

Original Research Article

Cognitive abilities and toothbrushing amongst orphans: a kinship in disguise

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ABSTRACT

Background: Oral hygiene practices in children are influenced by their cognitive abilities, particularly sustained attention and working memory. To understand whether these cognitive functions affect oral hygiene outcomes over time may help design better preventive programs in orphanage. To evaluate the correlation between sustained attention, working memory, and oral hygiene status using the oral hygiene index–simplified in children in orphanage.

Method: A cross-sectional observational study was conducted among typically developing children in orphanage aged 9–12 years. Baseline oral hygiene status was recorded by OHI-S index after using disclosing agent at baseline. Sustained attention and working memory were assessed using standardized neurocognitive tools like Stroop test and Corsi block test respectively. All participants received uniform toothbrushing instructions and a standardized brushing kit including toothbrush and toothpaste. Again OHI-S index is assessed after brushing. Data were analyzed using appropriate statistical tests with a significance level of $p < 0.05$.

Results: The sustained attention, working memory, and toothbrushing efficacy increased significantly with age, and an association of sustained attention and working memory was seen with toothbrushing efficacy, irrespective of the child's age, which was reported using Spearman's coefficient ($p = 0.000$).

Conclusion: Both sustained attention and working memory significantly increased with age, and were significantly associated with higher toothbrushing efficacy in orphans.

Keywords: Sustained attention, Working memory, OHI-S, Children, Cognitive skills, Oral hygiene

INTRODUCTION

Dental plaque serves as a major etiological factor in the development of dental caries and periodontal disease. Good oral hygiene practices, such as regular and effective toothbrushing, are fundamental means of plaque control.¹ To be able to maintain and improve oral health, proper tooth brushing is essential.² Due to cognitive impairment, children with neurodevelopmental disorders exhibit poor oral hygiene and a higher prevalence of dental caries.³ Cognitive functions related to planning, cognitive flexibility, selective attention, sustained attention, and procedural/working memory are necessary for brushing for the recommended two minutes, reaching all tooth

surfaces, and utilizing optimal technique. "Executive functioning" is a more comprehensive word that includes all of these cognitive abilities.⁴

Maeneja et al and colleagues, through their systematic review, found that heavy digital media use during childhood and adolescence substantially undermines the development of executive functions, with working memory standing out as one of the domains most strongly impacted. Prolonged use of digital devices has been strongly associated with reduced attention spans and impairments in core cognitive abilities.⁵ Since effective toothbrushing largely depends on underlying cognitive skills, this study investigates whether attention span

influences brushing performance and effectiveness in children. Working memory, a core component of executive functioning, refers to the capacity to briefly retain information while simultaneously manipulating or processing it, and is closely tied to an individual's ability to sustain attention over time. Within community-based literature, toothbrushing has consistently been characterized as a habitual, structured behavioral routine that follows a repeated pattern.⁴

Existing evidence suggests that children with attention deficit (ADHD) commonly experience poorer oral health, including higher plaque indices, relative to their typically developing peers. This association is frequently linked to core features of the disorder, particularly limited attention span and difficulty sustaining focus during daily self-care tasks such as toothbrushing. Notably, stronger executive function performance has emerged as a protective factor against dental caries, whereas children identified by parents as inattentive or hyperactive show a higher prevalence of caries.⁶

The oral health status and overall quality of life of orphaned children and adolescents in a population widely recognized as vulnerable to carry significant implications for both individual well-being and broader public health outcomes.⁷ Nonetheless, limited research has examined the link between cognitive functioning and oral hygiene practices among orphaned children, pointing to a notable gap in our understanding of how cognitive abilities shape toothbrushing quality.³

Therefore, the present study aimed to evaluate the relationship between cognitive abilities like sustained attention, working memory, and the effectiveness of unsupervised toothbrushing in orphans aged 9–12 years.

METHODS

Study design and settings

This was an observational, cross-sectional study which was reported in conformance with Strengthening the Reporting of Observational Studies in Epidemiology guidelines. The present study was conducted using an observational study design at Unmuktanand Orphanage from January 2026 to March 2026.

Sample size calculation and selection of participants.

A minimum sample size of 42 was calculated at power of 80% and alpha error of 5%, using formula.

$$N = \frac{\left(Z_{1-\frac{\alpha}{2}} + Z_{1-\beta}\right)^2 [s]^2}{d^2}$$

$Z_{(1-\alpha/2)}$ is z variate of alpha error (constant with value 1.96)

$Z_{(1-\beta)}$ (constant with value 0.84)

d is true difference of 1.7 units between time intervals

s is pooled standard deviation of 3.7

Inclusion criteria

Orphans with age 9-12 year. Children who were present on the day of examination and willing to participate. Children who were physically and mentally capable of performing cognitive test.

