

Powered or manual toothbrushing for people with physical or intellectual disabilities – A systematic review

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Abstract

Aims: The aim of this systematic review is to compare the effectiveness of a powered (PTB) and a manual (MTB) toothbrush in the hands of people with physical (PD) or intellectual (ID) disabilities or in the hands of a caregiver on parameters of plaque and gingival inflammation.

Methods: MEDLINE-PubMed, Cochrane-CENTRAL and EMBASE databases were searched from initiation up to February 2022. The inclusion criteria were clinical trials conducted in people with PDs or IDs and comparing the effect of toothbrushing with a PTB to an MTB on plaque removal and gingival health. Data were extracted from the eligible studies and analyzed in four subgroups based firstly on the person performing the toothbrushing, either the participants or a caregiver, not a dental professional, and secondly on the main disability of the participants, either PD or ID. Heterogeneity and risk of bias were assessed, data were extracted from the eligible studies, and a descriptive analysis was performed.

Results: The search yielded 294 unique papers; after selection 16 eligible publications describing 25 comparisons were included: 12 self-brushing and 13 caregiver-brushing comparisons. Considerable clinical and methodological heterogeneity was present; together with limited numerical data, not allowing for a meta-analysis. The descriptive analysis showed, in the majority, no statistically significant difference between PTB and MTB. This applied to self-brushing and caregiver-brushing in both disability groups.

Conclusion: This review demonstrates with a low level of evidence that a PTB compared to an MTB in the hands of people with PD or ID or in the hands of their caregivers results in no clinical difference in effectiveness on parameters of plaque and gingival inflammation.

KEYWORDS

caregiver, disability, manual, powered, systematic review, toothbrush

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1 | INTRODUCTION

Good oral hygiene through effective toothbrushing plays an important role in maintaining oral health. People with physical (PD) or intellectual disabilities (ID) are consistently reported to have poorer oral hygiene than the general population, with higher levels of dental plaque and gingivitis.^{1–6} Toothbrushing is a complex sequential task that requires manual dexterity.⁷ It is possible that people with PD lack the manual dexterity to brush effectively. Similarly, people with ID may lack the cognitive skills to perform a sequential task such as daily toothbrushing. In addition, people with ID, also those with mild or borderline ID, are more likely to have impaired motor function, impacting their manual dexterity as well.⁸ People with PD may also have ID, for instance, approximately 50% of those diagnosed with cerebral palsy (CP) also have an ID.⁹ As a consequence, people described as having PD or ID may face similar barriers in achieving an effective toothbrushing technique. Nevertheless, in studies often the main disability being PD or ID is taken into account. To improve the oral hygiene of people with PD or ID, toothbrushing may be performed by caregivers, but even then, toothbrushing effectiveness is often limited.^{10–12}

Since the 1960s, the use of a powered toothbrush (PTB) has been suggested for people with disabilities, who may have difficulty mastering an effective manual brushing technique.¹³ Furthermore, in cases where a caregiver performs or assists with oral hygiene tasks, the PTB was suggested as a useful tool.¹³ However, at the time PTB's superiority over the manual toothbrush MTB could not be established.^{14,15} Recent systematic reviews of healthy individuals indicated that a PTB removes significantly more plaque and reduces gingivitis more than an MTB.^{16,17} However, a recent Cochrane review of the effectiveness of a PTB for those with ID found moderate- and low-certainty evidence for no difference between PTBs and MTBs in reducing the gingival index and plaque scores in the medium term and inconsistent results for the short-term.¹⁸ In this review, no distinction was made between participants brushing their own teeth and those whose teeth were brushed by a caregiver, while research has shown that differentiating between self-brushing and caregiver-brushed individuals may be important when selecting a toothbrush for people with disabilities.¹⁹ Moreover, studies evaluating people with PD were not included in this review.

In summary, it remains unclear whether a PTB would improve the oral hygiene of people with PD or ID who either brush their teeth themselves or depend on a caregiver for daily toothbrushing. Currently, this specific comparison is lacking in the scientific literature. Therefore, this systematic review aims to aggregate and critically appraise the literature comparing the effectiveness of a PTB and a

MTB in the hands of people with PD or ID or in the hands of their caregivers on parameters of plaque and gingival health.

2 | MATERIALS AND METHODS

This systematic review was prepared and described in accordance with the Cochrane Handbook for Systematic Reviews of Interventions²⁰ and the guidelines of Transparent Reporting of Systematic Reviews and Meta-Analyses.²¹ If meta-analysis was not feasible, the reporting guideline for synthesis without meta-analysis (SWiM) in systematic reviews was applied.²² The protocol that details the review method was developed a priori and registered at PROSPERO by CRD42022151212 following an initial discussion among the research team members.

2.1 | Focused question

What is the effectiveness of a PTB compared to an MTB in the hands of people with PD or ID or in the hands of their caregivers on parameters of plaque and gingival inflammation.

