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Comparative Evaluation of Manual and Powered Toothbrushes on Oral Hygiene in Adolescents: A Group-Based Preventive Study

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Abstract: ***Objective: This study evaluates the effectiveness of manual and powered toothbrushes-including electric, sonic, and ultrasonic models-on the oral hygiene status of adolescents aged 11 to 13. Material and Methods: Conducted within a group-based preventive program, the study involved 106 children divided into four groups based on the toothbrush type. Oral hygiene was assessed using the Full Mouth Plaque Score Index (FMPS) at multiple intervals. Results: Results showed that all powered toothbrushes significantly reduced plaque accumulation compared to manual brushes, particularly when combined with structured training and education. These findings highlight the superior performance of powered devices in promoting oral health among children.***

Keywords: oral hygiene, electric toothbrush, adolescents, plaque control, dental education

1. Introduction

The World Health Organization considers children's dental health a key factor for maintaining an individual's overall health in the long term [1]. In order to maintain healthy oral conditions and prevent diseases, it is essential to reduce risk factors and promote protective factors [2]. In this context, control over the primary etiological factor of oral pathologies—the dental biofilm—is central to preventive oral care.

According to the American Academy of Pediatric Dentistry (AAPD), both personal and professional plaque control play a fundamental role in the prevention of oral diseases, involving several key guidelines [3]:

- Motivating and engaging children in oral health issues;
- Health education related to the etiology and prevention of oral diseases;
- Oral hygiene programs focused on individual plaque control;
- Professional plaque removal.

The application of various preventive measures aimed at oral health seeks to establish proper oral behavior at an optimal level, with the ultimate goal being control of bacterial colonization [4]. These preventive activities are implemented with the active participation of the children themselves. Depending on their age, cognitive capacity, and emotional-social development, different approaches may be necessary.

Studies indicate that prevention strategies involving motivation and education about proper oral hygiene significantly improve adolescents' oral health [5*]. The most commonly used means of removing dental biofilm is the toothbrush combined with an appropriate toothpaste. In addition to the standard manual toothbrush, numerous electric devices are available on the market that offer easier and more effective plaque removal.

Based on their motion type, electric toothbrushes are categorized as either vibrational or rotational-oscillatory. Vibrational toothbrushes utilize side-to-side bristle movement to help dislodge biofilm. In contrast, rotational-oscillatory brushes move the bristles back and forth in a circular motion. Depending on speed, electric toothbrushes are further divided into sonic and ultrasonic types. Sonic brushes operate at frequencies between 20Hz and 20,000Hz, while those exceeding this range are considered ultrasonic. Brushes with lower speeds fall under the category of standard electric toothbrushes [6], [7], [8], [9].

International literature often compares the effectiveness of electric brushes with rotational-oscillatory movements to manual brushes or sonic to manual brushes [10], [11], [12]. However, there are no existing studies comparing manual toothbrushes with sonic and ultrasonic brushes in children, nor is there research evaluating the effectiveness of different oral hygiene training methods based on the type of toothbrush used. These gaps form the basis of the present study.

Objective:
The aim of this study is to evaluate the effectiveness of manual and electric toothbrushes on the oral hygiene status of children aged 11 to 13 years within the framework of a group-based preventive program.

2. Materials and Methods

Materials
A total of 106 children were selected for the study: 52 aged 11, 28 aged 12, and 26 aged 13, all of whom were students in the city of Blagoevgrad. Inclusion criteria required signed informed consent from a parent, approved by KENIMUS under protocol №6/22.10.22.

The children were divided into four groups based on the type of oral hygiene tool provided to them (Fig. 1).

- Group 1 (control group) (A): Manual toothbrush – TePe Nova Medium (26 children);
- Group 2: Electric toothbrush (B) – Oral-B (28 children);
- Group 3: Sonic toothbrush (C) – Philips Sonicare (24 children);
- Group 4: Ultrasonic toothbrush (D)– MegaSonex (28 children).

Electric toothbrush devices

(a)

(b)

(c)

(d)

Figure 1: Different Types of Toothbrushes

Methods

1) Clinical Method

All children were examined in the school's dental office. Using sterile single-use examination instruments, a dental status was recorded. After identifying the teeth affected by caries, the clinical examination included an assessment of oral hygiene status using the Full Mouth Plaque Score Index (FMPS) [13], with the aid of the electronic periodontal probe PA-ON (Orangedental).

