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Toothpaste Consumption: Implications for Health and Sustainability in Oral Care

Fabiana Nicita[1,2] Cesare D'Amico[1] Giuseppe Minervini[3] Gabriele Cervino[1] Luca Fiorillo[1,3,4]

[1] Department of Biomedical and Dental Sciences and Morphofunctional Imaging, University of Messina, Messina, Italy
[2] Department of Biomolecular Strategies, Genetics and Cutting-Edge Therapies, I.E.ME.S.T., Palermo, Italy
[3] Multidisciplinary Department of Medical-Surgical and Dental Specialties, University of Campania Luigi Vanvitelli, Naples, Italy
[4] Department of Public Health Dentistry, Dr D.Y. Patil Dental College and Hospital, Dr D.Y. Patil Vidyapeeth, Pune, Maharashtra, India

Address for correspondence Fabiana Nicita, Department of Biomedical and Dental Sciences and Morphofunctional Imaging, University of Messina, via Consolare Valeria, 1, 98125 Messina, Italy (e-mail: fabnicita@unime.it).

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Abstract

Objective Toothpaste is a crucial component of daily oral hygiene routines and is significant in maintaining oral health. This study aimed to assess the amount of toothpaste consumed during tooth brushing and investigate the influence of toothbrush type on toothpaste consumption.

Materials and Methods Ten volunteer students of dentistry who regularly practiced oral hygiene at home were enrolled. Participants used a 15-mL tube of toothpaste with manual and electric toothbrushes and the amount consumed was recorded three times daily.

Statistical Analysis Variance analysis for repeated measures was applied for differences within groups for toothbrush types while the *t*-test was carried out to compare the mean quantities between groups. Statistical significance was set at $p < 0.05$.

Results The findings revealed no significant difference in toothpaste consumption across different time intervals for both manual and electric toothbrushes. However, a significant difference in toothpaste consumption was observed when comparing toothbrush types. Participants using electric toothbrushes consumed less toothpaste compared to those using manual toothbrushes.

Conclusion The observed differences in toothpaste consumption highlight the importance of considering toothbrush type when promoting appropriate usage. With their advanced brushing mechanisms, electric toothbrushes may enhance cleaning efficiency and reduce the need for a large amount of toothpaste. Reducing toothpaste consumption benefits oral health and contributes to environmental sustainability. It minimizes packaging waste, conserves energy and resources, promotes water conservation, preserves ecosystems, and encourages a culture of ecological responsibility. By embracing a more conscious approach to toothpaste usage, individuals can contribute to a greener and more sustainable future.

Keywords
- oral hygiene
- toothpaste consumption
- sustainability
- oral care

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Introduction

In recent years, the consumption of oral care products has increased significantly, and among these, the most used cosmetic product for oral health is represented by toothpaste.[1–3] A cosmetic product is defined by The European Regulation (EC) No 1223/2009 as "any substance or mixture intended to be placed in contact with the external parts of the human body [...] or with the teeth and the mucous membranes of the oral cavity with a view exclusively or mainly to cleaning them, perfuming them, changing their appearance, protecting them, keeping them in good condition or correcting body odours."[4] In addition, a cosmetic product made available on the market "shall be safe for human health when used under normal or reasonably foreseeable conditions of use."[4]

