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ORIGINAL ARTICLE

# Influence of visual acuity, manual dexterity and handgrip strength on oral and denture hygiene ability of non-frail older people: Development of the Gerostomatological Assessment Battery

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## Abstract

**Background:** Due to the heterogeneity of older people, it is difficult to identify reliable factors influencing oral health.

**Objective:** The aim was to illustrate the influence of visual acuity, manual dexterity, and handgrip strength on the oral and denture hygiene ability of older non-frail people.

**Methods:** In a cross-sectional study, conducted at a specialized dental clinic, at baseline, all participants received professional prophylaxis and instruction on daily oral and denture hygiene regimes for a 6-week intervention period. Data on the Quigley and Hein modified plaque index (QHI), respectively, the Denture Hygiene Index (DHI), visual acuity, manual dexterity and handgrip strength in non-frail participants (≥ 65 years) were collected. Recruitment was done within the clinic's patient clientele and within the staff (control cohort).

**Results:** Women showed significantly better manual dexterity than men (Mann–Whitney U, $p = .01$), while women's mean handgrip strength was significantly lower (Mann–Whitney U, $p < .01$). Manual dexterity (Mann–Whitney U, $p = .003$) and handgrip strength (Mann–Whitney U, $p = .052$) were associated with age. However, visual acuity, manual dexterity and handgrip strength had no influence on oral or denture hygiene.

**Conclusion:** Visual acuity, manual dexterity and handgrip strength have no influence on oral and denture hygiene ability in older non-frail people. Further studies should investigate whether these factors also have no influence on oral and denture hygiene in vulnerable older patients. Therefore, an assessment tool for the evaluation of potential influencing factors of oral and denture hygiene is proposed in a dental context. This Gerostomatological Assessment Battery (G-AB) can be used as a helpful

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tool to check the individual cognitive function and comprehension, dental therapy approaches and their individual adaption.

**KEYWORDS**
denture hygiene, frailty, handgrip strength, manual dexterity, oral hygiene ability, visual acuity

## 1 | BACKGROUND

Functional and cognitive impairments become increasingly important in medicine and society as people age. In the dental field, they can lead to difficulties in performing adequate oral and denture hygiene, which affects oral health and thus general health.[1–3] Orofacial pain, as well as the loss of chewing function, can affect the quality of life and nutritional performance, thus being a cofactor for sarcopenia and frailty.

However, due to the heterogeneity of older people, it is difficult to identify reliable factors influencing oral health. There is a difference in oral hygiene ability between older people living independently at home and those being dependent on care at home or in long-term care facilities (LTCF) since oral health care is poor there.[4–6]

In addition to reduced cognitive functions, decreasing visual acuity[7] and manual capabilities[8] in old age lead to functional limitations in the performance of the activities of daily living (ADL) and quality of life.[9] Oral hygiene[10] may also be affected. Lee et al. demonstrated that poor oral self-care habits may be a risk factor for reduced handgrip strength.[11] Komulainen et al. observed that the functional status by means of the instrumental activities of daily living (IADL) is an important determinant of oral self-care instead of handgrip strength.[12]

Some studies have identified reduced manual dexterity as a risk factor for increased plaque accumulation of both teeth and dentures in older[13–16] and younger people.[17] Additionally, vision impairments in children and adolescents have been observed to result in negative oral health outcomes.[18] To the author's best knowledge, it is not known whether the handgrip strength or visual acuity of older people has an influence on oral and denture hygiene ability.

Patients often require a high degree of manual dexterity in individual oral and denture hygiene as well as in the handling of removable dentures, for example during insertion and removal of telescopic crown-retained dentures. Manual dexterity seems to decrease with increasing age in both sexes.[19–21] In addition to factors such as gripping capability, and handgrip strength, manual dexterity seems to be critical for the success of personal oral hygiene.[22]

In patients with functional limitations, which affect oral health, the dentist can easily assess manual dexterity prior to treatment. On the contrary, assessment is usually difficult in older people who do not suffer from obvious manual restrictions. Incorporation of or adaptation to dentures becomes more likely if the patient does not have any difficulties with handling them.

In the field of oral and denture hygiene, the measurement of reduced manual dexterity is regarded as a predictor for reduced oral hygiene ability.[23]

The aim of the present study was to illustrate the influence of handgrip strength, manual dexterity and visual acuity on the oral and denture hygiene ability of non-frail older people.

It was hypothesized that the quality of oral hygiene is more dependent on manual dexterity, and handgrip strength than visual acuity while denture hygiene is dependent on all three tested parameters.

## 2 | METHODS

The study was conducted at a specialized dental clinic for treating old and geriatric patients as well as people with disabilities in Zurich, Switzerland. In the first step, the non-frail older study participants were recruited within the clinic's patient clientele. For this purpose, a targeted search was made in the clinical routine for patients who met the inclusion criteria (see below). In the second step, the participants for the younger control cohort were recruited within the patient and staff population of the clinic.

In a cross-sectional study, data on oral and denture hygiene, handgrip strength, manual dexterity and visual acuity in non-frail older people aged 65 years or older were collected.

### 2.1 | Study design

At baseline, to minimize individual influencing factors and to create an equal starting situation, all participants received professional prophylaxis treatment by a dentist (professional tooth and denture cleaning, duration: 45–60 min). Immediately after the prophylaxis procedure, the intervention started for a period of 6 weeks. Participants were instructed to perform their individual oral and denture hygiene at home as usual. The participants received a soft manual toothbrush (Meridol Toothbrush Gentle, GABA Switzerland) and, if dentures were present, a denture brush (Oral-B Denture Brush, Oral-B Laboratories), which they were to use in combination with their previous individual oral and denture hygiene aids (excluding electric toothbrushes, previous used manual toothbrushes, denture brushes or denture cleaning tabs) for daily, at-home oral and denture hygiene.

At follow-up 6 weeks after baseline, the current oral and denture hygiene was re-evaluated by staining the teeth with erythrosine solution (paro®plak, paro®, Profimed AG) and recording the Turesky modified plaque index according to Quigley & Hein (QHI)[24,25] Regarding denture hygiene, the Denture Hygiene Index

(DHI) according to Wefers was recorded (the higher the index score the worse the denture hygiene).[26] In addition, further parameters (e.g. handgrip strength, manual dexterity, near visual acuity, sociodemographic characteristic as well as geriatric assessment tools such as the Mini Mental State Examination (MMSE)[27] and the Body Mass Index (BMI)[28]) were collected to describe the participants. Furthermore, the DMFT index (D—decayed, M—missing, F—filled, T—teeth)[29] was evaluated in a modified version for use in older people.

To compare the values for handgrip strength with the JAMAR® dynamometer[30,31] and manual dexterity with the Purdue® Pegboard[13] of men and women with previous studies,[19–21,32] a reference group was evaluated for these two parameters.

Dental intervention, examination and data collection were carried out by one dental examiner.

## 2.2 | Instruments

All measurements were recorded at follow-up 6 weeks after baseline (after the intervention) by one examiner.

### 2.2.1 | Turesky modified plaque index according to Quigley and Hein

The modified plaque index according to Quigley and Hein (QHI)[24,25] was used as a measuring instrument for oral hygiene. It measures the amount of plaque on the coronal tooth surface. Before the measurement, the teeth are stained with plaque revealers. Each vestibular and oral tooth surface is assessed and receives a value of 0 to 5 (the lower the number, the less plaque). The score is calculated from the average appraisal value per number of valuated areas.