2.2 | Search strategy

A structured search strategy was designed to retrieve all relevant studies. The National Library of Medicine, Washington, D.C. (MEDLINE-PubMed), the Cochrane CENTRAL Register of Controlled Trials (CENTRAL), and EMBASE were searched from initiation up to February 2022 for appropriate papers that answered the focused question. Furthermore, the reference lists of the included studies were hand-searched to identify additional potentially relevant studies. No further hand-searching was performed other than the Cochrane worldwide hand-searching program, which is uploaded to CENTRAL. For details regarding the search terms used, see Table 1.

2.3 | Screening and selection

Two independent reviewers (S.K.S. and C.V.) screened the titles and abstracts of the studies obtained from the searches using the Rayyan web application²³ to select studies that potentially met the inclusion criteria. There were no language restrictions. The full-text versions of potentially relevant papers were obtained based on the title and abstract. After the independent screening process, the search was unblinded, and the conflicts that were identified by Rayyan were resolved by the reviewers.

TABLE 1 Search terms used.

The search strategy was customized according to the database being searched. The following strategy was used for PubMed

{(< Patient > and < intervention >)}

<patient>

{< [(MeSH terms) (developmental disabilities) OR (disabled persons) OR (neuromuscular diseases) OR (intellectual disability) (text words) (developmental disorder)OR handicapped OR handicap* OR disability OR disabled OR impairment OR impaired OR compromised OR retardation OR retarded OR disorder OR (mental disorders) OR (disabled persons) OR (cerebral palsy) OR (neuromuscular disorder) OR (intellectual disability) OR syndrome OR (mental retardation)>

and

<intervention>

<[(MeSH terms) Toothbrushing OR oral hygiene OR (text words) toothbrush OR toothbrushing OR toothbrush OR (oral hygiene strategy)]

and

[(text words) (power OR electric OR sonic OR automatic OR mechanical)] >}

The asterisk (*) was used as a truncation symbol.

The included studies were considered to meet the following criteria:

1. the design was either a randomized controlled clinical trial (RCT) or a controlled clinical trial (CCT),
2. the study was conducted in humans with PDs or IDs,
3. the participants were not wearing fixed orthodontic appliances,
4. the study compared the effect of a PTB to an MTB on parameters of plaque and/or gingival inflammation,
5. toothbrushing was performed by either the participants or by a parent, nurse or other caregiver responsible for daily oral hygiene. Assisted-brushing groups were considered caregiver-brushed. Mixed groups, in which self-brushers and caregiver-brushed subjects were assessed in the same group were excluded. Dental care professionals were excluded as caregivers.

Studies in which participants had a visual impairment, autism, or care dependency because of high age, dementia, or stroke as their primary and only disability were excluded. Two reviewers (S.K.S. and C.V.) independently performed the screening and selection, quality assessment, and data extraction using specially designed forms. Disagreement between the reviewers was resolved by discussion and consensus. If disagreement persisted the judgement of a third reviewer (D.E.S.) was decisive.

2.4 | Assessment of heterogeneity

The following factors were considered to explain the heterogeneity of the outcomes of the different studies: study design, subject characteristics, brushing regimen, adverse effects, and industry funding (for details, see Online Appendix A).

2.5 | Assessment of methodological quality and risk of bias

The studies were classified as having an estimated low, moderate, or high risk of bias (ROB), using a checklist as detailed in Online Appendix B.^{24,25} In summary, a study was classified as having an estimated low ROB when random allocation, defined eligibility criteria, masking of examiners, balanced experimental groups, identical treatment between groups (except for the intervention) and reporting of follow-up were present. The study was considered to have an estimated moderate ROB when one of these six criteria was missing. When two or more of these criteria were missing, the study was estimated to have a high ROB. The experimental groups were considered balanced (item 7 in Online Appendix B) if the participants were their own control, as in crossover studies, or their characteristics were assessed at baseline and found statistically balanced.

2.6 | Data extraction

Means and standard deviations were extracted if available. In case of missing or incomplete numerical data, the original authors were contacted if possible and requested to provide these additional data. If numerical baseline and intermediate or end data were available, the percentage reduction per index score was calculated for each toothbrush group of the included studies. Data retrieved from studies presenting a crossover design were assessed as those from parallel designs.

2.7 | Data analysis

Analyses were performed in four subgroups, based firstly on the individual performing the toothbrushing: the

participants themselves (self-brushing) or a caregiver (caregiver-brushing) and secondly on the main disability of the participants, be it ID or PD. A quantitative meta-analysis was planned, conditional upon a minimum of two comparisons in the same subgroup using the same scoring index for single-use and multiple-use studies separately, using a random effect model of the mean difference as a summary effect measure. A descriptive data presentation of the statistical significance of individual study outcomes²⁶ was used for all studies, as a summary.

2.8 | Grading the body of evidence

The Grading of Recommendations Assessment, Development and Evaluation (GRADE) system²⁷ was used to appraise the evidence emerging from this review per subgroup. Three reviewers (S.K.S., C.V., D.E.S.) independently rated the quality of the evidence and the strength and direction²⁸ of the recommendations according to the following aspects: ROB, consistency of results, directness of evidence, precision of data, publication bias, and magnitude of the effect. Any disagreement between the reviewers was resolved after additional discussion with a fourth reviewer (G.A.W.).