Exclusion criteria

Children with systemic diseases or medical conditions. Children with neurological or developmental disorders that could interfere with cognitive testing.

Measures and procedure

A total of 146 children who were examined and fulfilled the eligibility criteria were enrolled in the study. Oral health status was assessed using the DMFT/DMFT index in accordance with WHO criteria, through clinical examination performed with a plane mouth mirror and a community periodontal index (CPI) probe to record the number of decayed (D), missing (M), and filled (F) teeth.

Executive function's assessment

Sustained attention assessment

Selective attention was evaluated using the Stroop test.⁸ In the Stroop test, participants are instructed to name the colour of the ink rather than read the word displayed (e.g., "red" printed in green ink), responding as quickly as possible. The task requires inhibition of the more automatic process of reading in favour of the less automatic process of colour identification, thereby assessing the children sustained attention, with higher scores reflecting greater attentional capacity.

Working memory assessment

Working memory was evaluated using the Corsi block tapping test (CBT).⁹ participant undergoing the CBT are shown a sequence of illuminated blocks, beginning with two, out of a total of nine displayed on screen. They are required to reproduce the sequence by clicking the blocks in identical order, with the sequence increasing in length after each successful trial. The test concludes when the children fail to replicate the sequence correctly, and the highest span achieved is taken as the final score, with greater spans denoting stronger working memory.

Toothbrushing efficacy evaluation

Dental plaque was disclosed using plaque disclosing gel, PLAQUE D by Maarc dental. The scores were recorded

under standardized light conditions using OHI-S index, calibrated dentist (P1). Participants were then provided with a standardized brushing kit, comprising a 1000 ppm fluoridated toothpaste and an extra-soft bristle toothbrush, and instructed to brush as they normally would. Plaque was redisclosed afterward to record the post-brushing score (P2), and toothbrushing efficacy was calculated as the difference between the pre- and post-brushing plaque scores (P1–P2).

Statistical analysis

The data collected were compiled on a MS Office Excel Sheet (v 2019, Microsoft Redmond Campus, Redmond, Washington, United States) and subjected to statistical analysis using Statistical package for social sciences (SPSS v 26.0, IBM) (Armonk, New York, United States). Descriptive statistics like frequencies and percentage were used for gender; mean and standard deviation for age distribution.

Normality of numerical data was checked using Shapiro–Wilk test, and data did not follow a normal curve, hence non parametric tests were used. The association between cognitive skills and toothbrushing efficacy with age and cognitive skills with toothbrushing efficacy were reported using Spearman’s rho coefficient. For all statistical tests, $p < 0.05$ was considered to be statistically significant,

keeping α error at 5% and β error at 20%, thus giving a power to study as 80%.

RESULTS

Table 1 shows a nearly equal gender distribution among participants, with no statistically significant difference ($\chi^2=0.054$, $p=0.816$), indicating an absence of gender bias in the study population. Table 2 demonstrates that with increasing age, Stroop and Corsi scores showed a significant increase, indicating improvement in sustained attention and working memory. Toothbrushing efficacy (P1–P2) also increased significantly with age. Conversely, DMFT scores decreased with age.

Table 3 shows A significant inverse relationship was observed between sustained attention and baseline plaque scores. Children with higher Stroop scores demonstrated lower plaque levels. Table 4 suggests that a significant positive association was observed between cognitive skills and toothbrushing efficacy. Children with higher Stroop and Corsi scores demonstrated greater reduction in plaque after brushing. Table 5 depicts that children with higher combined cognitive index showed significantly greater toothbrushing efficacy compared to children with lower cognitive index, demonstrating the clinical impact of executive functioning on oral hygiene performance.

Table 1: Distribution of participants based on gender.

Gender	Frequency (N)	%
Males	74	50.7
Females	72	49.3
Total	146	100

Chi-square test: $\chi^2=0.054$, $p=0.816$.

Table 2: Comparative evaluation of DMFT, Stroop score, Corsi score, and toothbrushing efficacy based on age.

Parameters	9 years	10 years	11 years	12 years	Spearman’s rho	P value
DMFT	4.82±1.21	4.35±1.04	3.92±0.88	3.40±0.79	−0.521	0.000*
Stroop score	0.86±0.15	0.98±0.17	1.08±0.19	1.18±0.21	0.612	0.000*
Corsi score	4.21±0.74	4.88±0.81	5.36±0.92	5.90±0.85	0.648	0.000*
P1–P2	0.42±0.26	0.71±0.34	1.02±0.39	1.18±0.41	0.573	0.000*

*Statistically significant at $p < 0.05$.

Table 3: Correlation between cognitive functions and baseline plaque scores (P1).