### 2.2.2 | Denture hygiene index according to Wefers

The Denture Hygiene Index (DHI)[26] is an instrument for measuring denture hygiene. The denture surface is divided into 10 areas. It does not matter whether the denture is a maxillary or mandibular, total or partial denture. Any remaining elements are also evaluated depending on their position. Each area is checked for the presence of plaque and evaluated purely quantitatively (categories: plaque present, no plaque present). No distinction is made between hard and soft plaque. The areas are divided into a vestibular area (areas 1–3), oral area (areas 4–6) and denture base (areas 7–10).

Since with the DHI, there is a separate score for each denture area, the individual scores are combined into a DHI score (the higher, the worse). The score is calculated as follows:

$$\text{DHI Score} = \frac{\text{Sum of all surfaces with plaque}}{\text{Sum of all evaluated surfaces}}$$

### 2.2.3 | Handgrip strength

Different methods are used to assess manual function.[14] Handgrip strength can be measured by the Jamar® dynamometer (Sammons Preston),[30] which has been validated in clinical studies[31] (Figure 1A). The measurement was performed three times for the dominant and the non-dominant hand each. The mean value in kilograms (kg) was calculated.

### 2.2.4 | Manual dexterity

The Purdue® Pegboard (Lafayette Instrument Co.) is well established for manual dexterity testing and has already been used in a similar context[13] (Figure 1B).

Participants were able to take part in this study if they had the necessary manual abilities. Manual ability describes the fact that a person is physiologically able to perform manual actions which may be reduced in case of, for example limb paralysis, arthritis or stiffening. Manual dexterity on the contrary describes the proficiency of the skill to perform a manual task depending on cognition and other factors. The basis of any manual dexterity is the degree of a person's manual ability.

The Purdue® Pegboard[13] is a rectangular board with four recesses at the top. The two outer recesses contain 25 cylindrical metal pins each. The rest of the surface contains two rows of holes that extend along the whole board. To measure their manual dexterity, the participants are instructed to insert as many metal pins as possible from the recess into the boreholes within 30 seconds. For each hand, only one pin at a time may be taken from the corresponding recess (right or left). The participants carry out the test separately for both hands and with both hands at the same time (setting pen pairs). The participants are instructed and given the opportunity to practice the movement on four pins or pairs before a measurement is taken (Figure 1B).

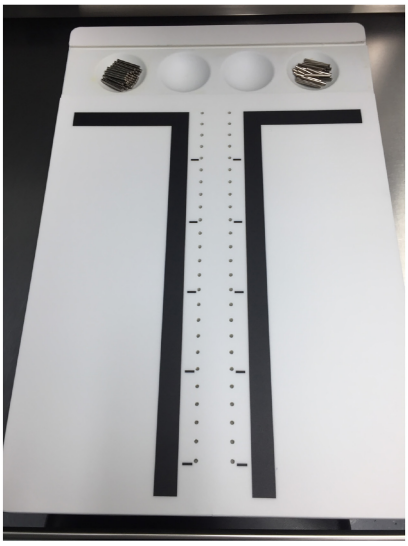
### 2.2.5 | Near visual acuity

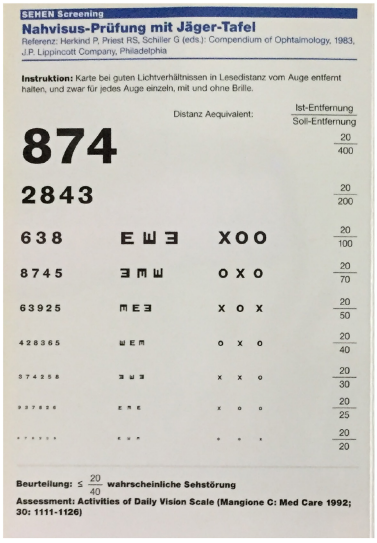
To measure the near visual acuity, the participant keeps the Jaeger chart at a comfortable distance for reading. The visual inspection takes place once with and once without glasses, if available. The values of the line which the participant can still read out correctly are recorded. The values can range from 20/20 (best visual acuity) to 20/400 (lowest visual acuity). Visual impairment is assumed from a visual acuity of 20/40 or worse[21] (Figure 1C).

### 2.2.6 | Sociodemographic items

Sociodemographic items such as age (in years), sex (male/female) and living situation (items: at home alone or with family, LTCF) of each participant were recorded.


(A)


(B)



(C)

**FIGURE 1** Overview of the measuring instruments to assess (A) handgrip strength (JAMAR®-Dynamometer), (B) manual dexterity (Purdue® Pegboard) and (C) visual acuity (Jaeger chart.[33]).

### 2.2.7 | Mini mental state examination

The cognitive abilities of the participants were tested using MMSE[27] as a screening tool for dementia diagnosis. An MMSE of 28 is typical for cognitively healthy participants. The statistical evaluation is carried out using the total value. For the descriptive description of the participants, graduations are used: MMSE 28–30 no dementia; 25–27 slight cognitive impairment; 18–24 mild dementia, 17–10 moderate dementia; and ≤ 9 severe dementia.

### 2.2.8 | Body mass index

The BMI is calculated by participant height and weight [kg/m$^2$].[28]

### 2.2.9 | DMFT index

The DMFT index[29] is used to measure caries experience. It assesses the caries activity of the teeth. Teeth that have been destroyed by caries (D—Decayed), extracted due to caries (M—Missing) or filled (F—Filled) are counted in the index. In the field of senior dentistry, it is often no longer possible to determine the exact extraction reason for the missing teeth. Therefore, as is common in the field of senior dentistry, all missing teeth are counted as 'missing' in this analysis, regardless of the reason for the loss. In addition, all teeth are included in the evaluation (including third molars), resulting in a maximum DMFT value of 32.

Additionally, age- and sex-dependent benchmark values for the handgrip strength and manual dexterity of younger men and women (age: 20–60 years) with the JAMAR® Dynamometer were collected as a control cohort.

For some analyses, age groups were defined (age group 1: 65–74 years, age group 2: (≥ 75 years of age)).

## 2.3 | Eligibility criteria

Included were non-frail participants without cognitive impairments, who live independently at home and do not exhibit mobility limitations, at least 65 years of age. A frailty evaluation was not conducted. They needed to have at least six natural teeth distributed over two quadrants in one jaw (opposite jaws could be edentulous) and showed no need for acute dental treatment. Participants with cognitive impairments affecting the ability to carry out their own oral and denture hygiene independently,

determined by interviews or based on medical records (MMSE ≤18), were excluded. Participants without dentures were assigned to the analysis group for oral hygiene ability (OHA group). Participants with dentures were analysed in both the OHA group and the denture hygiene ability group (DHA group), if meeting the inclusion criteria of both groups.

### 2.4 | Statistical evaluation

The evaluation was performed separately by group (OHA group, DHA group) as previously described.

The statistical evaluation was performed using SPSS version 27.[34] The significance level was set to $\alpha = .05$ for all analyses. Additionally, statistical analysis and plots were calculated with the statistical software R.[35]

For descriptive statistics, frequencies, means and standard deviations as well as medians and ranges were calculated. To calculate the monotonic relationship between two variables, where a linear relationship was suspected, the Pearson chi$^{-square}$ test or the rank correlation according to Spearman-Rho was used. To compare the central tendency of variables in two independent samples between two groups, for example two age groups, the Mann–Whitney *U* test was used. If more than two groups were to be compared, the Kruskal–Wallis test was used.