The oral hygiene status was assessed after staining the teeth with a plaque-disclosing solution, by noting the presence or absence of staining on all fully erupted permanent teeth. For the FMPS calculation, the presence of dental biofilm was evaluated on four gingival-adjacent surfaces of each tooth crown — mesio-buccal, buccal, disto-buccal, and oral. The index calculation was performed automatically by the software of the electronic probe and indicated the relative percentage of plaque-covered surfaces.

For the purposes of the study, we compared plaque accumulation values between the control group and the groups using electric, sonic, and ultrasonic toothbrushes, which were combined into one common group — electrical devices.

To monitor and assess the effectiveness of various oral hygiene aids, the oral hygiene status was recorded at several points: during the initial examination (Visit I), one week after conducting an educational module described in the next section (Visit II), two weeks after the beginning of the study (Visit III), and one and a half months from the start of the study (Visit IV).

2) Group Preventive Program Methodology

The program consisted of two consecutive modules. In the first module, a PowerPoint presentation was delivered to familiarize the children with the main oral diseases and their role in the prevention of oral pathology. In the second module, training was conducted on the proper use of different personal oral hygiene tools, using demonstrations on a model and custom-made educational videos specifically developed for the program (Table 1).

Table 1: Program Modules

I[st] module Motivation	**II[nd] module** Education			
1. Interactive Method – Presentation 2. Game-Based Method – "What Did I Remember?"	Manual toothbrush	Electric toothbrush	Sonic toothbrush	Ultrasonic toothbrush
	1. Interactive Method (audio-video film) 2. Demonstration Method (on a Model) 3. Game-Based Method – "How Is It Done?"			

Training Methodology

Children were trained using interactive, demonstrative, and game-based techniques, applied sequentially based on their assigned toothbrush type.

Interactive Method – Educational Videos

Original audiovisual films were created, each focused on a different type of individual oral hygiene device (manual, electric, sonic, ultrasonic), and presented to the children in their respective groups. Each video included detailed information about the toothbrush, its operating principle, and a demonstration of its use. The duration of each video was approximately 2 minutes.

Demonstration Method – Using a Model

Each child was shown how to use the corresponding toothbrush on a plastic dental model. The children were divided into small groups of five. The demonstrated technique was explained in detail, specific to the type of oral hygiene device:

- **Manual Toothbrush** – The Stillman technique was demonstrated. The toothbrush is placed at a 45° angle to the tooth surface, pressed gently, and moved in a rotary motion toward the occlusal surface to clean it. This movement is repeated several times before moving to the next section.
- **Electric Toothbrush** – A small amount of toothpaste is applied to the brush head, which is then placed perpendicularly to the tooth surface with the jaws closed. Only then is the brush turned on. The head is held for several seconds on each surface before being moved to the next one. This is repeated for all tooth surfaces.
- **Sonic Toothbrush** – Toothpaste is applied to the brush head, which is then placed at a 45° angle to the tooth surface. The device is switched on, and with light pressure, the brush is moved from the gingival margin toward the occlusal surface. The same process is repeated for each surface until all teeth are cleaned.
- **Ultrasonic Toothbrush** – The procedure mirrors that of the sonic brush. A small amount of toothpaste is applied, the brush is held at a 45° angle, the device is activated, and gentle movements are made from the gingival margin to the occlusal surface across all tooth areas.

Game-Based Method – "How Is It Done?"

This method was applied individually to each child, depending on the toothbrush they received. Each child was asked to reproduce the correct technique on a plastic model, under the supervision and guidance of the facilitators.

At the end of the session, each child received plaque-disclosing tablets for home use, toothpaste, and a toothbrush (manual, electric, sonic, or ultrasonic), depending on their group assignment.

Statistical Methods

Statistical analysis of the data was conducted using the specialized software IBM SPSS, version 19.0. The adopted significance level for testing the null hypothesis (H_0) was $\alpha = 0.05$.

To objectify the analysis results, the following statistical methods were used:

- Descriptive analysis
- Paired samples T-test (for comparison of related groups)
- Independent T-test (for comparison of independent groups)
- Pearson Chi-Square test (χ^2)

3. Results

1) Dynamics of Oral Hygiene Status at the Beginning and End of the Study

The following table and chart present the values of plaque accumulation, measured by the FMPS index, comparing manual toothbrushes and electric devices for personal oral hygiene at the beginning and at the end of the study (Table 2 / Chart 1).

