Influence of Digit Sucking Habit on Masseter Muscle Thickness and Upper Airway Dimensions in Nigerian Children

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ABSTRACT

Background: Digit sucking habit (DSH) generates functional forces that can influence craniofacial morphology. Although the dental effects have been widely reported, their influence on the masseter muscle thickness (MMT) and upper airway (UA) dimensions is not well known.

Methods: Thirty (30) children selected from the orthodontic clinic (OAUTHC) with a DSH were matched with a group of 30 children without a DSH. Each group was comprised of 16 males and 14 females. Ultrasonographic evaluation of the masseter muscle (MM) was performed to measure the left and right MMT in the relaxed and contracted states. Lateral cephalometric radiographs were obtained, and six UA variables were measured on the x-ray. The data was analyzed using SPSS version 20.0. Statistical significance was set at $p<0.05$.

Inferential statistics were done using an independent sample t-test to compare means.

Results: Participants in the DS group had a mean age of 7.7 ±2.2 years, whereas those in the non-DS group had a mean age of 8.1 ±2.1 years. The MM was generally thicker among the DS group, both in the contracted and relaxed states, when compared with the non-DS group, but these differences were not statistically significant ($p > 0.05$). The mean measurement of the width of the nasopharynx (P1) was significantly decreased among the DS group when compared with the non-DS group ($p<0.05$). There was no statistically significant difference in the mean values for the width of the oropharynx (P2), hypopharynx (P3), soft palate length (PNS-U1), thickness (MPT), and the posterior bony boundary of the nasopharynx (PNS-Ba) between both groups. ($p>0.05$).

Conclusion: The rigid sucking habit caused a statistically significant narrowing of the width of the nasopharynx ($p<0.05$). The MMT did not differ significantly between the DS and non-DS groups, both in the relaxed and contracted states.

INTRODUCTION

Oral habits can alter oro-facial functional forces that may influence dentofacial growth and development.[1] Facial growth increases during the primary dentition stage with an even greater increase in length during the mixed dentition stage.[2] The digit-sucking habit is considered normal up to 3 years of age[3] and becomes a cause for concern if it persists beyond 3 to 4 years of age. Between the ages of 4 and 12, the length of the face doubles in comparison to its width. This age range coincides with the crucial period of dentofacial development. Harmful oral habits occurring within this period can lead to unbalanced functional forces that affect the orofacial neuromuscular balance and may cause distorted facial growth and malocclusion, along with changes in the upper airway dimension.[4,5] Respiration through the upper airway is a vital functional process that can have a profound influence on normal craniofacial development.[6,7] Increased resistance in the upper airway caused by a reduction in the upper airway dimension has been reported to be a contributing factor to deviant facial growth patterns as a result of the prolonged presence of unbalanced oropharyngeal muscle activity. [8]Computed tomography scans, magnetic resonance imaging, and lateral cephalometric x-rays are some of the methods that have been used to assess the upper airway dimension.[8-11] The lateral cephalometric x-ray is a valid means for assessing the upper airway.[12] However, studies on the relationship between digit sucking habit and upper airway space are limited [13] and upper airway values for Nigerian children could not be found in the literature.

The masseter muscle is the largest facial muscle and it is a muscle of mastication.[14] It is involved in a wide variety of activities, including mastication, swallowing, and speech. The masseter muscle, which originates from the zygomatic arch and inserts along the angle and lateral surface of the mandible, provides powerful elevation and protrusion of the mandible.[1] Previous studies have shown that the elevator muscles of the mandible influence transverse and vertical facial dimensions.[15]

[16]Functional influences of a muscle may be assessed by measuring its length, thickness, width, cross-sectional area, or volume. However, previous studies have reported that masseter muscle thickness was significantly correlated to vertical facial pattern and body mass index, with individuals with a thick masseter muscle having a shorter facial pattern.[17,18]

Despite the reported influence of the masseter muscle on dentofacial growth and development, studies on the effect of digit sucking on masseter muscle thickness are scarce in the literature. Agnihotri et al[19] in their study in India, conducted among 9- to 11-year-old children, functionally assessed the effects of thumb-sucking habits on the masticatory and circumoral musculature. They compared the change in muscle thickness between the contracted and relaxed states with the muscle thickness in the contracted state (standardized fractional shortening) of the study and control groups. They then reported a statistically significant difference in fractional shortening in masseter mid-belly ($p = 0.00237$) between the study group and the control group.

