

Characteristics of effective toothbrushing: results of the 6th German Oral Health Study (DMS • 6). Online Appendix

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ABSTRACT

Objective: The objective was to better understand why toothbrushing often fails to achieve the desired state of plaque-free dentition, by systematically analyzing toothbrushing behavior in four age groups (12-year-olds, 20-year-olds, 35- to 44-year-olds, 65- to 74-year-olds).

Method and Materials: Analyzable video recordings of toothbrushing, as well as plaque scores assessed immediately after brushing, were available from 1,941 participants of the 6th German Oral Health Study (DMS • 6). All videos were analyzed in terms of tooth contact time (TCT), use of interdental cleaning aids, and type of toothbrush (electric/manual). A more detailed analysis of oral hygiene behavior was conducted in two extreme groups comprising the 10% of adults who showed the lowest (n = 35) vs the highest (n = 33) Plaque scores after manual brushing.

Results: Only younger seniors (65- to 74-year-olds) showed a mean TCT below 2 minutes. Interdental cleaning was practiced by 25% of the participants, while 44% used electric toothbrushes. The extreme-group comparison revealed significant differences across all observed behavioral aspects, except for correct dental floss use, which no participant was able to master. The use of interdental cleaning aids was associated with a more elaborate toothbrushing behavior.

Conclusions: These findings highlight the critical role of toothbrushing behavior in achieving oral cleanliness. The extent of plaque removal is associated with various aspects of toothbrushing behavior.

KEYWORDS: cross-sectional studies, dental care, dental health surveys, dental plaque, dentists, DMS 6, epidemiology, Germany, oral health, oral hygiene, primary prevention, secondary prevention, toothbrushing

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Appendix 1

Description of the video analysis procedure

Overall Screening

All toothbrushing recordings were reviewed regarding the following aspects:

- Clear identification of the test subject
- Assessability of start and end of the toothbrushing process
- Type of toothbrush used (electric, manual, both)
- Interdental hygiene (Performance, used tools)
- Presence of fixed orthodontic appliances
- Analysis of tooth contact time (TCT) (see below)

To ensure consistency in the observations, 10% of the videos were double coded by a second observer. The agreement between the two evaluations was $\geq 96\%$. The TCT was verified by calculating the intraclass correlation coefficient (ICC), which was $ICC > 0.94$.

Extreme-group comparison

Toothbrushing behavior was analyzed using category systems of the IMP Giessen (Weik et al. 2023; Weik et al. 2022; Petker-Jung et al. 2022) with the INTERACT® observation software (Version 18, Mangold International GmbH, Arnstorf, Deutschland). During the analysis, video observers were blinded towards the group affiliation of the participants.

First, the TCT was measured to determine the duration of tooth contact of the toothbrush and the tooth surface. Any interruptions were classified as 'no tooth contact'. If tooth contact could not be visually assessed, the sequence was coded as 'unassessable/not visible'. During this TCT, the *surfaces* (occlusal, vestibular oral) and *sextants* (1-6) brushed, as well as the *brushing movements* used (circular, horizontal, vertical, Bass technique or no movement) were observed. It was also assessed whether *interdental cleaning* was performed, and which cleaning aids were used (dental floss, flosspicks, interdental brushes, tooth sticks). Finally, it was determined whether floss was applied correctly (van der Weijden und van Loveren 2023).

For double coding, a calibrated observer who had not yet been involved in the analysis reanalyzed 10% of the recording. ICC values were ≥ 0.8 for the parameters TCT, surfaces, sextants, and brushing movements. Agreement for interdental cleaning was $\geq 80\%$.

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Appendix 2

Table A2: Oral hygiene aids used in video observations by gender (overall screening)

	Gender	
	male	female
Interdental cleaning		
Yes	178 (18,2%)	308 (32,1%)
No	796 (81,4%)	644 (67,2%)
Unclear	4 (0,4%)	7 (0,7%)
Toothbrush type		
Electric	428 (43,8%)	412 (43,0%)
Manual	543 (55,5%)	540 (56,3%)
Electric and manual	7 (0,7%)	7 (0,7%)