3 | RESULTS

3.1 | Search and selection results

Figure 1 shows the results of the search and selection of the included publications. Out of the 294 unique titles and abstracts there were two conflicts (<1%) scored by the two reviewers. In total, 16 publications^{29,30,31–38,39–44}, describing 25 comparisons were included in this systematic review.

3.2 | Study characteristics and heterogeneity assessment

Detailed information regarding the heterogeneity of study characteristics can be found in Online Appendix B, and an overview summary is presented in Table 2. The included studies exhibited extensive heterogeneity in study design, duration, number and age of participants, and brushing regimen. In addition, a variety of indices and their modifications was used to measure plaque and gingival inflammation. In four studies scoring was applied on a selection of teeth or on a limited number of tooth surfaces.^{33,38,41,43} The primary disability, either PD or ID, varied by the used definition and description.

3.2.1 | Comparisons with self-brushing participants

Twelve comparisons described a total of 347 self-brushing participants; 37 teenagers and young adults with PD in two comparisons^{31,32} and 310 children and adults (age range 6–79 years) with ID in 10 comparisons.^{29,33,37–39,41–44} The PD of the participants was described as Apert-syndrome with syndactyly in one study³¹ and as differently abled and mentally undisturbed in the other.³² Both studies evaluated a single-brushing exercise in a cross-over design. The comparisons with participants with ID had a study duration of one week³⁹ up to 16 months.⁴² The level of the ID of the participants varied from mild to severe or was unspecified.

3.2.2 | Comparisons with participants brushed by a caregiver

Thirteen comparisons described a total of 360 caregiver-brushed participants: 125 with PD in five comparisons^{34–36,40} and 235 with ID in eight comparisons.^{29,30,38,41,42,44} Study duration varied from a single brushing exercise^{30,35} to 16 months.⁴² The participants with PD as primary disability were children with CP in three of the five comparisons. The other two comparisons were part of one study³⁴ with participants with a neuromuscular disability (age range 16–79 years) who were evaluated in two subgroups of participants with or without communication ability. The participants with ID were children and adults (age range 2–64 years) and all levels of ID were represented. One study³⁰ evaluated only children with Down syndrome.

3.3 | Methodological quality and risk of bias assessment

The methodological quality and potential ROB of the included studies were assessed using a checklist as presented in detail in Online Appendix B, and the overall result is included in Table 2. As the studies focused on the use of powered or manual toothbrushes, blinding those who brushed to the intervention was not possible. Based on a summary of the proposed criteria, the estimated potential ROB was low for eight studies^{32–36,39,40,43}, moderate for five studies^{29,30,37,38,41}, and high for three studies.^{31,42,44}

3.4 | Study outcomes

The data extraction results for the plaque and gingival inflammation indices are presented in Online Appen-