Toothpaste is essential to daily oral hygiene routines and has significantly maintained oral health for centuries.[3] Adding fluoride to toothpaste formulations became a breakthrough in preventing tooth decay.[5,6] Today, toothpaste is available in various formulations to cater to oral health needs. To prevent tooth decay and reduce the amount of dental plaque, it is common practice to brush teeth with a fluoride toothpaste at least twice a day,[7,8] with the recommended annual consumption of four toothbrushes and six tubes of toothpaste.[8] It is well known that brushing teeth with a fluoride toothpaste containing 1.000 to 1.500 ppm F^- reduces the incidence of caries by at least 25% in adolescents.[9] However, an excessive fluoride exposure can interfere with the dental formation in children and promote the risk of fluorosis with white or brown lesions on the teeth depending on the severity of the cases.[9,10] This risk increases due to the lack of experience in oral hygiene maneuvers by young children who could ingest the toothpaste during brushing.[11] Guidelines have been established to mitigate the risk of excessive fluoride consumption regarding the appropriate amount of toothpaste. In fact, it is recommended that young children brush their teeth using a quantity of toothpaste equal to the "size of a pea" twice a day.[12] The Scientific Committee of the European Union for Cosmetic Products and Non-food Products for Consumers has estimated that this amount should be 0.25 g.[13] However, it was found that adults and parents of children consume an average dosage of 0.3 to 0.5 g, leading to potential overconsumption of fluoride.[14,15] The data on toothpaste consumption obtained by the Cosmetics Europe[16–18] are used by the Scientific Committee on Consumer Safety to assess daily exposure levels for European consumers.[19] In the literature, several studies have been conducted on the consumption of toothpaste during oral hygiene practices in several European countries.[20–24] However, different methods have carried out the quantitative assessment of the use of the product concerned, and comparing their results is difficult. Therefore, this research aimed to evaluate the daily consumption of toothpaste during oral hygiene at home according to the habits of Italian consumers. The evaluation also included the influence of the type of toothbrush used on consuming the cosmetic product.

Materials and Methods

Study Design

This study included volunteer students enrolled in the degree course in Dentistry and Dental Prosthesis of the University of Messina who regularly practiced oral hygiene at home, with healthy oral mucosa, and knew how to use both manual and electric toothbrushes. Subjects who had allergies to cosmetic products or drugs with a generally compromised state of health were excluded. All participants received an informed consent form and all information regarding the conduct of the study.

Each subject was given a 15-mL tube of toothpaste (AZ Pro-Expert, Gross-Gerau, Germany) for use with the manual and electric toothbrush. All participants used the same product to limit the variability of the results. According to their daily habits, each subject extracted a dose of toothpaste from the tube to place it on the brush head for manual and electric toothbrush, then it was taken and weighed with a precision balance of sensitivity equal to 0.01 g. The amount of toothpaste consumed was recorded thrice daily (T0, T1, T2). At the end of the study, the toothpaste tubes were weighed with the same precision balance to determine the total individual amount of product used. Toothbrush types with the amount of toothpaste consumed are shown in ►**Figs. 1** and **2**.

Fig. 1 Manual toothbrush head and a quantity of toothpaste consumed in a timeframe.

Fig. 2 Electric toothbrush head and a quantity of toothpaste consumed in a timeframe.

Data Analysis

All data were presented as mean ± standard deviation (SD). Numeric variables had normal distribution from the Kolmogorov–Smirnov test and the parametric method was used. Variance analysis for repeated measures with Bonferroni correction was used to verify differences within groups regarding toothbrush types. In addition, the *t*-test was carried out to assess the distribution of toothpaste quantities between toothbrushes. A *p*-value of < 0.05 was considered statistically significant. All statistical analyses were performed using SPSS 25.0 software (IBM SPSS Statistics, New York, United States) for the Windows system.

Results

In total, 10 participants were enrolled for this study. Six measurements were recorded for each subject about the amount of toothpaste consumed for both toothbrushes ($n = 3$ for the manual toothbrush and $n = 3$ for the electric toothbrush). Therefore, the total measurements were 60 and divided according to the time considered (T0 = 20, T1 = 20, T2 = 20). ►**Table 1** shows all the data found as means and SDs. Variance analysis for repeated measures showed that there is no significant difference both for the manual toothbrush (►**Table 2**) and the electric toothbrush (►**Table 3**). Profile plots for toothbrush types are shown in ►**Figs. 3** and **4**.

As for the comparison between toothbrush types, the *t*-test reported a significant difference in the total amount of toothpaste consumed ($t = 2.59$, $p = 0.018$). Specifically, the mean of values reported at T2 was significantly lower for the electric toothbrush ($t = 2.42$, $p = 0.026$). The distribution of measurements recorded at T0 and T1 was the same between the two types of toothbrushes ($t = 1.86$, $p = 0.079$ and $t = 1.82$, $p = 0.085$, respectively).