Parameter	Correlation coefficient	P value
Stroop score	−0.348	0.001*
Corsi score	−0.219	0.009*

*Statistically significant at $p < 0.05$.

Table 4: Correlation between cognitive functions and toothbrushing efficacy (P1–P2).

Parameter	Correlation coefficient	P value
Stroop score	0.462	0.000*
Corsi score	0.389	0.000*

*Statistically significant at $p < 0.05$.

Table 5: Comparison of toothbrushing efficacy between low and high combined cognitive index groups.

Cognitive index group	N	Mean P1-P2	SD	P value
Low cognitive index	73	0.68	0.29	0.000*
High cognitive index	73	1.16	0.37	

*Statistically significant at $p < 0.05$.

DISCUSSION

Dental caries remains one of the most widespread oral health diseases affecting children and continues to pose a significant public health challenge worldwide. According to a systematic review by Kazeminia et al the global prevalence stands at 46.2% for primary and 53.8% for permanent dentition.¹⁰

Typically developing children are those who attain standard developmental milestones at appropriate ages, and the effectiveness of toothbrushing mainly depends on parental knowledge and attitude toward oral hygiene during early childhood. However, existing literature indicates that 9%–72% of children under the age of six brush their teeth without parental supervision, with unsupervised brushing associated with a minimal mean active brushing time of only 10 seconds posing a significant risk for the development of dental caries.¹¹

Considerable research has explored how toothbrushing efficacy relates to factors like technique, frequency, and duration. However, few studies have explored the connection between cognitive skills and brushing effectiveness and to our knowledge, no study has examined this specifically in typically developing children aged 9–12 years. In the present study, we recorded the DMFT index simply to standardize participants with respect to their baseline oral health status.

Various tests have been created to evaluate cognitive skills. These are goal-oriented behaviour tasks that are linked to the activity of frontal lobes and anterior cingulate cortex, which include activation and transportation of signals along white matter tracks that connect the superior longitudinal fasciculus, inferior longitudinal fasciculus, and other areas.¹² The SCWT is a neuropsychological test which was originally proposed by Stroop in the 1935.⁸ CBT test was developed by Milner et al and modified by Corsi et al for measuring visuospatial and working memory. A computer-based version was adapted in late 1990s, which has good reliability and validity scores.⁹

The present findings support the observations of Rivera et al, Scarpina et al and Tagini et al who identified the Stroop colour–word test as a measure of attentional control and executive functioning. In the current study, Stroop scores increased significantly with age, reflecting age-related improvement in sustained attention.^{13,14} Moreover, the significant negative correlation between Stroop scores and baseline plaque levels suggests that children with better attentional abilities may be more capable of maintaining effective oral hygiene. This association highlights the

influence of cognitive processes, particularly sustained attention, on oral health behaviors in children.⁸ Consistent with the findings of Winni et al and Kamlabadi et al the present study found a significant decrease in DMFT scores with age, suggesting that improving cognitive abilities may be associated with better oral health and lower caries experience.^{3,15}

Brunetti et al demonstrated a significant age-related difference in Corsi span scores, with younger adults (mean 6.10 ± 0.80) outperforming older adults (mean 4.76 ± 1.18), confirming that visuospatial working memory capacity improves systematically with developmental maturation.¹⁶ This is consistent with the age-related increase in Corsi scores observed in the present study (4.21 at 9 years to 5.90 at 12 years). Kessels et al established normative data for the CBT in adults, reporting an average forward Corsi span of five to seven blocks, with scores showing significant variation across age groups.¹⁷ The Corsi scores of older children (11–12 years) in the present study begin to approach this normative adult range, supporting the developmental trajectory captured by the test.

A key strength of this study was the use of a plaque disclosing agent, which enhanced the accuracy and consistency of plaque assessment while minimizing examiner bias. Another notable strength lay in the use of brief, child-friendly cognitive assessment tools, who's engaging, play-based format allows easy administration while creating a nonthreatening environment. This approach enables early behavioral and attentional screening, offering pediatric dentists a practical means of educating and guiding parents on the potential need for continued brushing supervision beyond 8 years of age.

Limitations

This study focused on two key domains of executive function sustained attention and working memory given their well-established relevance to toothbrushing performance; future research may build on these findings by exploring additional domains such as cognitive flexibility and inhibitory control. Similarly, toothbrushing efficacy was assessed during a single observed session, which provided a standardized and controlled measure of performance, though habitual day-to-day brushing patterns may be explored in subsequent longitudinal studies.

CONCLUSION

The present study concludes that there is a significant correlation between sustained attention, working memory, and toothbrushing efficacy in children aged 9–12 years.

Both cognitive parameters and brushing performance improved consistently with age, and this association remained significant independent of age, indicating that executive functioning plays a substantive role in unsupervised toothbrushing effectiveness.

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