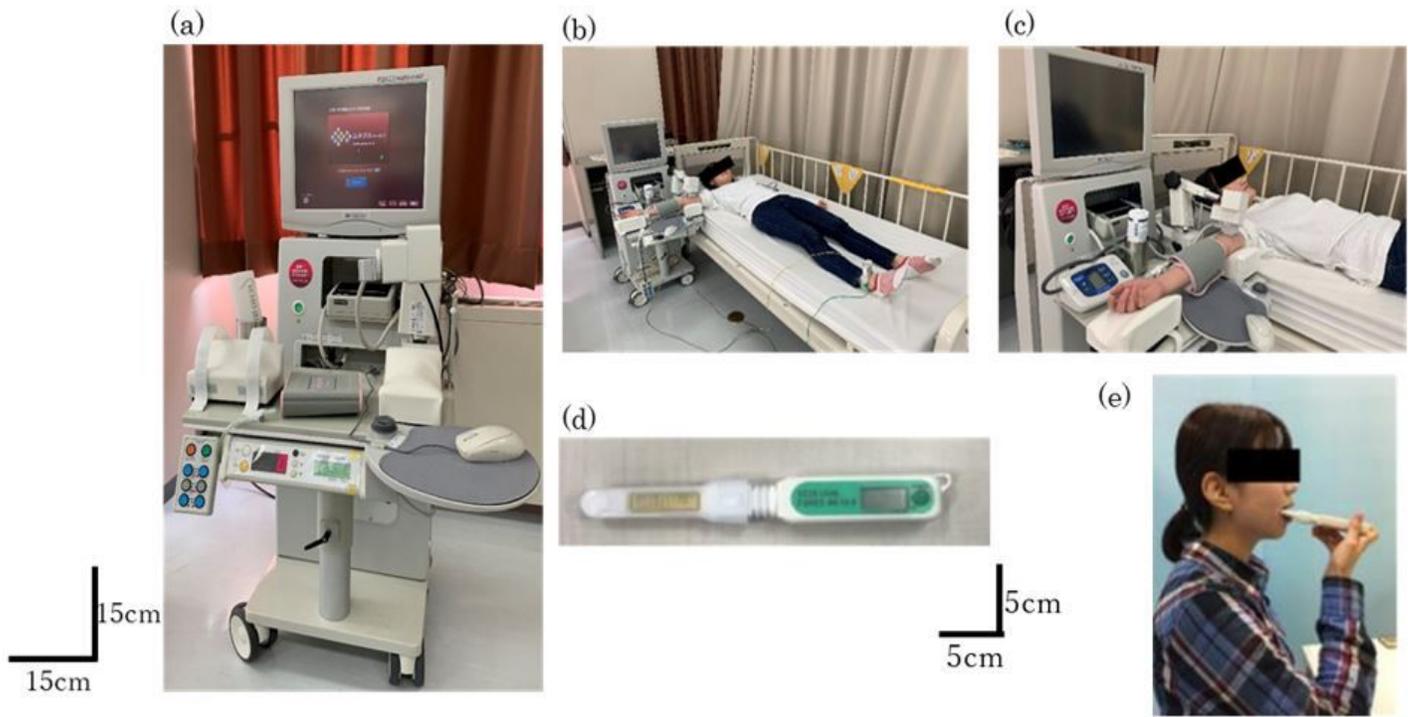
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## Tables

Due to technical limitations, the tables are only available as a download in the supplementary files section.

## Figures



**Figure 1**

Measuring tool and position. (a, b, c): Measuring tool and position for FMD (d, e): Measuring tool and position for occlusal force

## Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

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