Table 1 The amount of toothpaste consumed is measured in grams (g) according to the type of toothbrush

Groups	Amount of toothpaste consumed (g)			
	T0 (mean ± SD)	T1 (mean ± SD)	T2 (mean ± SD)	Total (mean ± SD)
Manual toothbrush	1.26 ± 0.27	1.32 ± 0.36	1.48 ± 0.35	4.06 ± 0.81
Electric toothbrush	0.98 ± 0.38	1.06 ± 0.28	1.16 ± 0.22	3.21 ± 0.65

Abbreviation: SD, standard deviation.

Table 2 Pairwise comparison for the manual toothbrush based on estimated marginal means

Manual toothbrush				95% Confidence interval for difference[a]	
Pairwise comparisons	Mean difference (I-J)	Standard error	Significance[a]	Lower bound	Upper bound
T0-T1	−0.066	0.087	1.000	−0.321	0.189
T0-T2	−0.218	0.111	0.246	−0.545	0.109
T1-T0	0.066	0.087	1.000	−0.189	0.321
T1-T2	−0.152	0.112	0.619	−0.479	0.175
T2-T0	0.218	0.111	0.246	−0.109	0.545
T2-T1	0.152	0.112	0.619	−0.175	0.479

[a]Adjustments for multiple comparisons: Bonferroni.

Table 3 Pairwise comparison for the electric toothbrush based on estimated marginal means

Electric toothbrush				95% Confidence interval for difference[a]	
Pairwise comparisons	Mean difference (I-J)	Standard error	Significance[a]	Lower bound	Upper bound
T0-T1	−0.078	0.140	1.000	−0.490	0.334
T0-T2	−0.178	0.114	0.455	−0.511	0.155
T1-T0	0.078	0.140	1.000	−0.334	0.490
T1-T2	−0.100	0.072	0.590	−0.310	0.110
T2-T0	0.178	0.114	0.455	−0.155	0.511
T2-T1	0.100	0.072	0.590	−0.110	0.310

[a]Adjustments for multiple comparisons: Bonferroni.

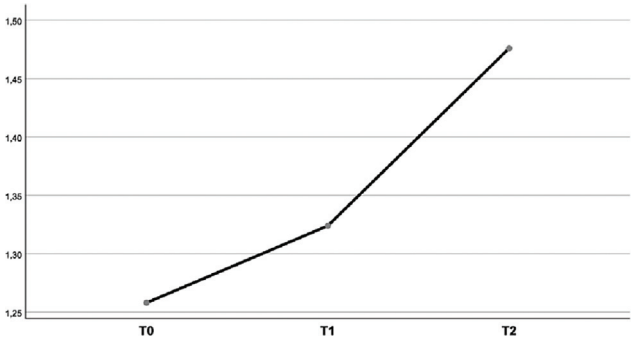

Fig. 3 Profile plot on the estimated marginal means of toothpaste consumed at T0, T1, and T2 for manual toothbrush.

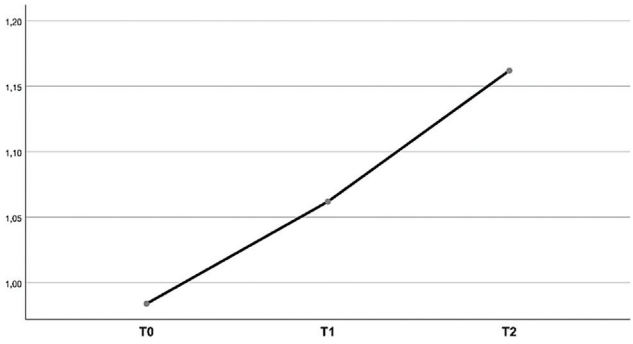

Fig. 4 Profile plot on the estimated marginal means of toothpaste consumed at T0, T1, and T2 for electric toothbrush.