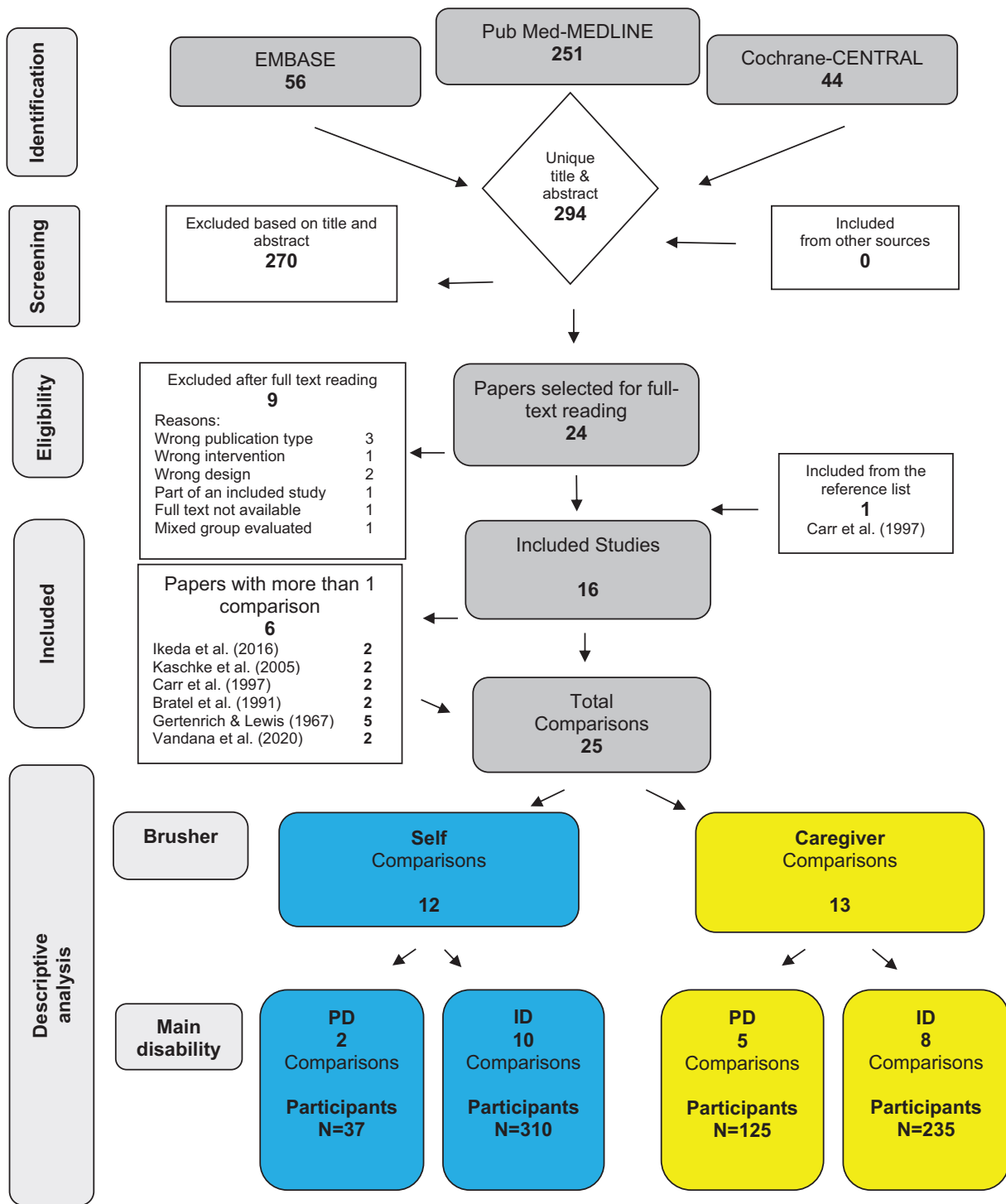


FIGURE 1 Flowchart of the search and selection process

dices C and D. All 25 comparisons measured plaque, 13 also measured gingival inflammation. The comparisons were analyzed in four subgroups based firstly on the person performing the toothbrushing, either the participant or a caregiver, and secondly on the main disability of the participants, either PD or ID. Within each subgroup, studies were ordered chronologically by duration.

3.4.1 | Descriptive analysis

Only a descriptive analysis was possible due to the heterogeneity in study design, participant characteristics, and used indices. In addition, a lack of numerical data was present even after contacting the original authors. Table 3 presents an overview of the individual study outcomes. In all evaluated subgroups, the majority of the studies

TABLE 2 Characteristics of the included studies

Study characteristics					
Authors (year) ROB*	Country Setting	Duration of study (per TB)*	Disability Age group	#Participants Brusher	Conclusion of the original authors
Studies with participants with physical disabilities (PD)					
Kaizer et al. (2018) High	Brazil Hospital Dental Center	Single brushing	Pert syndrome and syndactyly 11–30 years	17 self	Both MTB and PTB significantly reduced the plaque index
Neelima et al. (2017) Low	India Residential care center	Single brushing	Differently abled, no ID adolescents	20 self	MTB was equally effective compared to PTB. Both brushes showed significant plaque-reduction post-brushing.
Ikeda et al. (2016) Low	Japan Hospital	4 weeks	Neuro- muscular disease. 16–79 years	28 caregiver: (18 Ca+ 10 Ca-)	PTB is beneficial for maintaining oral health in patients with neuromuscular disability and is reducing the caregivers' oral care burden.
Maiya et al. (2015) Low	India Home	6 weeks	Cerebral palsy 6–18 years	32 caregiver	Generalized reduction of gingivitis and plaque formation independent of the type of brush used.
Ferraz et al. (2015) low	Brazil Rehabilitation Center	Single brushing	Cerebral palsy 16 years	40 caregiver	PTB and MTB were equally effective in removing biofilm.
Bozkurt et al. (2004) low	Turkey Daycare center	3 weeks	Spastic cerebral palsy, no ID 7–21 years	25 caregiver	All oral hygiene strategies reduced plaque and gingival inflammation. The PTB could be more recommendable to neuromuscular disabled people.
Studies with participants with intellectual disabilities (ID)					
Vandana et al. (2020) Moderate	India Home	3 weeks	Mild to moderate ID 15–30 years	30 self	MTB was more effective than PTB in reducing plaque levels in the mentally challenged individuals. ^a
Silva et al. (2020) Moderate	Brazil Health Center	single brushing	Down syndrome 6–14 years	30 caregiver 32 caregiver	PTB and MTB are similarly effective for biofilm removal
Garcia-Carillo et al. (2016) Low	Spain Training center	6 months	Mild-moderate ID adults	64 self	The tested sonic PTB was as effective and safe as the MTB.
Goyal et al. (2011) Moderate	India Residential care center	3 months	Mild-moderate ID 15–25 years	16 self	For mentally challenged individuals MTB reinforced with video instructions may be comparable to the use of PTB.
Kaschke et al. (2005) Moderate	Germany Home	2 weeks	ID 18–45 years	12 self 24 caregiver	Both toothbrushes appear to be suitable for carrying out oral hygiene in disabled people.
Doğan et al. (2004) Low	Turkey School	1 week	Mild ID 6–18 years	30 self	The PTB is the most effective for plaque removal in mentally disabled children.