Otaren et al[20] in Benin City, Nigeria, in a case-control study among 7- to 12-year-old Nigerian children with a digit-sucking habit, reported that participants in the digit-sucking group showed a significant increase in the masseter muscle thickness at contraction in the mid-belly region of the muscle and a reduction in fractional shortening ($p<0.05$)[20]. A study conducted in Kano, the northern region of Nigeria, assessed the impact of habitual activities, such as the use of wind instruments, but found that the observed increased masseter muscle thickness among wind instrument players did not attain statistical significance.[21] In another study from Nigeria on the relationship of masseter muscle thickness to overbite values,[17] the masseter muscle on the habitual side of mastication of participants was found to be generally thicker. However, the difference was not statistically significant ($P<0.05$). Egwu et al[22] in Abakilili, the south-eastern region of Nigeria, reported that the masseter muscle thickness was significantly thicker in males than in females among an adult population. Baril and Moyers[23] studied the effects of digit sucking on the temporalis, mentalis, orbicularis, and buccinator muscles. They reported that the abnormal patterns seen during the sucking action in these muscles are so firmly established that they persist in the participants even in the period after the sucking action. Identification of unbalanced forces as a result of changes in masseter muscle thickness due to oral habits is therefore important in orthodontic treatment planning, active treatment, and post-treatment retention, as vertical changes in facial dimensions due to unbalanced forces from oral habits can be difficult to treat. Therefore, the purpose of this study is to determine the effect of digit sucking on masseter muscle thickness and upper airway dimensions in Nigerian children.

MATERIALS AND METHODS

Ethical approval for the study was obtained from the Ethics Committee of the Obafemi Awolowo University Teaching Hospitals Complex in Ile-Ife, Nigeria, with ethical protocol number ERC/2016/10/04. Written informed consent was obtained from all eligible participants before enrollment. They were also informed of the voluntary nature of participation and the freedom to withdraw from the study at any time. The study was conducted at the Orthodontic Unit of the Department of Child Dental Health and the Department of Radiology, Obafemi Awolowo University Teaching Hospitals Complex, Ile-Ife, Osun State, Nigeria, between August 2018 and December 2019. A total of 60 participants aged 4 to 12 years old were enrolled in the study, comprising 30 children diagnosed with a persistent digit-sucking habit in the digit-sucking group (DS group), who were matched for age (± 1 year), sex, and skeletal pattern, and 30 children without a digit sucking habit in the non-DS (control) group. Participants assessed to be in the healthy weight range (5th to 85th percentile) according to the body mass index (BMI) to percentile chart from the Centre for Disease Control and Prevention24 (CDC) (Figures 1a and 1b) were recruited consecutively into both groups from patients who presented at the orthodontic clinic, Department of Child Dental Health, provided they met the inclusion criteria.

All participants enrolled in the study had their masseter muscle thickness assessed by ultrasound at the Radiology Department of the OAUTHC in Ile-Ife, Osun State, utilizing a real-time MINDRAY DC-7 ultrasound machine with a 7.5 MHz linear probe. A radiologist experienced in ultrasonographic studies[17⁄8] of the masseter muscle thickness performed the measurements for each participant according to a method described by Kiliaridis and Kalebo[2]5. The left and right masseter muscle thickness of each participant recruited into the study was measured using ultrasonography at the Radiology Department, OAUTHC Ile-Ife, Osun State, using a real-time Mindray DC-7 ultrasound machine with a 7.5 MHz linear probe.

The participants were placed in a supine position with their heads turned sideways to provide good access to the probe (Figure 2). A generous amount of water-based ultrasound gel was applied directly over the masseter region and also under the probe to avoid tissue compression. To register the scan plane at right angles to the long axis of the muscle, the probe was oriented at an estimated angle of 30 degrees to the Frankfort plane. The orientation of the probe was maintained manually, and the full length of the muscle was scanned from origin to insertion. The measurement was taken from the thickest part of the masseter muscle (mid-belly) close to the level of the occlusal plane, halfway between the zygomatic arch and the gonial angle.[26-28] Bilateral measurements were taken, and the angle of the probe was adjusted during scanning to produce the strongest echo from the ramus of the mandible. The measurements were made directly from the image at the time of scanning. The imaging and measurements were performed three times, with an interval of five minutes between each measurement, and the average was recorded.

