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Development of Automatic Toothbrush with Elastomer Material Alloy to Improve Brushing Skills in Children with Disabilities

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Abstract: Children with physical disabilities, particularly those with impaired fine motor skills, face significant challenges in performing independent toothbrushing. These limitations make them highly vulnerable to oral health problems such as dental caries and periodontal disease. Data indicate that only 3.3% of children with disabilities are able to brush their teeth properly, while the prevalence of dental caries reaches 84.6%. Therefore, this study aims to develop an automatic toothbrush with an ergonomic elastomer-based handle designed to improve toothbrushing skills in children with physical disabilities. The research employed a Research and Development (R&D) approach using a quasi-experimental design with a pretest–posttest one-group model. The development procedure included information gathering, model design, expert validation, and product trials. The study involved 13 children with physical disabilities who participated in the intervention for 10 days. The feasibility of the tool was assessed using Aiken's V, while its reliability was tested through the Intraclass Correlation Coefficient (ICC). Changes in toothbrushing skills were measured through pre- and post-intervention observations. Validation results indicated that the automatic toothbrush with elastomer-based handle was considered feasible, with an Aiken's V score of 0.843 and a p-value of 0.000. Effectiveness testing further showed a significant improvement in toothbrushing skills after the intervention, with a p-value of 0.001. These findings demonstrate that the developed device is effective in improving toothbrushing skills among children with physical disabilities, providing a practical and educational solution to support their independence in maintaining oral health.

Keywords: *Automatic Toothbrush; Elastomer Material; Toothbrushing Skills; Children with Physical Disabilities.*

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I. INTRODUCTION

Conventional toothbrushes are still widely used; however, they are less effective for children with physical disabilities (tunanadaksa) who have motor limitations. Therefore, an innovative automatic toothbrush made with elastomer material has been developed to assist children with physical disabilities in maintaining oral hygiene. The ergonomic design and elastomer components provide an easier grip and reduce the need for complex motor control. With automatic brushing movements, this device supports children's independence in performing oral care while also providing an enjoyable experience that encourages the development of healthy habits [8]. Children with special needs, including those with physical disabilities, have a higher prevalence of dental caries and periodontal disease compared to children without disabilities. Motor impairments hinder their ability to maintain optimal oral hygiene, often making them dependent on parents or caregivers. Research data even indicate that the prevalence of caries among children with physical disabilities exceeds 90%. Therefore, a coordinated approach between dental and social health services, supported by specialized assistive devices, is urgently needed [9].ious studies have shown that proper brushing techniques and ergonomic toothbrush design can enhance the effectiveness of oral care in children with special needs. For example, the use of toothbrushes with appropriately designed handles improves gripping ability and brushing control. Ballini (2021) reported that toothbrushes made of thermoplastic elastomer (TPE) are effective in reducing plaque index and maintaining gingival health in children with special needs [10].

Based on these findings, the development of an automatic toothbrush made with elastomer materials tailored to the hand structure of children with physical disabilities is highly needed. This device is expected to improve toothbrushing skills, support independence, and enhance the overall oral hygiene of children with physical disabilities. Training for parents, caregivers, and teachers is also an essential component to ensure proper and sustainable oral hygiene practices.

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II. METHOD

This study employed a Research and Development (R&D) approach aimed at developing and testing the effectiveness of an automatic toothbrush with an elastomer material blend to improve toothbrushing skills among children with disabilities. The research design used was quasi-experimental with a one-group pretest–posttest design, which measured changes in toothbrushing skills before and after the intervention. The research procedure consisted of five main stages: 1) information gathering, 2) product/model design, 3) expert validation and revision, 4) product/model trial, and 5) final product/model outcome.

The information-gathering stage was conducted through observations and interviews with school principals, special education teachers, dental health professionals, and parents of children with disabilities to obtain an overview of user needs and characteristics. This information served as the foundation for designing the Automatic Toothbrush with Elastomer Material, including determining the appropriate size and ergonomic elastomer handle model suitable for the motor skills of children with disabilities, so that it can be easily held and operated independently, with five adjustable vibration speed levels tailored to user needs.