(Continues)

TABLE 2 (Continued)

Study characteristics					
Authors (year) ROB*	Country Setting	Duration of study (per TB)*	Disability Age group	#Participants Brusher	Conclusion of the original authors
Carr et al. (1997) Moderate	USA Residential care center	12 months	ID 25–64 years	37 self	Those who used the PTB and brushed by themselves had the lowest gingival, debris and calculus scores.
				19 caregiver	
Bratel and Berggren (1991) High	Sweden Hospital dental center	16 months	ID adults	12 self	A PTB is not superior to an MTB.
				11 caregiver	
Shaw et al. (1983) Low	UK School	4 weeks	Severe ID 9–16 years	53 self	With both PTB and MTB plaque and bleeding indices showed highly statistically significant reductions. No significant difference between the brushes.
Gertenrich and Lewis (1967) Phase I High	USA Residential care center	2 months	Down syndrome or severe ID 5–25 years	70 caregiver	The oral hygiene of all patients, whether using the PTB or the MTB, improved.
Gertenrich and Lewis (1967) Phase II High	USA Residential care center	2 months	Severe ID 2–12 years	37 caregiver	PTB and MTB were equally effective.
Gertenrich and Lewis (1967) Phase III High	USA Residential care center	2 months	Moderate ID 15–26 years	12 self	PTB and MTB showed significant improvement. Most significant improvement in the group brushed with a PTB by attendants.
Gertenrich and Lewis (1967) Phase IV High	USA Residential care center	2 months	mild ID 15–30 years	44 self	Both PTB group and MTB group showed significant improvement in oral hygiene. No significant difference in effectiveness between the PTB and the MTB.

Note: Studies are ordered by the main disability of the participants, either physical (PD) or intellectual (ID) and listed by year of publication. For further details see Online Appendix A.

TB/PTB/MTB Toothbrush/powered toothbrush/manual toothbrush.

(per TB)* Duration of brushing period per TB-type.

ROB* Risk of bias (see online Appendix B).

Ca+/Ca- Participants with/without communication ability as described by the original authors.

^a The conclusion is adjusted by the review authors based on contact with the original authors, the original conclusion was that PTB was more effective than MTB.

reported no significant difference in effectiveness between the PTB and the MTB for both plaque removal and changes of gingival inflammation.

3.5 | Grading the body of the evidence

Table 4 shows a summary of the various aspects used to rate the quality of the evidence and the strength of the rec-

ommendations according to the GRADE working group.²⁷ These are presented separately for the four evaluated subgroups. There is a low level of evidence for no clinical difference in effectiveness of a PTB compared to an MTB on plaque removal and reduction of gingival inflammation in the hands of people with disabilities or in the hands of caregivers. This is irrespective of the disability, being either PD or ID.

TABLE 3 A descriptive summary of the statistical significance of individual study outcomes related to the effect on plaque removal and gingival inflammation of tooth brushing with a powered toothbrush compared to a manual toothbrush

Brusher	Main disability	Duration (per TB)*	Authors (year)	Intervention	PI	GI	Control	
self	Physical	single brushing	Kaizer (2018)	PTB	O	□	MTB	
			Neelima (2017)	PTB	O	□	MTB	
	Intellectual	0–2 months	Vandana (2020)	PTB	-	O	+	MTB
			Kaschke (2005)	PTB	O	O	MTB	
			Dogan (2004)	PTB	+	□	MTB	
			Shaw (1993)	PTB	O	O	MTB	
			Gertenrich III (1967)	PTB	O	□	MTB	
			Gertenrich IV (1967)	PTB	O	□	MTB	
			3–16 months	Garcia (2016)	PTB	O	O	MTB
				Goyal (2011)	PTB	O	O	MTB
	caregivers	Physical	0–6 weeks	Ikeda (2016) group Ca+	PTB	+	□	MTB
				Ikeda (2016) group Ca-	PTB	O	□	MTB
				Ferraz (2015)	PTB	O	□	MTB
				Maiya (2015)	PTB	O	O	MTB
Bozkurt (2004)				PTB	+	O	O	MTB
Intellectual		0–2 months	Vandana (2020)	PTB	-	O	O	MTB
			Silva (2020)	PTB	O	□	MTB	
			Kaschke (2005)	PTB	O	O	MTB	
			Gertenrich I (1967)	PTB	O	□	MTB	
			Gertenrich II (1967)	PTB	O	□	MTB	
			Gertenrich III (1967)	PTB	O	□	MTB	
			12–16 months	Carr (1997)	PTB	O	O	MTB
				Bratel (1991)	PTB	O	O	MTB

Note: Comparisons are ordered by the person performing the toothbrushing, the main disability of the participants and the duration of the study, and are listed by year of publication.