Since the present study is an exploratory pilot study, a power analysis was not conducted. Power analysis was performed with the program G*Power ad interims revealing that a higher number of participants would have had no effect on the statistical analysis and the results reported.[36]

### 2.5 | Ethical considerations

Written informed consent to study participation was obtained from all participants. The study was previously examined and approved by the Cantonal Ethics Committee Zurich (KEK-ZH-2010-0515/5).

## 3 | RESULTS

### 3.1 | General description of the study population

Of 99 recruited participants, 71 were included in the evaluation (drop out $n = 28$; 33 mentioned reasons (naming of multiple reasons possible): medical incidents or hospitalization of the participants or their relatives ($n = 18$), withdrawal of consent due to the effort ($n = 8$), missed appointment ($n = 3$) and no reasons mentioned ($n = 4$)).

According to the eligibility criteria, 57 participants were assigned to the analysis of the oral hygiene ability group (OHA group) (age: median 73 years, range 65–89 years; females 47.4%), and 44 participants were assigned to the analysis of the denture hygiene ability group (DHA group) (age: median 72.5 years, range 65–89 years; females 52.3%). Further characteristics of the two study groups are displayed in Table 1.

The reference group for manual dexterity and visual acuity consisted of 100 healthy participants (age: median 43 years, range 20–69 years).

### 3.2 | Influence of visual acuity, manual dexterity and handgrip strength on oral hygiene ability (results of the OHA group)

The QHI score averaged 2.2 (range 0–3.4), which suggests good oral hygiene of the participants. Men showed statistically not significantly poorer oral hygiene than women (mean QHI score: men 2.2, women 2.0) (Mann–Whitney *U* test $p = .1$).

The age of the participants had no influence on their oral hygiene (Mann–Whitney *U* test $p = .122$). Similarly, the frequency of individual oral hygiene by the participants (Kruskal–Wallis test $p = .765$) and the number of oral and dental hygiene aids used (Spearman-Rho test $p = .542$, $r = .082$) did not have any influence on the results of oral hygiene.

No difference was found in near visual acuity without glasses between men and women (Mann–Whitney *U* test $p = .293$) and related to age (Kruskal–Wallis test $p = .424$).

The manual dexterity of women was significantly better than that of men (Mann–Whitney *U* test $p = .01$). Similarly, there was a significant difference in manual dexterity (with the dominant hand) between age groups: The older seniors were less dexterous than the under 74-year-olds (Mann–Whitney *U* test $p = .003$).

The parameter handgrip strength (dominant hand) was not identified as an influencing factor on oral hygiene. (Pearson chi-square test $p = .325$, $r = .134$). There was no influence on oral hygiene of the parameters manual dexterity (Pearson chi-square test $p = .291$, $r = -.144$) and visual acuity (near visual acuity without glasses) (Pearson chi-square test $p = .862$, $r = .023$; Spearman-Rho test $p = .953$, $r = .008$) as measured with the QHI score.

Regarding the handgrip strength of the dominant hand, there was a gender-specific significant difference (Mann–Whitney *U* test $p = .000$) and an age-specific significant difference (Mann–Whitney *U* test $p = .026$). Men and younger seniors (age group 1: 65–74 years) showed greater handgrip strength.

### 3.3 | Influence of visual acuity, manual dexterity and handgrip strength on denture hygiene ability (results of the DHA group)

The DHI score averaged 0.2 (range 0–0.7), which suggests a good denture hygiene of the participants. No statistically significant difference was found between genders (Mann–Whitney *U* test $p = .142$) and between age groups (Mann–Whitney *U* test $p = .863$) regarding denture hygiene.

**TABLE 1** Description of the study population separated by evaluation group.

| | OHA group ($n=57$) | | DHA group ($n=44$) | |
|---|---|---|---|---|
| | **Median (Range)** | **%** | **Median (Range)** | **%** |
| Age [years] | 73 (65–89) | | 72.5 (65–89) | |
| Sex | | | | |
| Male | | 52.6 | | 47.7 |
| Female | | 47.4 | | 52.3 |
| Living conditions | | | | |
| Living at home with family | | 40.4 | | 43.2 |
| Living alone at home | | 56.1 | | 52.3 |
| Long-term care facility | | 3.5 | | 4.5 |
| Cognitive impairment (MMSE) | | | | |
| No dementia (MMSE 28–30) | | 47.4 | | 43.2 |
| Mild cognitive impairment (MMSE 25–27) | | 36.8 | | 43.2 |
| Mild dementia (MMSE 18–24) | | 15.8 | | 13.6 |
| BMI | 26 (17–42) | | 26 (17–42) | |
| Time span since last visit to a dentist or dental hygienist | | | | |
| Within last 2 years | | 0 | | 2.3 |
| Within last year | | 17.5 | | 13.6 |
| Within last 6 months | | 82.5 | | 84.1 |
| QHI score | 2.2 (0–3.4) | | | |
| DHI score | | | 0.2 (0–0.7) | |
| DMF/T index (based on 32 teeth) | 25 (17–32) | | 27 (19–32) | |
| DMF/T index (based on 28 teeth) | 21 (13–28) | | 23.5 (15–28) | |
| Manual dexterity (Number of correctly placed pins in purdue pegboard, max. 25 pins per side) | | | | |
| Dominant hand | 12 (7–19) | | 12 (6–14) | |
| Non-dominant hand | 12 (0–16) | | 11 (6–16) | |
| Both hands (2 pins at the same time) | 9 (0–14) | | 9 (5–12) | |
| Handgrip strength | | | | |
| Dominant hand | 27.7 (15–50) | | 25.3 (9–50) | |
| Non-dominant hand | 25.7 (7–51) | | 23.7 (7–51) | |
| Visual acuity | | | | |
| Visual acuity—probable visual impairment (Cut-off 20/40[a]) (without glasses) | | 82.6 | | 70.4 |
| | Median (Range) | Mean ± SD | Median (Range) | Mean ± SD |
| Near visual acuity (indicated as 20/xx) | | | | |
| With glasses | 20/25 (20/20–20/50) | 20/28.0 ± 20/8.6 | 20/25 (20/20–20/70) | 20/29.0 ± 20/10.9 |
| Without glasses | 20/70 (20/20–20/400) | 20/89.9 ± 20/87.4 | 20/60 (20/20–20/200) | 20/71.4 ± 20/52.7 |
| Visual acuity score | | | | |
| With glasses | 0.8 (0.4–1) | 0.8 ± 0.2 | 0.8 (0.29–1) | 0.8 ± 0.2 |
| Without glasses | 0.3 (0.05–1) | 0.3 ± 0.2 | 0.3 (0.1–1) | 0.4 ± 0.3 |

Abbreviations: BMI, Body Mass Index; DHA, denture hygiene ability; DHI, Denture Hygiene Index; DMF/T index (decayed, missing, filled teeth); MMSE, Mini Mental State Examination; OHA, oral hygiene ability; QHI, Quigley & Hein Hygiene Index.

[a]A visual impairment is assumed from a visual acuity of 20/40 or worse.

No statistically significant correlation was found between the frequency of denture cleaning (during the study period) and the DHI score (Pearson chi-square test $p=.763$, $r=.047$; Spearman-Rho test $p=.706$, $r=.059$).

No statistically significant correlation was found between handgrip strength of the dominant hand and denture hygiene (DHI score) (Pearson chi-square test $p=.461$, $r=.115$; Spearman-Rho test $p=.639$, $r=.074$). (Figure 2).