The designed product was then validated by four experts, namely a health promotion specialist, a dentist, an oral health therapist, and a special education teacher, using a checklist instrument analyzed through Aiken's V validity test and the Intraclass Correlation Coefficient (ICC) reliability test. The model validity test using Aiken's V obtained a score of 0.843, which falls into the very high category, indicating that all items were valid. Meanwhile, the model reliability test using ICC produced a value of 0.849, indicating high reliability. These results confirm that the automatic toothbrush with an elastomer blend is feasible for improving toothbrushing skills in children with physical disabilities.

Following expert validation confirming the feasibility of the product, the next step was product revision and testing. The trial was conducted on a sample of 13 children with physical disabilities (tunadaksa) selected through purposive sampling. Prior to receiving the intervention using the automatic toothbrush with an elastomer handle for 10 days, the participants were first treated with the automatic toothbrush without the elastomer handle. Toothbrushing skills were then assessed using an observation sheet, with performance categorized as very good, good, fair, or requiring guidance.

The data on toothbrushing skills obtained from the use of the automatic toothbrush without the elastomer handle and the automatic toothbrush with the elastomer handle over the 10-day period were analyzed univariately for descriptive purposes, and bivariately using the non-parametric Wilcoxon test to determine the significance of differences in outcomes. The result of this study, namely the Automatic Toothbrush with Elastomer Material, is expected to provide benefits in the field of oral health, particularly as a practical and effective toothbrush innovation that can enhance toothbrushing skills among children with physical disabilities.

III. RESULTS AND DISCUSSION

This study developed an automatic toothbrush integrated with an elastomer handle specifically designed to improve toothbrushing skills among children with physical disabilities (tunadaksa). The sample consisted of 13 children with physical disabilities from SLB Negeri Semarang and SLB Negeri Ungaran.

The initial stage, which involved assessments through interviews and observations, revealed that children with physical disabilities face considerable motor challenges, particularly difficulties in gripping and controlling an automatic toothbrush without an elastomer handle. These difficulties negatively impact their oral hygiene practices.

Table 1 Frequency Distribution of the Average Skill Level of Children with Physical Disabilities (Tunadaksa) using an Automatic Toothbrush without an Elastomer Handle.

Number	Category	Total	%
1.	Very Good	0	0%
2.	Good	0	0%
3.	Fair	0	0%
4.	Needs Guidance	13	100%

Table 1 shows that the average toothbrushing skill score of children with physical disabilities (tunadaksa) using an automatic toothbrush without an elastomer handle was 41.53.

Table 2 Frequency Distribution of the Average Skill Level of Children with Physical Disabilities (Tunadaksa) using an Automatic Toothbrush with an Elastomer Handle.

Number	Category	Total	%
1.	Very Good	2	14,4%
2.	Good	11	85,6%
3.	Fair	0	0%
4.	Needs Guidance	0	0%

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Based on Table 2, the univariate analysis showed a significant improvement in the average toothbrushing skills of children with physical disabilities (tunadaksa) after using the automatic toothbrush with an elastomer handle, with the mean score increasing to 74.80. The findings indicate that brushing teeth with an automatic toothbrush equipped with an elastomer handle is effective in enhancing the ability of children with physical disabilities to maintain oral hygiene.

The effectiveness of the automatic toothbrush with an elastomer blend was further tested using the Wilcoxon test, which revealed a significant difference between pre-intervention (using the automatic toothbrush without the elastomer handle) and post-intervention (using the automatic toothbrush with the elastomer handle). The difference was 33.27, with a p-value of 0.001 ($p < 0.05$), confirming that the automatic toothbrush with an elastomer handle is effective in improving toothbrushing skills among children with physical disabilities.

This effectiveness is influenced by the design of the elastomer handle, which was specifically tailored to the hand size of children with physical disabilities (tunadaksa), thereby making it easier for them to grip and control the toothbrush during use. This study is in line with research conducted by Efzi at SLB N Jepara (2022), which reported that the use of an elastomer-based grip aid on a toothbrush facilitated toothbrushing among children with physical disabilities [11]. The findings are further supported by Fadhilah, K. A., who stated that modifying toothbrush handles according to hand size helps children with physical disabilities grip and control the toothbrush more effectively, thereby improving their toothbrushing skills [12].