Appendix 3

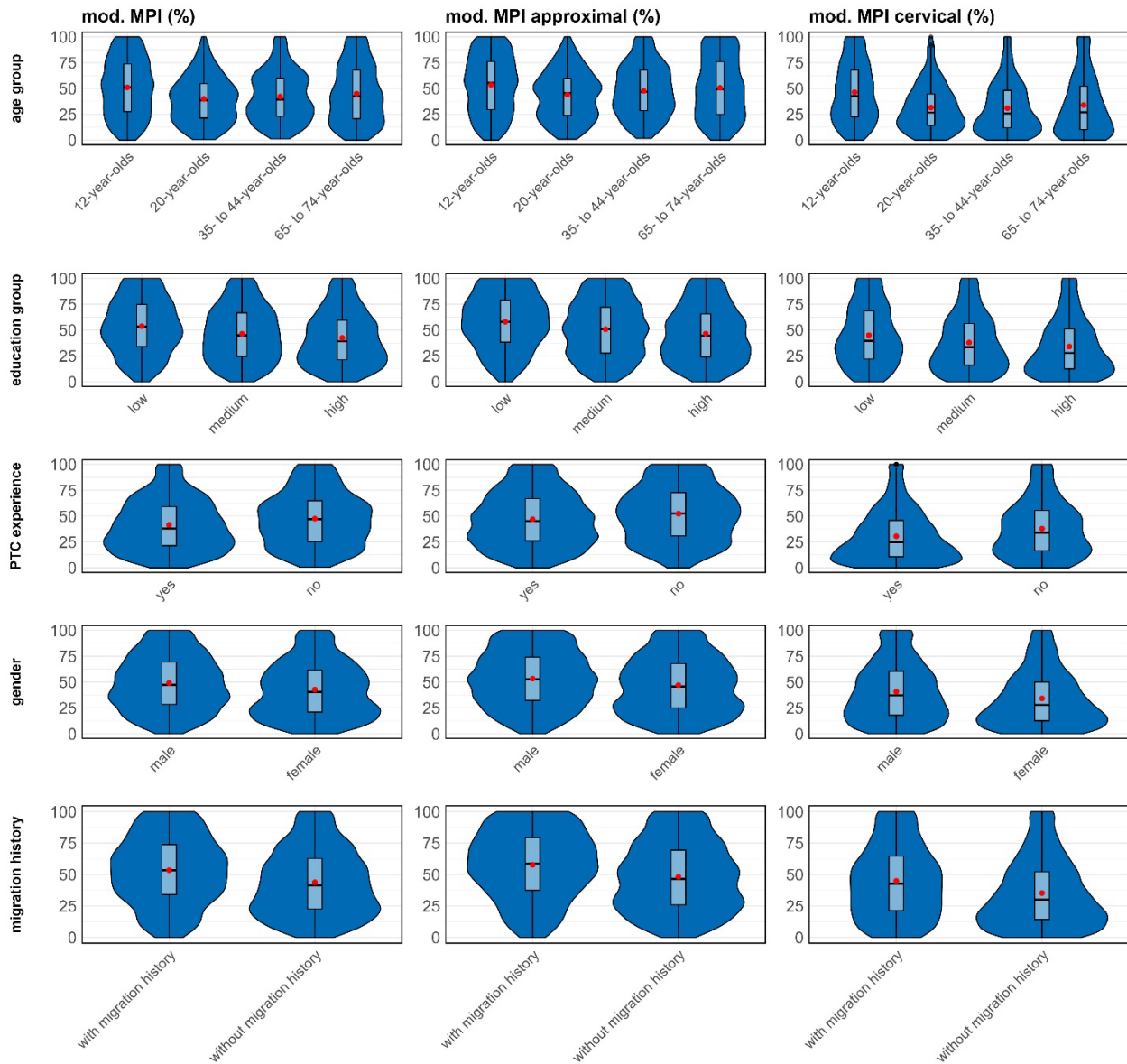


Fig 3 Association between age group, education group, PTC experience, gender, migration history and the modified Marginal Plaque Index (mMPI).

The violin plots illustrate the distribution of the mMPI (overall, approximal, and cervical) by education group, PTC experience, gender, migration history.

The red dot indicates the mean. The black line represents the median. The ends of the box correspond to the 25th and 75th percentiles, respectively. The whiskers extend to 1.5 times the interquartile range. The black dots represent outliers.

Gender-diverse individuals (n = 3) were included in stratified analyses by education group, PTC experience, and migration history, but were excluded from gender-stratified analyses.