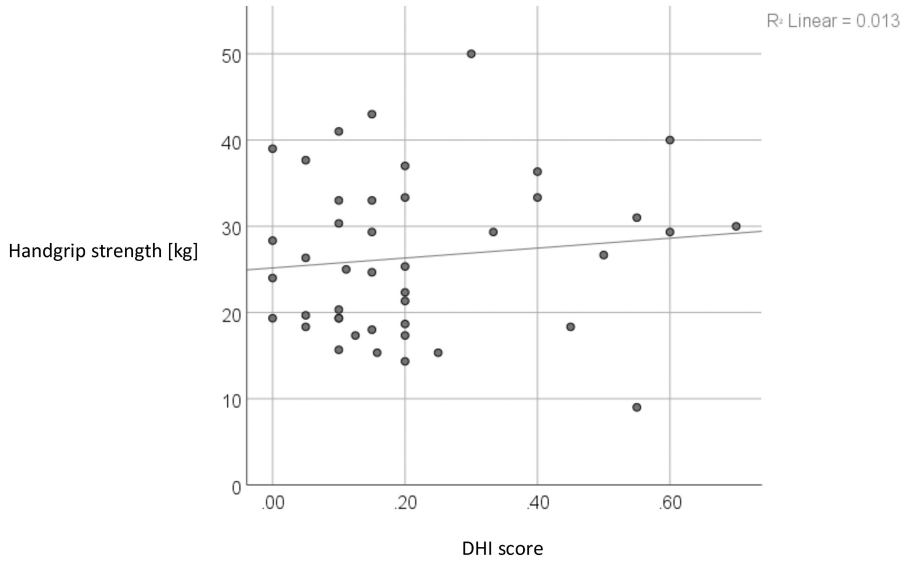



**FIGURE 2** Relationship of handgrip strength of the dominant hand (in kg) and Denture Hygiene Index score (DHI score) ($R^2$ Linear = .013).

No statistically significant correlation was shown between visual acuity (visual acuity score without glasses) and DHI (Pearson chi-square test $p = .416$, $r = .126$; Spearman-Rho test $p = .522$, $r = .099$). Likewise, no correlation could be found between visual acuity with or without disease value and denture hygiene (Mann–Whitney *U* test $p = .219$).

Since both hands are involved in denture cleaning, the measure of dexterity was the Purdue Pegboard score for both hands. No statistically significant correlation with denture hygiene was found (Pearson chi-square test $p = .056$, $r = -.294$; Spearman-Rho test $p = .241$, $r = -.183$). The values for dexterity of the dominant hand also showed no statistically significant correlation with denture hygiene (Pearson chi-square test $p = .147$, $r = -.225$; Spearman-Rho test $p = .214$, $r = -.194$).

Women's manual dexterity was significantly better than men's for both the dominant hand and both hands (dominant hand: Mann–Whitney *U* test $p = .014$; both hands: Mann–Whitney *U* test $p = .013$). There was a significant difference in manual dexterity (for the dominant hand) between age groups: The older seniors were less dexterous than the under 74-year-olds (Mann–Whitney *U* test $p = .004$). There was no difference between the age groups in the values for both hands (Mann–Whitney *U* test $p = .113$).

There was a significant difference between genders regarding handgrip strength of the dominant hand (Mann–Whitney *U* test $p = .000$). Men had greater handgrip strength than women. There was no statistically significant difference in handgrip strength between age groups (Mann–Whitney *U* test $p = .094$).

## 3.4 | Comparison of handgrip strength and manual dexterity values

Age- and sex-dependent benchmark values for handgrip strength and manual dexterity of younger men and women (age: 20–60 years) with the JAMAR® Dynamometer were collected as a control cohort. All values for handgrip strength and manual dexterity (younger control cohort and older adults of this study) have been compared in Tables 2 and 3 to age-dependent values found in other studies[19–21,32] for the respective test devices separately according to gender. The values obtained for handgrip strength and manual dexterity in this study correspond to the standard values in similar populations.[14,37]

## 3.5 | Proposal for a Gerostomatological Assessment Battery (G-AB)

This study showed no effect of visual acuity, manual dexterity and handgrip strength on oral and denture hygiene in non-frail older people. However, it can be observed in the everyday life of a dentist working in the field of gerostomatology that the increase in the need for assistance and care is always accompanied by a decrease in the ability to adequately clean the teeth and dentures independently. The question, therefore, arises as to whether the results would be different in vulnerable patients (e.g. patients requiring care or suffering from diseases such as Parkinson's disease and dementia).

This should be investigated in future studies. Since the causes responsible for the decrease in oral and denture hygiene observed in everyday life in older vulnerable patients may be multifactorial as shown in other studies,[38] the authors suggest the use of an assessment battery to clarify the relationships in future studies.

In general dentistry, findings of the oro-facial system (e.g. dental status and X-ray findings) are at the forefront of diagnostics and serve as the basis for therapy planning. In the field of gerostomatology, due to the heterogeneity of the patients (fit, frail, in need of care), it is important and fundamental to consider additional findings from the geriatric assessments. For this purpose, the authors would

**TABLE 2** Age-dependent benchmarks and study values for handgrip strength of men and women with the JAMAR® Dynamometer (R—right hand and L—left hand) compared to a previous study.[32]

| Males | | | | | | | | Females | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mathiowetz et al. (1985)[32] | | | | Nitschke et al. 2023 (data from this study) | | | | Mathiowetz et al. (1985)[32] | | | | Nitschke et al. 2023 (data from this study) | | | |
| Age [years] | Hand | Mean | SD | Age [years] | Hand | Mean | SD | Age [years] | Hand | Mean | SD | Age [years] | Hand | Mean | SD |
| | | $n=29$ | | | | $n=10$ | | | | $n=26$ | | | | $n=12$ | |
| 20–24 | R | 54.9 | 9.3 | 20–29 | R | 44.5 | 8.0 | 20–24 | R | 31.9 | 6.6 | 20–29 | R | 33.6 | 6.5 |
| | L | 47.4 | 9.9 | | L | 42.6 | 8.4 | | L | 27.7 | 5.9 | | L | 30.0 | 6.8 |
| | | $n=27$ | | | | | | | | $n=27$ | | | | | |
| 25–29 | R | 54.7 | 10.4 | | | | | 25–29 | R | 33.8 | 6.3 | | | | |
| | L | 50.1 | 7.3 | | | | | | L | 28.8 | 5.5 | | | | |
| | | $n=27$ | | | | $n=10$ | | | | $n=26$ | | | | $n=11$ | |
| 30–34 | R | 55.2 | 10.1 | 30–39 | R | 39.1 | 7.2 | 30–34 | R | 35.7 | 8.7 | 30–39 | R | 25.3 | 2.6 |
| | L | 50.0 | 9.8 | | L | 36.6 | 9.6 | | L | 30.8 | 8.0 | | L | 25.1 | 4.1 |
| | | $n=25$ | | | | | | | | $n=25$ | | | | | |
| 35–39 | R | 54.3 | 10.9 | | | | | 35–39 | R | 33.6 | 4.9 | | | | |
| | L | 51.2 | 9.8 | | | | | | L | 30.1 | 5.3 | | | | |
| | | $n=26$ | | | | $n=11$ | | | | $n=31$ | | | | $n=10$ | |
| 40–44 | R | 53.0 | 9.4 | 40–49 | R | 42.4 | 11.1 | 40–44 | R | 31.9 | 6.1 | 40–49 | R | 27.3 | 3.9 |
| | L | 51.2 | 8.5 | | L | 41.3 | 9.5 | | L | 28.3 | 6.3 | | L | 26.1 | 3.1 |
| | | $n=28$ | | | | | | | | $n=25$ | | | | | |
| 45–49 | R | 49.8 | 10.4 | | | | | 45–49 | R | 28.2 | 6.8 | | | | |
| | L | 45.7 | 10.3 | | | | | | L | 25.4 | 5.8 | | | | |
| | | $n=25$ | | | | $n=10$ | | | | $n=25$ | | | | $n=10$ | |
| 50–54 | R | 51.5 | 8.2 | 50–59 | R | 37.8 | 9.1 | 50–54 | R | 29.8 | 5.3 | 50–59 | R | 23.6 | 5.3 |
| | L | 46.2 | 7.7 | | L | 36.5 | 14.7 | | L | 26.0 | 4.9 | | L | 21.4 | 7.2 |
| | | $n=21$ | | | | | | | | $n=25$ | | | | | |
| 55–59 | R | 45.9 | 12.1 | | | | | 55–59 | R | 26.0 | 5.7 | | | | |
| | L | 37.7 | 10.6 | | | | | | L | 21.5 | 5.4 | | | | |
| | | $n=24$ | | | | $n=8$ | | | | $n=25$ | | | | $n=8$ | |
| 60–64 | R | 40.7 | 9.3 | 60–64 | R | 39.7 | 5.7 | 60–64 | R | 25.0 | 4.6 | 60–64 | R | 20.5 | 0.8 |
| | L | 34.8 | 9.2 | | L | 36.9 | 5.9 | | L | 20.7 | 4.6 | | L | 18.6 | 1.7 |
| | | $n=27$ | | 65–69 | | $n=11$ | | | | $n=28$ | | | | $n=7$ | |