TB/PTB/MTB Toothbrush/powered toothbrush/manual toothbrush.

Duration (per TB)* Duration of brushing period per TB-type.

PI Plaque index score.

GI Score of gingival inflammation.

□ Not assessed.

O No significant difference between the two compared toothbrushes.

+ Significant difference in favor of the intervention (PTB).

- Significant difference in favor of the control (MTB).

Ca+/Ca- Participants with/without communication ability as described by the original authors.

4 | DISCUSSION

4.1 | Major findings

This review gives an overview of studies comparing the effectiveness of PTBs and MTBs in people with PD or ID. Data from 707 participants in the period from 1967 to 2020 exhibited extensive heterogeneity and did not allow for a meta-analysis. A descriptive analysis revealed with a low

level of evidence that for people with disabilities a PTB compared to an MTB results in no clinical difference in outcomes on plaque removal and reduction of gingival inflammation. This is irrespective of the main disability, either physical or intellectual, and applies both to people brushing their own teeth and to those whose teeth are brushed by a caregiver. The outcome does not support the original opinion from the 1960s, which primarily suggested PTB use for people with disabilities.¹³

TABLE 4 Summary of Findings table on the body of the estimated evidence profile (GRADE, 2015) and appraisal of the strength of the recommendation regarding the effectiveness of tooth brushing with a PTB compared to a MTB in the hands of people with physical disabilities (PD) or intellectual disabilities (ID) or in the hands of a caregiver on parameters of plaque and gingival inflammation

Determinants of quality	Summary of findings table on body of the estimated evidence profile			
	Self-performed brushing		Caregiver-performed brushing	
	Physical disabilities (PD)	Intellectual disabilities (ID)	Physical disabilities (PD)	Intellectual Disabilities (ID)
Study design (Table 2)	CCT/RCT crossover	CCT/RCT crossover/parallel	CCT/RCT crossover/parallel	CCT/RCT crossover/parallel
# comparisons (Table 2, Figure 1)	2	10	5	8
Risk of bias (online appendix B)	Low and high	Low to high	Low	Low to high
Consistency (Table 3)	Rather consistent	Rather consistent	Rather consistent	Rather consistent
Directness	Limited generalizability	Rather generalizable	Rather generalizable	Rather generalizable
Precision (Table 3)	Rather imprecise	Rather imprecise	Rather imprecise	Rather imprecise
Reporting bias	Possible	Possible	Possible	Possible
Strength of the recommendation based on the quality and body of evidence	Low certainty	Low certainty	Low certainty	Low certainty
Magnitude of the effect (Table 3)	No difference	No difference	No to a very small difference	No difference
Overall of recommendation	There is a low level of evidence for no benefit regarding plaque removal and reduction of gingival inflammation of a PTB over an MTB for people with disabilities. This applies to people brushing their own teeth and those whose teeth are brushed by a caregiver and is irrespective of the disability, being either PD or ID.			

4.2 | Improvements in both toothbrush groups

Interestingly, significant improvements in plaque removal in both the control group (MTB) and the intervention group (PTB) were reported. Apparently, factors other than the assigned toothbrush substantially influenced the improvement in plaque removal. Possible factors are the increased attention to daily toothbrushing during the study period and the toothbrushing instructions given in the studies. Moreover, several studies included a professional prophylaxis at baseline, which has a positive effect on gingival health⁴⁵ and subsequently inhibits the regrowth of biofilm.⁴⁶ However, the current review cannot substantiate the relative contribution of each of these factors.

4.3 | Type of powered (PTB) and manual (MTB) toothbrush

Since their introduction, PTBs have been innovated constantly. Recent studies have shown the oscillating-rotating type of PTB to be the most effective for reducing plaque and gingivitis.^{16,47} Included studies were performed as early as

1967,⁴⁴ when oscillating-rotating PTBs were not yet available. Similarly, a variety of MTBs was used, and in one study, a PTB in power-off mode was used as the MTB.²⁹ Consequently, there appears to be significant heterogeneity among the brushes used, the impact of which the present review cannot substantiate.

4.4 | Brushing duration

Efficacy studies have demonstrated that plaque reduction improves for both the PTB⁴⁸ and the MTB⁴⁹ when brushing duration is prolonged. In addition, it is known that in the home setting, brushing duration is usually considerably shorter than the generally advised two minutes.^{50,51} The included studies in this review are effectiveness studies, and, in most studies, brushing duration was advised but not supervised. Therefore, it cannot be ruled out that the brushing duration deviated from the advised time and that brushing time may have varied between participants within a study. These variations may have influenced the effectiveness of the brushing, as illustrated by the included study by Shaw et al.⁴³ in which schoolchildren with a severe ID brushed their teeth once a

day at school for 5 min. The teachers were asked to encourage the children to continue brushing for this length of time without assisting them in any way. After four weeks, the scores of the plaque index⁵² and the gingival bleeding index⁵³ were statistically significantly improved for both the PTB and the MTB. Apparently, it was not the choice of the toothbrush, but the supervision of brushing duration that induced the improvements. Parents were not involved in this study, and a prolonged school holiday was included as a wash-out period. It is worth mentioning that after this wash-out period, the plaque and gingival inflammation scores reverted to almost the same level as before the study. This suggests the importance of continued supervision of brushing duration by parental involvement to achieve sustained improvement. At the same time, the role of school-based interventions cannot remain unmentioned. Parents of children with a severe ID face a high burden of care tasks, and daily toothbrushing adds to this burden.¹¹ School-based toothbrushing may not only encourage and improve self-care of children with disabilities, but may also relieve the care burden of their parents.