All participants were examined by the same operator to eliminate inter-observer error. The measurements for the masseter muscle were recorded for each participant, both in the relaxed and contracted states (Figure 3). The subject was instructed to relax but to maintain slight occlusal contact. This was to prevent muscle stretching during mouth opening. In the contracted state, the participants were instructed to clench maximally in the intercuspal position.[29] Measurements taken in millimeters included right masseter muscle thickness is relaxed, left masseter muscle thickness is relaxed, right-masseter muscle thickness contracted, left masseter muscle thickness contracted

Standardized lateral skull radiographs were taken for all the subjects using a Pan-Blue-Oris Machine (BlueXTM Imaging SrlBldXpPanceph Metric 71680000700 Assago, Italy). The cephalometric radiographs were traced manually using a sharp HB lead pencil on a 0.003” matte-finish acetate sheet placed over the radiograph and secured with masking tape on an illuminated viewing box. All radiographs were traced by the principal investigator (A.N.). Linear measurements were recorded in millimeters (mm). The landmarks shown in Table 1 and Figure 4 were identified on the cephalometric radiographs of each participant in the present study, and the values obtained were compared between subjects in the DS group and the non-DS group.

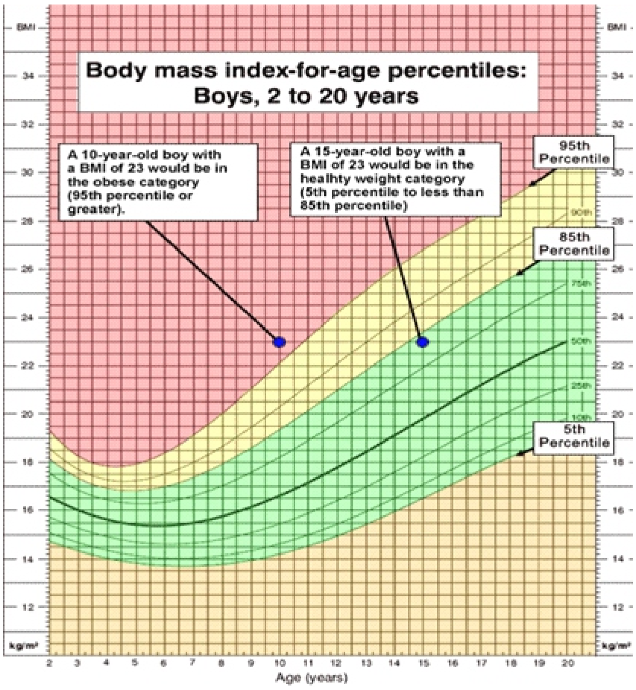


Figure 1a: CDC chart showing BMI to percentiles conversion for boys aged 2-20 years.