TABLE 2 (Continued)

| Males | | | | | | | Females | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 65–69 | R | 41.3 | 9.3 | R | 34.4 | 11.2 | 65–69 | R | 22.5 | 4.4 | 65–69 | R | 24.9 | 4.5 |
| | L | 34.8 | 9.0 | L | 34.5 | 9.8 | | L | 18.6 | 3.7 | | L | 20.7 | 6.5 |
| | | $n=26$ | | | $n=6$ | | | | $n=29$ | | | | $n=10$ | |
| 70–74 | R | 34.2 | 9.8 | R | 36.6 | 7.1 | 70–74 | R | 22.5 | 5.3 | 70–74 | R | 24.3 | 5.5 |
| | L | 29.3 | 8.2 | L | 37.6 | 8.2 | | L | 18.8 | 4.6 | | L | 23.8 | 4.4 |
| | | $n=25$ | | | $n=13$ | | | | $n=26$ | | | | $n=10$ | |
| 75+ | R | 29.8 | 9.5 | R | 29.7 | 6.8 | 75+ | R | 19.3 | 5.0 | 75+ | R | 18.5 | 5.1 |
| | L | 24.9 | 7.7 | L | 28.3 | 7.2 | | L | 17.1 | 4.0 | | L | 19.4 | 3.4 |

like to introduce the Gerostomatologic Assessment Battery (G-AB), which consists of several modules (Figure 3A).

These modules are:

- Oral functional capacity,[37,39]
- Handgrip strength (refer to age-dependent benchmarks in Table 2),
- Manual dexterity (refer to age-dependent benchmarks in Table 3),
- Visual acuity,[33]
- Barthel Index,[40]
- Mini Mental State Examination (MMSE),[27]
- Chewing function (chewing efficiency, bite force),
- Mini Nutritional Assessment (MNA).[41]

The eight modules aim to identify patients with reduced functional or cognitive abilities more easily. Dentists could include this assessment in their therapy planning. In this context, the clarification of the dental aftercare competence[42] could then also include a prognosis if third parties should become responsible for the daily oral and denture hygiene as well as the handling of dentures.

For all modules, there are age- and gender-specific comparison values or already validated test procedures for examination and evaluation. Since the authors consider manual dexterity to be particularly important in connection with oral and denture hygiene, a proposal for a Gerostomatological Manual Dexterity Assessment (G-MDA) is also made here (Figure 3B).

For the evaluation of manual dexterity data in the application of the G-MDA, patients are divided into three age groups of 60–69 years, 70–79 years, and 80 years and older. Within the age groups, manual dexterity is determined by the outcome of the Purdue® Pegboard test in this study and classified according to gender (age-dependent benchmarks for manual dexterity (Figure 3B)).

Patients within the range of the age-dependent benchmarks for manual dexterity (Table 3) can use various aids for individual oral and denture hygiene. With reduced manual dexterity, it is important to increase the frequency of professional dental hygienist recalls so that manual deficits can be compensated. For prosthetic work, restorations that are difficult to handle should be avoided according to the g-3-S gerostomatological treatment principle for geriatric patients.[42] In patients with severe cognitive impairment, for example dementia, it can generally be assumed that manual dexterity is greatly reduced. The assessment instrument can be used to evaluate the first indications of a need for more frequent recall appointments. It can be carried out by a dental nurse and takes approximately 2 min which is a major benefit when introducing the test in a practice setting. In a first pilot step, the authors have therefore attempted to categorize the manual dexterity of seniors (without previous illnesses, values for both hands at 30s test duration) and derive therapeutic consequences (Figure 3B). Further research on therapeutic consequences due to the results of manual dexterity is needed.

**TABLE 3** Age-dependent benchmarks and study values for the manual dexterity of men and women with the Purdue® Pegboard.

| | | Males | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Agnew et al. 1988[19] | | Desrosiers et al. 1995[a] [20] | | Wittich & Nadon 2017[c] [21] | | Nitschke et al. 2023 (data from this study)[b] | | | |
| Age [years] | Hand | Mean | SD | Mean | SD | Mean | SD | Age [years] | Hand | Mean | SD |
| | | *n* = 91 total | | *n* = 60 per age group | | | | | | *n* = 10 | |
| 20–29 | D | / | | / | | / | | 20–29 | D | 16.9 | 1.5 |
| | ND | / | | / | | / | | | ND | 16.0 | 0.9 |
| | B | / | | / | | / | | | B | 13.9 | 1.4 |
| | | | | | | | | | | *n* = 10 | |
| 30–39 | D | / | | / | | / | | 30–39 | D | 13.9 | 1.6 |
| | ND | / | | / | | / | | | ND | 16.3 | 4.0 |
| | B | / | | / | | / | | | B | 12.3 | 1.6 |
| | | | | | | | | | | *n* = 11 | |
| 40–49 | D | 14.6 | 2.06 | / | | / | | 40–49 | D | 14.0 | 1.4 |
| | ND | 14.4 | 2.35 | / | | / | | | ND | 13.6 | 1.1 |
| | B | 12.2 | 2.43 | / | | / | | | B | 11.1 | 2.0 |
| | | | | | | | | | | *n* = 10 | |
| 50–59 | D | 14.4 | 2.15 | / | | / | | 50–59 | D | 12.2 | 2.8 |
| | ND | 13.9 | 2.19 | / | | / | | | ND | 11.7 | 3.6 |
| | B | 11.9 | 2.22 | / | | / | | | B | 8.9 | 2.7 |
| | | | | | | *n* = 7 | | | | *n* = 8 | |
| 60–69 | D | 13.6 | 1.7 | 12.7 | 1.5 | 7.1 | 2.2 | 60–64 | D | 11.1 | 1.6 |
| | | | | | | | | | ND | 11.1 | 1.2 |
| | | | | | | | | | B | 9.9 | 0.8 |
| | ND | 13.1 | 1.6 | 12.7 | 1.5 | 7.7 | 2.1 | | | *n* = 11 | |
| | B | 10.9 | 1.5 | 10.2 | 1.3 | 5.2 | 2.2 | 65–69 | D | 12.2 | 1.9 |
| | | | | | | | | | ND | 11.6 | 1.7 |
| | | | | | | | | | B | 9.0 | 1.8 |
| | | | | | | *n* = 5 | | | | *n* = 13 | |
| 70–79 | D | 13.0 | 1.9 | 11.2 | 1.9 | 9.8 | 1.9 | 70–79 | D | 10.4 | 1.5 |
| | ND | 12.4 | 1.5 | 10.7 | 2.1 | 9.1 | 2.4 | | ND | 10.4 | 1.8 |
| | B | 10.4 | 1.2 | 8.2 | 2.0 | 7.5 | 2.2 | | B | 8.3 | 1.7 |
| | | | | | | *n* = 16 | | | | *n* = 6 | |
| 80–89 | D | 10.8 | 1.3 | 10.1 | 20. | 6.7 | 2.6 | 80–89 | D | 10.5 | 1.1 |
| | ND | 10.6 | 1.8 | 9.8 | 1.7 | 5.9 | 2.7 | | ND | 11.0 | 0.6 |
| | B | 8.5 | 1.2 | 7.4 | 1.6 | 4.2 | 2.3 | | B | 8.0 | 2.5 |