Discussion

The present study aimed to assess the amount of toothpaste consumed during tooth brushing and investigate the influence of toothbrush type on toothpaste consumption. The findings provide valuable insights into the patterns of toothpaste usage and have implications for oral health practices. The results showed no significant difference in toothpaste consumption across different time intervals (T0, T1, and T2) for manual and electric toothbrushes. This suggests that the duration of tooth brushing did not substantially impact the amount of toothpaste used. These findings are consistent with previous studies that have reported constant toothpaste consumption over time intervals during oral hygiene practices.[15,20–24] However, there was a significant difference in the total mean amount of toothpaste consumed when comparing toothbrush types (4.06 ± 0.81 vs. 3.21 ± 0.65). In detail, the significance was observed in the mean values recorded at T2 (1.48 ± 0.35 vs. 1.16 ± 0.22). Participants using electric toothbrushes consumed less toothpaste compared to those using manual toothbrushes. This observed difference suggests the importance of considering toothbrush type when promoting appropriate usage. One possible explanation for this discrepancy is the advanced brushing mechanisms found in electric toothbrushes, such as oscillating or rotating brush heads, which may enhance cleaning efficiency and reduce the need for a large amount of toothpaste.[25,26] This aspect of electric toothbrushes not only has implications for toothpaste consumption but also for optimizing plaque removal and overall oral health. It is worth noting that the study had a relatively small sample size, consisting of only 10 participants. This limited sample size may restrict the generalizability of the findings to a larger population. Additionally, the study focused on a specific group of volunteer students enrolled, which may only partially represent the toothpaste consumption patterns of the general population. Future research with a more extensive and more diverse sample would be beneficial to validate these findings.

The findings from this study contribute to the existing literature by providing insights into toothpaste consumption patterns among Italian consumers. In addition, reduced consumption of toothpaste can have significant implications for the environment, aligning with principles of sustainability and conservation.[27] One of the critical ecological benefits is the reduction in packaging waste.[28,29] In fact, traditional toothpaste tubes are often made of nonrecyclable plastics, contributing to landfill accumulation and environmental pollution.[30,31] Toothpaste production requires energy-intensive processes, including manufacturing, packaging, and transportation.[30] By reducing the demand for toothpaste, there is a corresponding reduction in energy usage and greenhouse gas emissions associated with these activities.[32] Additionally, fewer raw materials, such as water and minerals, are required, and pressure on ecosystems is lessened, allowing them to thrive and maintain their ecological balance.[33,34] Water conservation is also promoted through reduced toothpaste consumption. The production of toothpaste involves significant water usage, including during manufacturing and equipment cleaning. Using less toothpaste requires less water throughout the production cycle, resulting in water savings and a reduced strain on water resources. Emphasizing conscious consumption and environmental awareness, reducing toothpaste consumption fosters a culture of environmental responsibility, encouraging people to reflect on their oral care practices and make sustainable choices.

It is essential to acknowledge the limitations of this study. First, the sample size was small: only 10 volunteer students from a dentistry program. Therefore, the findings may be different from the general population. Additionally, the study focused on a specific age group and did not consider other demographic factors that may influence toothpaste consumption, such as age, socioeconomic status, and oral health education. Moreover, the study relied on participant self-reporting, which may introduce bias and inaccuracies in recording the amount of toothpaste consumed.

Conclusion

Toothbrush type can influence toothpaste consumption patterns during tooth brushing. Electric toothbrush users consumed less toothpaste compared to manual toothbrush users. These findings emphasize the need for personalized oral health recommendations and highlight the potential benefits of electric toothbrushes in optimizing toothpaste usage, particularly for individuals who are concerned about

excessive toothpaste consumption. From a sustainability perspective, reducing toothpaste consumption has several positive implications. It aligns with the principles of environmental conservation by reducing packaging waste and preserving resources and raw materials. Understanding toothpaste consumption patterns and factors influencing usage is vital for promoting optimal oral health practices. By expanding our knowledge in this area, we can develop evidence-based guidelines and interventions promoting oral health and environmental sustainability.