4.5 | Acceptance

Acceptance of a toothbrush can be considered conditional for its effectiveness. In the current review, only seven^{29,30,32–34,42,43} of the 16 included studies reported on the assessment of adverse effects of the PTB intervention. A small number of problems were reported with the acceptance of the PTB, and most were temporary or could be resolved by modeling: that is, learning by observing and subsequently copying the behavior of a role model. In one study³⁴ a participant with neuromuscular disabilities was registered as a dropout for being unable to tolerate the vibrations of the PTB. The finding that only a few problems with the acceptance of PTBs were reported in the included studies is not in line with a recent survey by Chadwick et al. that assessed factors influencing daily oral care among 372 adults with an ID.⁵⁴ They found that the use of a specific type of toothbrush whether an MTB or a PTB comprised about 20 percent of the factors mentioned by those interviewed as important for the willingness of people with an ID to cooperate with oral care routines. While caregivers in this descriptive, phenomenological study believed PTBs would improve oral hygiene, the authors stated that “a number of people with ID were reported to dislike or even be scared of, electric toothbrushes because of the noise or vibration they make.”⁵⁴ However, the influence of the acceptance of the assigned toothbrush on its effectiveness could not be substantiated in the present review, as this was not systematically recorded in the included studies.

4.6 | Supervision

The included study by García-Carrillo et al. applied supervision during toothbrushing. In this cluster-randomized trial, support workers of adults with a mild ID were instructed in brushing methods and how to supervise the brushing at work.³³ The self-brushing participants received a document with a step-by-step description of the procedure, supported by graphics. During the first three months of this six-month study, participants were supervised by their support workers during daily brushing with the assigned toothbrush. This resulted in a statistically significant improvement of plaque and gingival index scores in both the PTB and MTB groups. The toothbrushing at work continued from the third to the sixth month, but the supervision stopped. After this period, plaque and gingivitis scores slightly deteriorated but were still significantly better than at the start of the study. The daily supervision in the first three months possibly helped the participants adopt an improved toothbrushing pattern that they could continue to use for three months. Although no strong conclusion can be drawn from this observation, the authors of the present review consider it worthwhile to further research the adoption of improved oral hygiene habits by daily supervision.

4.7 | Clinical indices

All 25 included comparisons evaluated plaque removal and 13 also evaluated gingival inflammation. Plaque and gingivitis indices that are used in dental research are surrogates for oral health.⁵⁵ Plaque indices can mainly be used as a surrogate for an instant effect on the short term while indices of gingival inflammation are considered relevant for the long-term effects. No difference between an MTB and a PTB could be found for people with PD or ID as main disability when gingivitis indices are taken into account.

Also, the scoring of indices by itself is complex and intra- and interrater reproducibility is key for comparing data in scientific research. The shortage or lack of cooperation by participants may further complicate scoring in a reproducible manner. It is unclear whether and to what extent the disabilities of the participants in the included studies and their level of cooperation may have impacted the scoring of the clinical indices. Four of the included studies reported to have modified the indices used, by scoring only a selection of the dentition such as Ramfjord teeth, or two randomly chosen quadrants or a limited number of tooth surfaces.^{33,38,41,43} It has been shown that scoring only Ramfjord teeth has a high overall agreement with full mouth measurements⁵⁶ and that random half-mouth assessments perform well in the evaluation of gingival

bleeding.⁵⁷ The impact of the possibly limited cooperation of the participants and the modifications of the indices on the validity of the results of the included studies can however not be substantiated within the scope of the present review.

4.8 | Justification of choices

4.8.1 | Inclusion criteria

In the included study by Goyal et al., only the MTB instructions were reinforced with a video showing the proper brushing technique. This can be considered a flaw of the controlled trials principle that control and intervention groups are treated the same, except for the intervention. Nevertheless, we decided to include the study, as it incorporated an extensive instruction program for both brushes. Thus, we considered the video on manual brushing techniques was not a decisive difference.

4.8.2 | Exclusion criteria

Visual impairment as only disability was excluded because it has no effect on the manual dexterity or cognitive abilities of an individual. During the current systematic review, the authors found two studies^{58,59} comparing the effectiveness of an MTB and a PTB on plaque removal by people with visual disabilities. Both studies were short-term and reported the PTB to be significantly more effective. Visual impairments are common in people with ID⁶⁰ and CP.⁹ However, in the included studies of this systematic review, comorbidities such as visual impairments were not described or addressed. Thus, their effect on the outcomes cannot be substantiated.