Abbreviations: both, both hands; D, dominant hand; ND, non-dominant hand.

[a]Normative data of epidemiological study in healthy participants (here): D, right hand; ND, left hand.

[b]Participants with corrected visual impairment and normal vision.

[c]Participants with visual impairment between 20/30 and 20/604.

## 4 | DISCUSSION

### 4.1 | Study results

This study, which focused on oral and denture hygiene in non-frail older people, produced several important findings. Firstly, no age or gender difference was observed for visual acuity, while gender differences were found for handgrip strength (males and younger seniors showed more handgrip strength) and manual dexterity (females and younger seniors showed better manual dexterity). Overall, visual acuity, manual dexterity and handgrip strength had no significant effect on oral and denture hygiene in older, non-frail people.

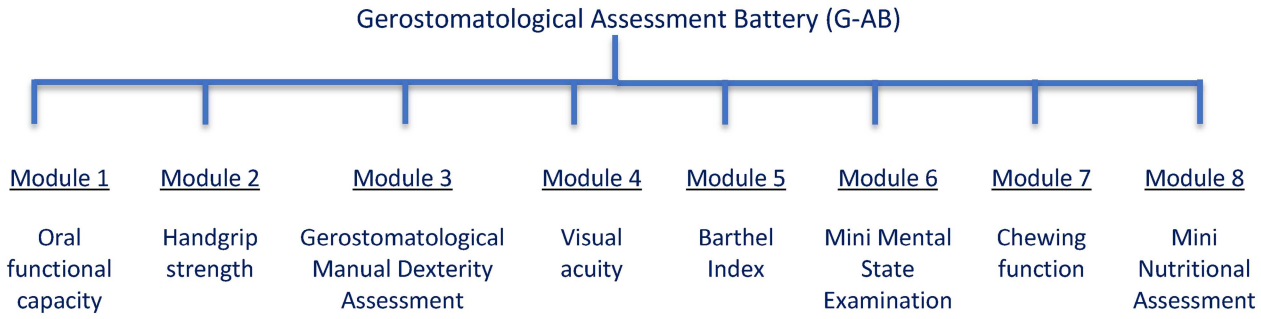
The study also proposes a Gerostomatological Assessment Battery (G-AB), consisting of eight modules, including measures of

| Females | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Agnew et al. 1988[19] | | Desrosiers et al. 1995[a 20] | | Wittich & Nadon 2017[c 21]w | | Nitschke et al. 2023 (data from this study)[b] | | | |
| Mean | SD | Mean | SD | Mean | SD | Age [years] | Hand | Mean | SD |
| $n=121$ total | | $n=60$ per age group | | | | | | $n=12$ | |
| / | | / | | / | | 20–29 | D | 17.5 | 1.2 |
| / | | / | | / | | | ND | 17.1 | 1.6 |
| / | | / | | / | | | B | 14.3 | 1.2 |
| | | | | | | | | $n=11$ | |
| / | | / | | / | | 30–39 | D | 17.4 | 1.8 |
| / | | / | | / | | | ND | 16.0 | 1.5 |
| / | | / | | / | | | B | 13.9 | 1.7 |
| | | | | | | | | $n=10$ | |
| 15.9 | 1.45 | / | | / | | 40–49 | D | 17.4 | 2.1 |
| 15.2 | 1.48 | / | | / | | | ND | 15.9 | 2.3 |
| 13.1 | 1.56 | / | | / | | | B | 13.1 | 1.1 |
| | | | | | | | | $n=10$ | |
| 15.0 | 1.56 | / | | / | | 50–59 | D | 14.7 | 1.9 |
| 14.4 | 1.69 | / | | / | | | ND | 13.0 | 2.9 |
| 12.1 | 1.30 | / | | / | | | B | 10.3 | 1.6 |
| | | | | $n=9$ | | | | $n=8$ | |
| 14.6 | 2.0 | 14.3 | 1.3 | 9.6 | 2.7 | 60–64 | D | 17.1 | 0.6 |
| | | | | | | | ND | 16.1 | 1.0 |
| | | | | | | | B | 12.0 | 1.1 |
| 13.9 | 1.8 | 13.7 | 1.3 | 8.9 | 2.6 | | | $n=7$ | |
| 11.6 | 1.9 | 10.9 | 1.5 | 7.5 | 2.4 | 65–69 | D | 13.0 | 0.6 |
| | | | | | | | ND | 11.0 | 5.0 |
| | | | | | | | B | 8.2 | 4.3 |
| | | | | $n=18$ | | | | $n=13$ | |
| 13.8 | 1.3 | 12.7 | 1.8 | 8.7 | 2.4 | 70–79 | D | 12.7 | 2.5 |
| 12.9 | 1.5 | 11.8 | 1.8 | 7.5 | 2.3 | | ND | 12.2 | 1.7 |
| 10.5 | 1.2 | 9.7 | 1.7 | 5.7 | 2.1 | | B | 9.9 | 2.1 |
| | | | | $n=43$ | | | | $n=7$ | |
| 12.9 | 1.8 | 11.5 | 1.8 | 7.3 | 2.7 | 80–89 | D | 11.4 | 1.3 |
| 11.3 | 2.1 | 10.7 | 2.1 | 7.0 | 2.5 | | ND | 11.3 | 2.7 |
| 9.2 | 1.9 | 8.3 | 1.9 | 5.0 | 2.2 | | B | 8.9 | 1.5 |

oral functioning, handgrip strength, manual dexterity, visual acuity and cognitive assessments. The G-AB aims to identify patients with impaired functional or cognitive abilities to provide dentists with additional information for treatment planning. Manual dexterity is considered critical for oral and prosthetic hygiene, leading to the proposal of a G-MDA. This will enable more personalized and accurate treatment planning based on the specific needs of each patient.

The results of this study can help dentists to better understand individual skills and take targeted measures to improve oral and denture hygiene. As the factors studied—handgrip strength, visual acuity and manual dexterity—do not have a significant impact on oral and denture hygiene in older, non-frail people, other factors may play a greater role in maintaining oral health. This should be investigated in the future.