Table 2: Oral Hygiene Status at the Beginning and End of the Study

Visits	FMPS		
	Manual toothbrush [1]	Electric devices[2]	Independent sample test
	Mean ±SD	Mean ±SD	
I visit	67,96±12,213	73,63±10,656	$t_{1,2}$= 1,851 p>0,05
IV visit	39,12±12,751	28,6±14,912	$t_{1,2}$=2,573 $p_{1,2}$<0,05*
Paire sample test	t=7,812p<0,05*	t=24,666 p<0,05*	

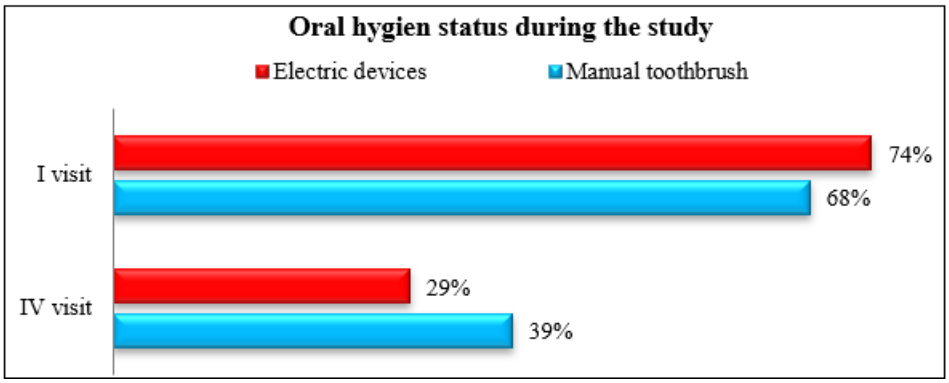

Chart 1: Dynamics of Oral Hygiene Status Throughout the Study

The table and chart show that the baseline oral hygiene status indicated plaque accumulation on 67–73% of the tooth surfaces examined across all children. No statistically significant differences were observed between the two groups at the start of the study ($p > 0.05$).

Interestingly, the control group, the FMPS index values were significantly higher at the end of the study compared to those of the children using electric devices ($p < 0.05$).

Among children using manual toothbrushes, plaque accumulation at the end of the observation period was 39%, indicating a 28% reduction in plaque-covered surfaces compared to baseline.

In the group using electric devices, plaque accumulation decreased to 29% by the end of the program—representing a 45% reduction compared to their baseline status.

The results demonstrate that throughout the study, plaque accumulation among children using electric devices was reduced by half, and the final oral hygiene index values indicate a good oral hygiene status.

These findings suggest that, under the same conditions, electric devices are more effective than manual toothbrushes in reducing dental plaque accumulation.

2. Evaluation of the Effectiveness of Different Electric Devices for Personal Oral Hygiene Over Time

To provide a detailed assessment of the effectiveness of different types of electric devices on children's oral hygiene status, we conducted a comparative evaluation between electric, sonic, and ultrasonic toothbrushes.

The following chart visualizes the dynamics of plaque accumulation across visits among the groups using electric, sonic, and ultrasonic toothbrushes (Chart 2).

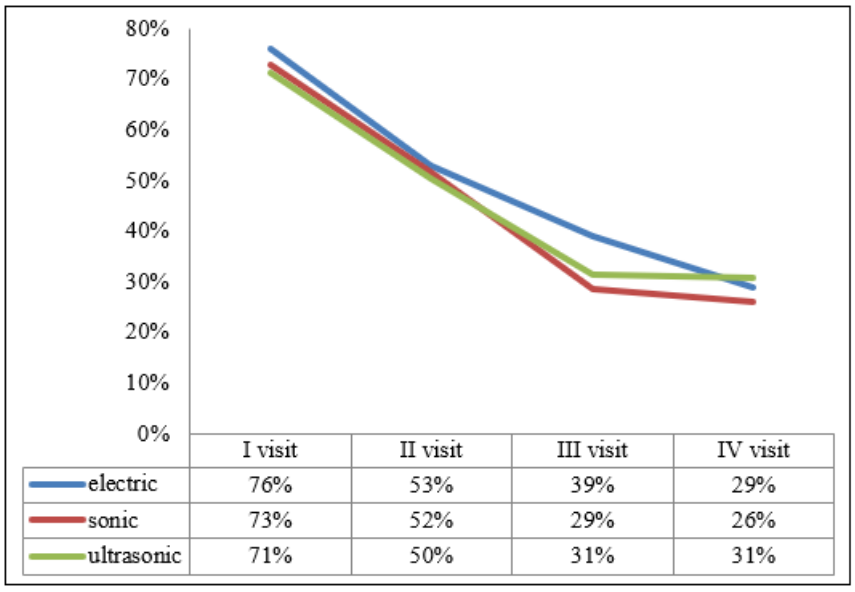

Chart 2: Dynamics of Plaque Accumulation Across Visits in Children Using Electric, Sonic, and Ultrasonic Toothbrushes

The chart shows that among children using electric, sonic, and ultrasonic toothbrushes, FMPS index values demonstrate a consistent decrease at each subsequent visit.