The toothbrushing skills of children with physical disabilities are influenced by various factors, one of which is the type of toothbrush used. These children generally face limitations in controlling movement and motor coordination, making manual toothbrushes less effective. Manual toothbrushes require fine motor skills to perform proper brushing motions. Although they can be modified with elastomer grips to improve comfort and ease of handling, their effectiveness remains suboptimal, as explained in the study by Malfa et al. (2022) [13]. Conversely, automatic toothbrushes with elastomer components are considered more effective for children with physical disabilities, as they perform brushing movements automatically without requiring complex motor control from the user. These findings are consistent with Silva et al. (2020), who stated that electric toothbrushes assist children with physical limitations because they eliminate the need to master complex brushing techniques. Moreover, automatic toothbrushes have several advantages, such as reducing the need for precise hand movements, maintaining consistency in cleaning motions, and enhancing efficiency, thereby promoting greater independence in maintaining oral hygiene among children with physical disabilities [14].


Fig 1 Front View


Fig 2 Rear View


Fig 3 Left Side View

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Fig 4 Right Side View

Figures 1, 2, 3, and 4 illustrate the front, back, left, and right views of the development of the automatic toothbrush with an elastomer material blend, designed to enhance toothbrushing skills among children with physical disabilities (tunadaksa). The innovation incorporates elastomer material, which is flexible and comfortable, into the toothbrush handle, allowing it to adapt to the shape of the fingers and the varying gripping abilities of children with physical disabilities. This provides extra comfort and makes it easier for them to hold and operate the toothbrush independently. In addition, the automatic toothbrush is equipped with five adjustable vibration speed levels, enabling optimal cleaning without requiring heavy or tiring manual movements, thus accommodating the physical limitations of children with disabilities. The prototype design also emphasizes practicality, featuring a USB charging system that is common and easily accessible, ensuring continuous use without power constraints.

The development of the automatic toothbrush with elastomer integration has made children more enthusiastic and engaged in toothbrushing activities, thereby helping to train their motor skills in brushing teeth. Furthermore, the habit of daily toothbrushing at home plays an important role in improving their toothbrushing skills [15].

IV. CONCLUSION

The application of an automatic toothbrush with an elastomer material blend has proven effective in improving toothbrushing skills among children with physical disabilities (tunadaksa). This is evidenced by the mean skill score before the intervention of 41.53, which increased to 74.80 after the intervention, with a difference of 33.27. The Wilcoxon test results also showed a p-value of 0.001 ($p < 0.05$), indicating a significant difference before and after the use of the toothbrush.

This improvement in skills can be attributed to the advantages of the automatic toothbrush, which features a specially designed elastomer handle adjusted to the hand size of children with physical disabilities, making it easier for them to grip and control the toothbrush while brushing independently. These findings are consistent with Fadhilah, K. A.'s research, which stated that toothbrush handle modifications, particularly adjustments to hand grip size, can help children with physical disabilities improve their toothbrushing skills [12].

An automatic toothbrush with an elastomer material blend is considered more effective for children with physical disabilities, as it can perform brushing movements automatically without requiring complex motor control from the user. In addition, this electric toothbrush facilitates children with physical limitations since it does not require them to master complicated toothbrushing techniques. Another advantage of the automatic toothbrush is its ability to maintain consistent cleaning motions without the need for precise hand movements, making its use more efficient and supporting children's independence in maintaining oral hygiene [14].

The development of an automatic toothbrush with an elastomer material blend also increases children's enthusiasm and encourages their active participation in brushing activities, which indirectly helps train their motor skills in toothbrushing. Beyond the use of appropriate media, the establishment of a regular brushing routine at home also plays a crucial role in improving children's skills. In this study, toothbrushing activities were carried out for ten consecutive days, and this consistent and repetitive practice helped form a habit. Ultimately, the habit made the children more accustomed to and skilled in brushing their teeth properly and correctly [15,16].

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