(A)




(B)

**Module 3**

Gerostomatological Manual Dexterity Assessment - Purdue® Pegboard

*(use of both hands, 30s ; max. 25 pins per side possible)*

| Age | Manual dexterity (n=Mean number of pins) | | | | | |
|---|---|---|---|---|---|---|
| | Normal (n) | | Reduced (n) | | None | |
| | ♂ | ♀ | ♂ | ♀ | ♂ | ♀ |
| 60-69 years | 10 | 10 | ≤ 9 | ≤ 9 | Patient is unable to perform the test due to cognitive and/or visual or physical impairments | |
| 70-79 years | 9 | 10 | ≤ 8 | ≤ 9 | | |
| 80-89 years | 8 | 9 | ≤ 7 | ≤ 8 | | |

Therapeutic consequences in dentistry

according to the g-3-S gerostomatological treatment principle for geriatric patients [40]

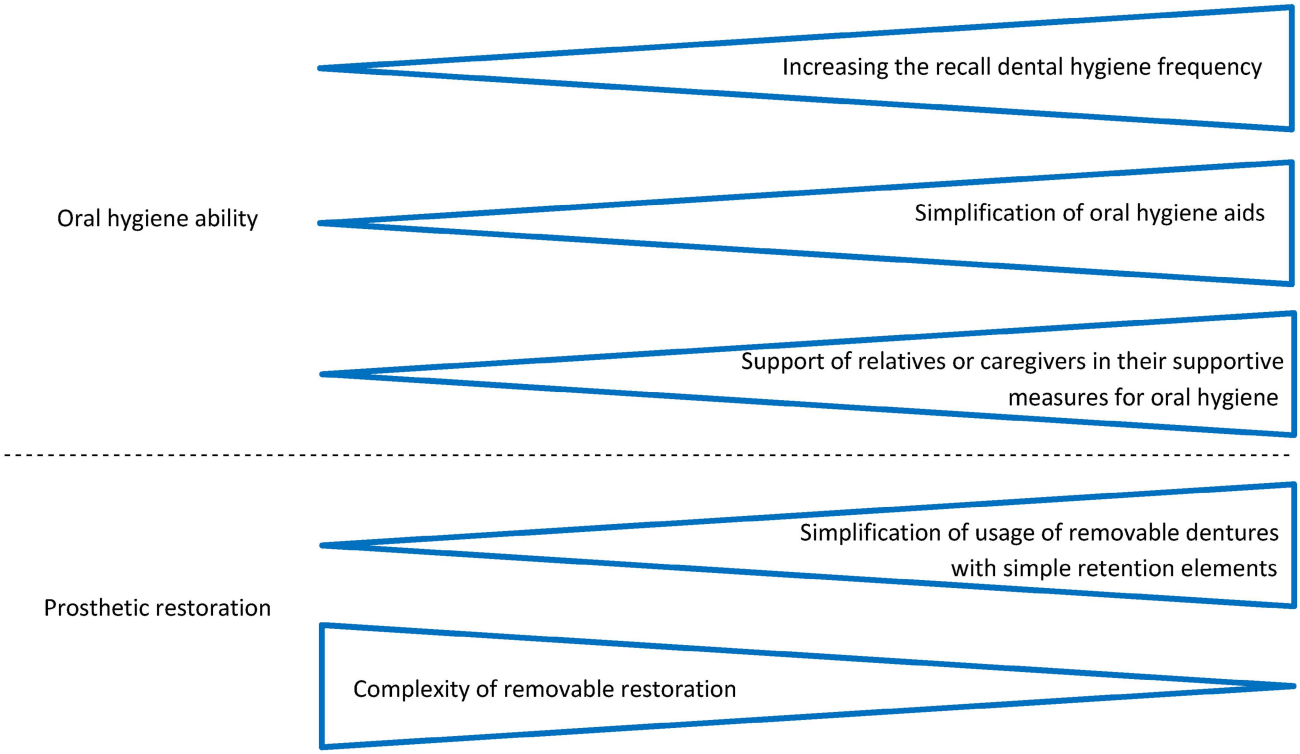



FIGURE 3 (A) Gerostomatologic Assessment Battery (G-AB) and its eight modules. (B) Gerostomatological Manual Dexterity Assessment and its therapeutic consequences in gerostomatology. (Module 3) Mean number of pins for normal function are resulting from the benchmarks for the Purdue® Pegboard for both hands by age and gender by Agnew et al. 1988,[19] Desrosiers et al. 1995*[20] and Nitschke et al. 2023 (this study) (Table 3). Reduced mean number of pins values are introduced by the authors.

## 4.2 | Study design limitations

The exclusion of cognitively impaired participants limits the resulting data in terms of informative value and generalizability while concentrating on non-frail people.

Due to the limited study population, however, it is possible to exclude other confounders of oral hygiene ability (e.g. reduced activities of daily living, cognitive impairments and diseases that restrict manual abilities). More extensive studies would be needed in this area.

There is no comparison in the present study between participants who brushed their teeth with either a manual or an electric toothbrush during the study period. There was no regard for the time spent brushing their teeth.[14] The question, therefore, arises as to whether these two factors would have made it possible to evaluate other findings concerning oral hygiene. The present study was not designed to examine these aspects.

In addition, data from patient surveys (eliciting information on the use of oral hygiene aids) must be assessed regarding bias. In the field of dentistry, the patient is taught from childhood onwards that prophylaxis comprising individual and professional oral hygiene is partly the responsibility of the patient himself. In addition, the patient in dentistry is more often included as a co-therapist in prevention activities than in medicine. It can therefore be assumed that participants know from the outset which answers are socially desirable. Another bias cannot be excluded, as only one dental examiner is responsible for all dental procedures, examinations and data collection. However, the use of only one examiner has the advantage that especially older participants trust and recognize this examiner, and thus, better participation could be guaranteed.

In the present study, the toothbrush was not renewed within the intervention period of 6 weeks, regardless of the individual period of use. With increasing time of using a toothbrush, wear and tear can occur, resulting in a reduced cleaning effect. The authors assume that this effect is insignificant in the case of the current study for the duration of only 6 weeks.

## 4.3 | Handgrip strength

Only a few studies with greatly differing populations are currently available regarding the influence of handgrip strength on the oral hygiene of older people. Lee investigated that older people with low handgrip strength showed poorer oral self-care habits.[11] Poole et al.[43] found lower handgrip strength values in patients suffering from scleroderma with poor oral hygiene than in those with good oral hygiene. Komulainen et al.[12] pointed out that the activities of daily living rather than handgrip strength were a decisive determinant for the individual oral hygiene ability of older patients living at home. Nevertheless, Moriya et al.[44] could show that there is a positive correlation between handgrip strength and the Geriatric Oral Health Assessment (GOHAI). Guimaraes et al. also concluded[45] that patients with myotonic dystrophy may have different negative effects on oral health due to weakness in the hand muscles. A reduction in handgrip strength and manual dexterity were found to be independent risk factors for the accumulation of dental plaque in older people.[46] Since the study by Shin et al. used a different method in revealing dental biofilm,[46] the results are not comparable to this study. Yun and Lee (2000) reported an association of handgrip strength with the utilization of complete dentures and a low number of remaining teeth in older men.[22] Aravindakshan et al. (2020) observed lower grip strength in individuals with moderate or severe periodontitis but emphasized a multifactorial aetiology for this observed association, primarily attributed to older age and common risk factors for periodontitis and frailty.[47]

It is possible that handgrip strength in the observed population is better than in older people with physical functional limitations living in LTCFs. But since a toothbrush only weighs approx. 20 grams, this would not explain the lack of correlation between handgrip strength and oral hygiene. Other factors or a combination of different factors, for example reduced handgrip strength and a loss in coordination skills, might be an explanation and should therefore be further investigated. In this study, no statistically significant correlation between the handgrip strength of the dominant hand and the oral hygiene ability of the participants was observed. A study by Felder et al. showed a significant correlation between handgrip strength and the amount of dental plaque measured with the modified QHI. Almost half of the participants lived in LTCFs and showed significantly lower handgrip strength and greater amounts of dental plaque than those living independently.[14] A study by Hamalainen et al.[48] of 80-year-olds found a steeper decline in handgrip strength over 5 years in patients with periodontitis compared to patients without periodontitis. The results were adjusted to age, gender, weight, number of chronic diseases and physical activity to minimize the influence of possible confounding factors. Oral hygiene itself was not evaluated in this study, but conclusions were drawn from the measured probing depths (< or >4 mm).