Future Directions

There are several potential future directions that researchers and oral health practitioners could explore:

- Large-scale population studies: Expanding the research to include a larger and more diverse population would help validate the observed differences in toothpaste consumption between manual and electric toothbrush users. This could involve studying individuals of different ages, oral health conditions, and socioeconomic backgrounds to provide a more comprehensive understanding of toothpaste usage patterns.
- Long-term oral health outcomes: Investigating the long-term effects of toothbrush type on oral health outcomes could be an important avenue. Do individuals who use electric toothbrushes and consume less toothpaste experience better oral health over time? Longitudinal studies could shed light on this aspect.
- Behavioral interventions: Research could focus on developing interventions aimed at optimizing toothpaste consumption based on toothbrush type. These interventions could target individuals using manual toothbrushes, encouraging them to use less toothpaste while maintaining oral health.
- Environmental impact studies: Expanding the sustainability aspect, researchers could conduct studies to quantify the environmental impact of reduced toothpaste consumption. This could involve assessing the reduction in plastic waste, energy savings, and resource conservation resulting from such practices.
- Innovations in toothpaste formulations: Future research might explore innovative toothpaste formulations that are more effective in smaller quantities. This could involve the development of toothpaste products that require less volume for optimal oral hygiene.
- Education and awareness campaigns: Based on the study's findings, public health campaigns could be designed to raise awareness about the benefits of reducing toothpaste consumption. These campaigns could promote not only oral health but also environmental responsibility.
- Children's oral health: Given the potential risk of excessive fluoride consumption among children, future studies could delve into effective strategies for teaching children proper toothpaste usage from an early age. This could include educational programs for both parents and children.
- Global comparative studies: Comparative studies across different countries and regions could provide insights into cultural and regional variations in toothpaste consumption patterns and their impact on oral health and the environment.

Conflict of Interest
None declared.

References

1 Jardim JJ, Alves LS, Maltz M. The history and global market of oral home-care products. Braz Oral Res 2009;23(Suppl 1):17–22
2 Cury JA, Tenuta LMA. Evidence-based recommendation on toothpaste use. Braz Oral Res 2014;28(Spec No):1–7
3 Fluoride toothpaste. Lancet 1971;2(7726):703–704
4 Regulation UNIONP. (EC) No 1223/2009 of the European Parliament and of the council. Off J Eur Union L 2009;342:59
5 Pollick H. The role of fluoride in the prevention of tooth decay. Pediatr Clin North Am 2018;65(05):923–940
6 Walsh T, Worthington HV, Glenny AM, Marinho VC, Jeroncic A. Fluoride toothpastes of different concentrations for preventing dental caries. Cochrane Database Syst Rev 2019;3(03):CD007868
7 Attin T, Hornecker E. Tooth brushing and oral health: how frequently and when should tooth brushing be performed? Oral Health Prev Dent 2005;3(03):135–140
8 O'Mullane DM, Baez RJ, Jones S, et al. Fluoride and oral health. Community Dent Health 2016;33(02):69–99
9 Marinho VCC. Cochrane reviews of randomized trials of fluoride therapies for preventing dental caries. Eur Arch Paediatr Dent 2009;10(03):183–191
10 ten Cate JM. Current concepts on the theories of the mechanism of action of fluoride. Acta Odontol Scand 1999;57(06):325–329
11 Ekambaram M, Itthagarun A, King NM. Ingestion of fluoride from dentifrices by young children and fluorosis of the teeth–a literature review. J Clin Pediatr Dent 2011;36(02):111–121
12 Pendrys DG, Haugejorden O, Bårdsen A, Wang NJ, Gustavsen F. The risk of enamel fluorosis and caries among Norwegian children: implications for Norway and the United States. J Am Dent Assoc 2010;141(04):401–414
13 Scientific Committee on Cosmetic Products and Non-Food Products intended for Consumers (SCCNFP). The safety of fluorine compounds in oral hygiene products for children under the age of 6 years. 24-25 June 2003, SCCNFP/0653/03
14 Cochran JA, Ketley CE, Duckworth RM, et al. Development of a standardized method for comparing fluoride ingested from toothpaste by 1.5-3.5-year-old children in seven European countries. Part 1: field work. Community Dent Oral Epidemiol 2004;32 (Suppl 1):39–46
15 Creeth J, Bosma ML, Govier K. How much is a 'pea-sized amount'? A study of dentifrice dosing by parents in three countries. Int Dent J 2013;63 Suppl 2(Suppl 2):25–30
16 McNamara C, Rohan D, Golden D, et al. Probabilistic modelling of European consumer exposure to cosmetic products. Food Chem Toxicol 2007;45(11):2086–2096
17 Hall B, Tozer S, Safford B, et al. European consumer exposure to cosmetic products, a framework for conducting population exposure assessments. Food Chem Toxicol 2007;45(11):2097–2108
18 Hall B, Steiling W, Safford B, et al. European consumer exposure to cosmetic products, a framework for conducting population exposure assessments Part 2. Food Chem Toxicol 2011;49(02):408–422
19 SCCS members Other experts. The SCCS Notes of Guidance for the testing of cosmetic ingredients and their safety evaluation, 11th revision, 30-31 March 2021, SCCS/1628/21. Regul Toxicol Pharmacol 2021;127:105052