At the second visit, children using ultrasonic toothbrushes exhibited significantly the lowest FMPS index values ($t = 3.143$, $p < 0.05$).

At the third visit, the lowest index values were observed in children using sonic toothbrushes ($t = 10.330$, $p < 0.05$).

The sharper decline observed at visits two and three in the sonic and ultrasonic groups is likely due to the similar operating principles of these devices, which may have made

it easier and faster for the children to master their use. In contrast, electric toothbrushes require holding the brush head near the tooth surface without moving it, which may present a temporary challenge for children until they develop lasting motor habits.

At the end of the follow-up period, plaque accumulation levels were around or below 30% across all electric device groups, with no statistically significant differences between the electric, sonic, and ultrasonic toothbrushes ($p > 0.05$).

These findings suggest that although there were some differences in the rate of FMPS reduction during the study, by the end of the program, the effectiveness of electric, sonic, and ultrasonic toothbrushes was comparable. However, the overall effectiveness of electric devices was clearly superior to manual toothbrushes under identical conditions.

4. Discussion

The results of this study showed that the baseline oral hygiene status of children ranged from 67–76% plaque accumulation (FMPS) on gingivally adjacent tooth surfaces. By the end of the observation period, the FMPS index dropped by half in both groups. However, in the manual toothbrush group, plaque accumulation remained significantly higher at 39% compared to children using electric devices.

The final FMPS values in the electric, sonic, and ultrasonic toothbrush groups were around or below 30%, with no statistically significant differences between the types of devices.

Numerous studies in the literature compare manual and electric toothbrushes for personal oral hygiene [14], [15], [16], [17], [18]. However, comparative studies examining manual vs. electric, sonic, and ultrasonic toothbrushes specifically in children are lacking. Moreover, most studies focus on the mechanical action (vibration, power) of toothbrushes without emphasizing the role of motivation and training in children, which requires a different approach depending on the type of brush.

Davidovich et al. compared the effectiveness of electric vs. manual toothbrushes in children aged 3–9 years, evaluating oral hygiene at three visits (baseline, 7 days, and 14 days). They concluded that electric toothbrushes were more effective in removing dental biofilm [19].

A meta-analysis confirmed that rotating–oscillating electric toothbrushes outperform sonic and manual brushes in plaque removal. However, this meta-analysis did not account for patient age [20].

In contrast, our results did not show a difference in effectiveness between electric, sonic, and ultrasonic brushes by the end of the study. However, we did observe differences during intermediate visits, likely due to how quickly children adapted to the specific operational requirements of each device.

A comparative pediatric study found that electric toothbrushes led to nearly 30% greater plaque reduction than manual ones [21]. Similar findings were confirmed by Garcia-Godoy et al. in children aged 6–11 [22]. Our data shows a 10% greater reduction in plaque when using electric, sonic, and ultrasonic toothbrushes compared to manual ones.
Jongenelis et al. reported almost double the reduction in plaque accumulation with ultrasonic brushes compared to manual ones in children with primary or mixed dentition [23].

Other authors observed similar outcomes in children aged 4–7 using Philips Sonicare for Kids ultrasonic brushes [24].

An original 2021 study comparing electric, ultrasonic, and manual brushes again found electric devices superior in biofilm removal. Interestingly, the authors also noted more pronounced tooth wear with ultrasonic brushes — a factor that should be considered, especially in pediatric use [25].

Global literature on toothbrush effectiveness spans nearly 30 years. Study designs vary from short-term (1–3 months) to long-term (>3 months) evaluation of oral hygiene tools.

Still, the consistent trend across studies supports the superiority of electric (including sonic and ultrasonic) toothbrushes in removing dental biofilm [25], [26], [27], [28], [29].

5. Conclusion

Our results demonstrate that when structured training is combined with oral health education, electric, sonic, and ultrasonic toothbrushes are more effective than manual toothbrushes for individual oral hygiene in children. This is likely due to the combined mechanical action — rotary-oscillating motion or high-frequency vibration — leading to enhanced biofilm removal.

The practical value of these training protocols is significant: they represent a step toward individualized preventive approaches in pediatric dentistry.

Currently, such individualized protocols are largely absent from clinical practice, despite the availability of diverse oral hygiene tools.

Childhood is a critical period for forming proper oral hygiene habits. Insufficient early instruction may contribute to persistent oral hygiene challenges in the future.

Therefore, toothbrushing training in children must include device-specific methodologies, tailored to the brush type and distinct from traditional manual brushing techniques.

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