## 4.4 | Manual dexterity

Regarding the influence of manual dexterity on the oral and denture hygiene ability of older people, contradictory results exist.[13–17] The majority of studies dealing with the influence of manual dexterity on oral hygiene ability examined senior citizens living in care facilities.[13–15] This means that considerably more interfering influences (cognitive restrictions, multi-morbidity, etc.) must be expected than in a collective of seniors living independently at home. Milleman et al. observed that poorer manual dexterity limits flossing ability.[49] Since flossing is a difficult task that requires good manual dexterity in both hands, these results cannot be compared to this study where only manual tooth and denture brushing was investigated. Additionally, in this study, a connection between manual dexterity and oral hygiene ability (as observed by means of the QHI) was not

detected while other studies demonstrated that reduced manual dexterity may be a predictor of poor oral health in terms of dental biofilm accumulation.[23]

The manual dexterity of the dominant hand in the Purdue Pegboard test, which was expected to be the factor with the presumed greatest influence on oral hygiene, showed no statistically significant association with oral hygiene ability in this study. In a study by Felder et al.[14] on seniors, a significant association between manual dexterity and oral hygiene was shown. Four different dexterity tests were used, including the Toothbrushing Ability Test (TAT), which directly evaluates tooth brushing. The modified QHI was used as a measure of oral hygiene. In addition, a measurement of handgrip strength was performed. Nearly half of the participants lived in a LTCF. These participants showed significantly poorer manual dexterity and larger amounts of dental plaque. The study by Felder et al. did not use the Purdue Pegboard to determine manual dexterity. In addition, participants in need of care were included, which does not allow a comparison of the results with the present study.[14]

In the study by Padilha et al.[13] on 49 residents of long-term care over 60 years of age (Mean age: 75.1), a correlation between manual dexterity and the amount of dental plaque could be established. Participants with poorer results in the Purdue Pegboard test had (after adjustment for age, gender and cognitive status) significantly more plaque on teeth and dentures.

### 4.5 | Visual acuity

Previous studies only produced contradictory results with regard to the influence of visual acuity[50–52] on the oral and denture hygiene ability of older people. Wittich and Nadon[21] were able to show that visual acuity had an important influence on the manual dexterity of older volunteers. The observation that visual acuity seems to have no influence on the oral hygiene ability of older non-frail people could be explained by the fact that visual acuity is not directly needed for brushing teeth. Brushing teeth with a toothbrush and toothpaste alone is often an early childhood trained skill that develops into an automatism. Therefore, visual impairment in old age does not seem to have much influence on oral hygiene. It should be noted, however, that today's older people have often come to know the additional aids, such as interdental brushes, only later in adulthood when automatisms may be more difficult to develop. This requires further investigation.

### 4.6 | Clinical, theoretical and practical implications

Clinical implications include that older women, due to their better manual dexterity, may be better able to perform certain oral and denture care measures. These may include proper tooth brushing, flossing or handling of dental prosthetics. This could lead to improved oral hygiene and reduced risk of cavities, periodontal diseases and other oral problems in older female patients. Due to lower hand grip strength in women, certain dental treatments or therapeutic devices that require higher grip strength may need to be adjusted for older female patients. Dentists should consider using alternative techniques or aids to ensure that older female patients receive treatment and therapeutic devices that meet their individual needs and abilities.

The identified gender differences in manual dexterity and hand grip strength, from a theoretical perspective, may be attributed to biological and genetic factors, as well as social and cultural influences. This could lead to further theoretical investigations to better understand the underlying mechanisms, such as the role of hormones, muscle mass or different lifestyles. This knowledge could contribute to the development of personalized treatment approaches that cater to the individual abilities and needs of older patients.

Practical implications include that awareness of gender differences in manual dexterity and hand grip strength can help dentists and dental professionals in gerodontology customize and individualize their treatment approaches. This may involve providing specific instructions for oral and denture care to older female patients to optimize their manual dexterity while incorporating ergonomic aids or alternative techniques for older male patients to overcome challenges associated with reduced dexterity. It is important to note that each patient is unique, and individual differences, as well as other factors such as physical health, cognitive abilities and personal preferences, should be considered to ensure comprehensive and patient-centred care in gerodontology.

### 4.7 | Requirement for further studies

Compared to other studies dealing with the same topic, it is noticeable that the focus was on vulnerable older people. In this study, however, healthy, non-frail older people were included. The conclusion that visual acuity, manual dexterity and handgrip strength do not seem to have an influence on oral and denture hygiene is therefore limited. However, since the deterioration of these two parameters can be observed in everyday dental practice with an increase in the need for assistance and care, it can be assumed that these factors (a) have an influence on other patient groups (vulnerable, in need of care, with co-morbidities) and (b) the process of deterioration of oral and denture hygiene is multifactorial. Therefore, the authors suggest that further studies on this should be conducted. Accordingly, due to the probable multifactorial relationships, other geriatric aspects should also be included in the evaluation. This is considered with the proposal of the G-AB including the GMDA. With the GMDA, an attempt was made to use the manual dexterity measurement as a basis for dental therapeutic approaches in older people. Particularly for the assessment of oral hygiene ability and prosthetic denture therapy planning, indications of manual dexterity can support and help to prevent failures in the context of individual prophylaxis and the handling of removable dentures.

It should be considered whether there is a connection between the ability to adapt to dentures and handgrip strength. Adapting to dentures or the ability to successfully handle dentures could be better assessed with the knowledge of handgrip strength. This tool is designed to make it easier to assess patients and help dentists to better foresee the outcome of planned therapy.

## 5 | CONCLUSION

Visual acuity, manual dexterity and handgrip strength have no influence on oral and denture hygiene in older non-frail people when using manual tooth and denture brushes.

The use of a G-AB can help to evaluate multicausal processes within the deterioration of oral and denture hygiene, review dental therapy approaches and adapt them individually. Further research is needed with different groups of participants (fit, frail, in need of care).

### AUTHOR CONTRIBUTIONS

I.N. and M.R.K. contributed to study conception and design; I.N. and J.J. contributed to methodology; A.A. performed screening; A.A. and J.J. performed data extraction and curation; I.N., A.A. and J.J. performed data analysis; A.A. and J.J. wrote the first draft; I.N., M.R.K. and B.S. critically edited the manuscript. All authors gave their final approval and agreed to be accountable for all aspects of the work. I.N. and A.A. contributed equally to this paper (equal contribution, joint first authorship).

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### CONFLICT OF INTEREST STATEMENT

The authors have no competing interests to declare that are relevant to the content of this article.

### DATA AVAILABILITY STATEMENT

Data collected for this study are available upon reasonable request to authors.

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