20 Ficheux AS, Wesolek N, Chevillotte G, Roudot AC. Consumption of cosmetic products by the French population. First part: frequency data. Food Chem Toxicol 2015;78:159–169
21 Ficheux AS, Chevillotte G, Wesolek N, et al. Consumption of cosmetic products by the French population second part: amount data. Food Chem Toxicol 2016;90:130–141
22 Garcia-Hidalgo E, von Goetz N, Siegrist M, Hungerbühler K. Use-patterns of personal care and household cleaning products in Switzerland. Food Chem Toxicol 2017;99:24–39
23 Dornic N, Ficheux AS, Roudot AC. Consumption of cosmetic products by the French population. Third part: product exposure amount. Food Chem Toxicol 2017;106(Pt A):209–222
24 Bernard A, Dornic N, Roudot A, Ficheux A. Probabilistic exposure assessment to face and oral care cosmetic products by the French population. Food Chem Toxicol 2018;111:511–524
25 Ng C, Tsoi JKH, Lo ECM, Matinlinna AJP. Safety and design aspects of powered toothbrush-a narrative review. Dent J 2020;8(01):15
26 Adam R. Introducing the Oral-B iO electric toothbrush: next generation oscillating-rotating technology. Int Dent J 2020;70 Suppl 1(Suppl 1):S1–S6
27 de Silva AM, Hegde S, Akudo Nwagbara B, et al. Community-based population-level interventions for promoting child oral health. Cochrane Database Syst Rev 2016;9(09):CD009837
28 Kedzierski M, Frère D, Le Maguer G, Bruzaud S. Why is there plastic packaging in the natural environment? Understanding the roots of our individual plastic waste management behaviours. Sci Total Environ 2020;740:139985
29 Porta R, Sabbah M, Di Pierro P. Bio-based materials for packaging. Int J Mol Sci 2022;23(07):3611
30 Madhumitha CT, Karmegam N, Biruntha M, et al. Extraction, identification, and environmental risk assessment of microplastics in commercial toothpaste. Chemosphere 2022;296; 133976
31 Ustabasi GS, Baysal A. Bacterial interactions of microplastics extracted from toothpaste under controlled conditions and the influence of seawater. Sci Total Environ 2020;703:135024
32 Bhagat J, Nishimura N, Shimada Y. Toxicological interactions of microplastics/nanoplastics and environmental contaminants: current knowledge and future perspectives. J Hazard Mater 2021; 405:123913
33 Suppipat S, Hu AH, Trinh LTK, Kuo CH, Huang LH. A comparative life cycle assessment of toothpaste cream versus toothpaste tablets. Sustain Prod Consum 2022;29:357–369
34 Heink U, Kowarik I. What are indicators? On the definition of indicators in ecology and environmental planning. Ecol Indic 2010;10(03):584–593