Autism was excluded, as it is not a cognitive impairment in itself. Autism, or autistic behavior, is a frequent comorbidity of ID, but its effect on functioning, and more specifically, toothbrushing cannot be generalized. On the one hand, an autism spectrum disorder (ASD) may affect oral hygiene negatively due to tactile defensiveness and hypersensitivity to sensory stimuli. On the other hand, self-brushing by people with ASD may be positively affected by a so-called “insistence on sameness”. In other words, once a proper pattern of oral hygiene habits is adopted, individuals with ASD tend to incorporate it in their daily structure.⁶¹ Within the limits of the underlying review, the effects of autism on the results cannot be substantiated.

Studies evaluating participants with care dependency because of high age, dementia or stroke were excluded as their toothbrushing effectiveness can be expected to depend on oral hygiene habits developed earlier in life.

In this respect these individuals differ from people with disabilities from childhood onwards whom this review is focused on.

Mixed groups, in which self-brushers and caregiver-brushed subjects are assessed in the same group, were excluded,¹⁴ as this review explores whether there is a difference between self-brushing and brushing by a caregiver when comparing the effectiveness of PTBs and MTBs. This requires that data are specific to self-brushing and caregiver-brushed participants. Assisted-brushing groups were considered caregiver-brushed since the caregivers brush the teeth that the participants may have skipped.

4.9 | Shortfall in reporting

The main limitation of this review is the high heterogeneity of the included studies in design, duration and participant characteristics. Furthermore, numerical data were lacking even after contacting the original authors. Consequently, it was chosen to present the data only in the form of a descriptive analysis. In addition, studies evaluating participants with a disability often lack a proper description of the disability, do not mention the extent and severity of a disability, or may even combine multiple disabilities. The same applies to comorbidities. Details on the toothbrush used and toothbrushing instruction or duration that apply to the evidence-based recommendation that emerges from the present review would be of interest.

4.10 | Recommendations

4.10.1 | Future research

On the basis of the currently available literature, no generalized advice can be given for the choice of a toothbrush for people with PD or ID. Apart from the choice of a toothbrush, a variety of personal and environmental factors may influence the effectiveness of individuals' brushing exercise in the home setting. The involvement of caregivers introduces even more variation. Abilities and effectiveness vary between caregivers and are influenced by a range of factors, including training and support.⁶² To obtain more insight into the contribution of these risk factors, future research on this topic should provide individual data and report on individual risk factors. Moreover, the impact of the different physical and intellectual disabilities on the reproducibility of plaque removal and gingival inflammation scores needs emphasis in future research. A direction for further research for this specific group of interest could be the scoring of plaque by digital image analysis.⁶³

4.10.2 | Dental professionals

For the clinical setting, some factors that may influence toothbrushing effectiveness emerged from this review, and these were discussed. Furthermore, dental professionals are recommended to take into account the individual preferences and abilities of those involved in the daily brushing procedure when giving toothbrush advice. This is in line with the recommendation in a recent Cochrane review on oral hygiene interventions for people with IDs.¹⁸

5 | CONCLUSION

This review demonstrates with a low level of evidence no benefit regarding plaque removal and reduction of gingival inflammation of a PTB over an MTB for people with a PD or ID. This applies to people brushing their own teeth and those whose teeth are brushed by a caregiver.

6 | CLINICAL RELEVANCE

6.1 | Scientific rationale for the study

In general, PTBs are considered more effective than MTBs regarding plaque removal and gingival inflammation reduction. It is unclear whether this applies to people with disabilities.

6.2 | Principal findings

In people with PD or ID, a PTB compared to an MTB results in no clinical difference in outcome on plaque and gingival inflammation. This applies to people brushing their own teeth and those whose teeth are brushed by a caregiver.

6.3 | Practical implications

There is a low level of evidence for no important benefit of a PTB over an MTB for people with PD or ID.

Any evidence-based advice should take into account the individual preferences and abilities of those involved in the daily brushing procedure.

AUTHOR CONTRIBUTIONS

All authors gave final approval and agreed to be accountable for all aspects of work ensuring integrity and accuracy. Sonja M. Kalf-Scholte contributed to conception

and design, search and selection, analysis and interpretation, and drafted the manuscript. Cees Valkenburg contributed to search and selection, analysis and interpretation, and critically revised the manuscript. Fridus (G.A.) van der Weijden contributed to conception and design, analysis and interpretation, and critically revised the manuscript. Dagmar Else Slot contributed to conception and design, analysis and interpretation, and critically revised manuscript.

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CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest. Van der Weijden, Slot and their research team at ACTA have previously received either external advisor fees, lecturer fees or research grants from toothbrush and dentifrice manufacturers. Those manufacturers included Colgate, Dentaïd, GABA, Lactona, Oral-B, Procter & Gamble, Sara Lee, Sunstar and Unilever.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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