Appendix 4

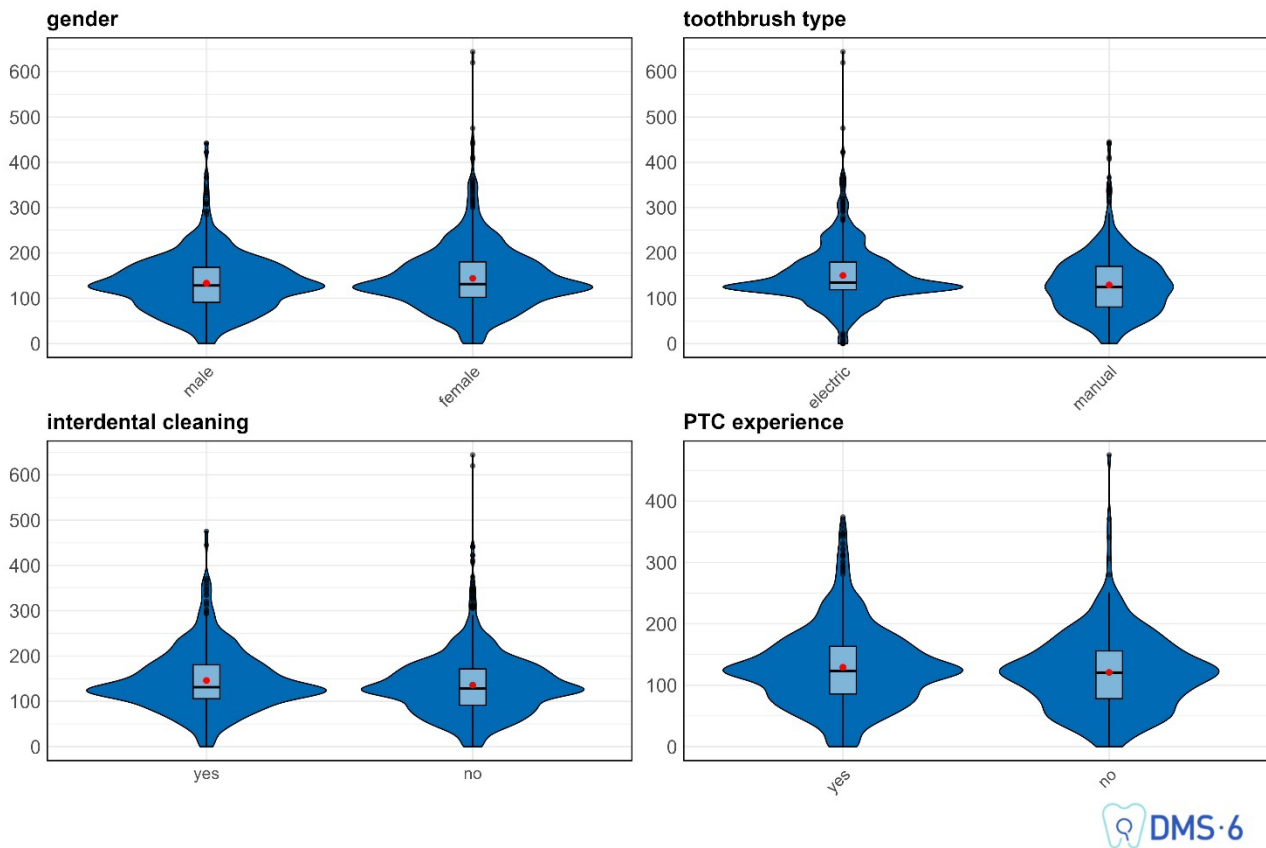


Fig 4 Total tooth contact time by gender, toothbrush type, interdental cleaning, and PTC experience.

The violin plots illustrate the distribution of the total tooth contact time (in seconds) by gender, toothbrush type, interdental cleaning, and PTC experience.

The red dot indicates the mean. The black line represents the median. The ends of the box correspond to the 25th and 75th percentiles, respectively. The whiskers extend to 1.5 times the interquartile range. The black dots represent outliers.

Gender-diverse individuals ($n = 3$) were included in stratified analyses by toothbrush type, interdental cleaning, and PTC experience, but were excluded from gender-stratified analyses.

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