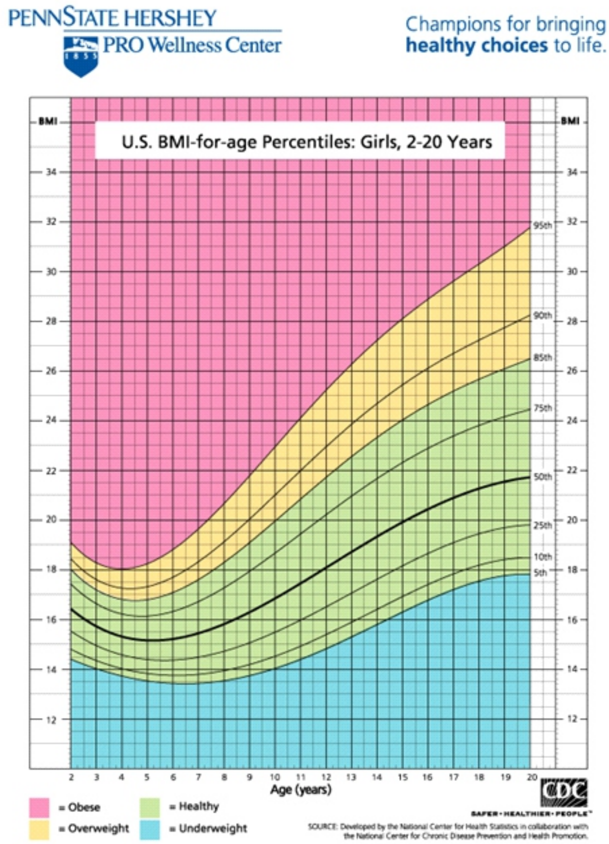


Figure 1b:CDC chart showing BMI to percentiles conversion for girls aged 2-20 years.

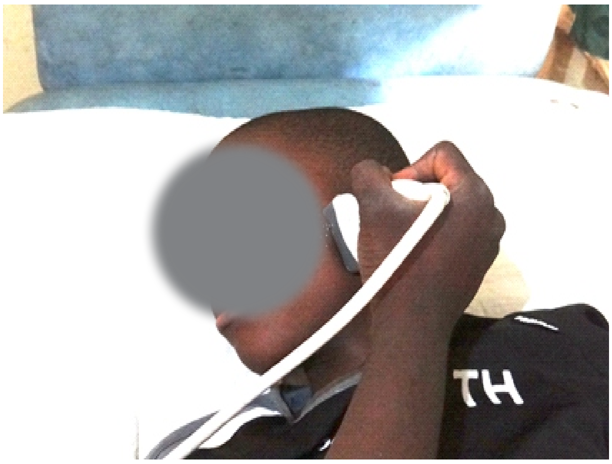
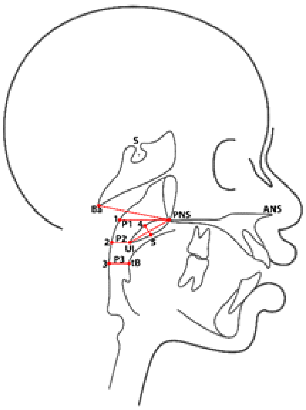


Figure 3: Ultrasonographic measurement of the masseter muscle thickness in the clenched and relaxed states

Table 1. Pharyngeal measurements taken on the cephalometric x-ray

Measurement	Abbreviation	Definition
Nasopharynx	P1	Linear distance from the PNS to point 1 on the posterior wall of the pharynx
Oropharynx	P2	Linear distance from the tip of the uvula to point 2 on the posterior pharyngeal wall
Posterior bony boundary of the nasopharynx	PNS-Ba	Linear distance from Posterior Nasal Spine to Basion
Soft palate length	PNS-U1	Linear distance between PNS and U1, the tip of the soft palate
Maximum palatal thickness	MPT	Linear distance between the thickest portion of the soft palate



Measurement	Description
Nasopharynx (P1)	PNS – Point 1
Oropharynx (P2)	U1- Point 2
Hypopharynx (P3)	tB – Point 3
Posterior boundary of the Nasopharynx	PNS-Basion

Figure 4: Diagram showing pharyngeal parameters.

RESULTS

Masseter muscle thickness and upper airway dimensions were determined in all study participants. Participants in the DS group had a mean age of 7.7 ±2.2 years, whereas those in the non-DS group had a mean age of 8.1 ±2.1 years. There were 16 males and 14 females in each group. (Table 2). Age and gender did not differ significantly between the two groups ($p>0.05$).Comparisons of the mean masseter muscle thickness for the DS and non-DS groups are shown in Table 3. The masseter muscle was generally thicker among the DS group, both in the contracted and relaxed states when compared with the non-DS group, although these differences were not statistically significant ($p>0.05$).

The differences in the upper airway dimensions among participants in the DS and non-DS group are shown in Table 4. The mean measurement of the width of the nasopharynx (P1) was significantly decreased among the DS group when compared with the non-DS group ($p<0.05$). Although the difference was not statistically significant, the mean values for the width of the oropharynx (P2), hypopharynx (P3) were wider, while the mean measurements of the posterior bony boundary of the nasopharynx (PNS-Ba) soft palate length (PNS-U1) and thickness (MPT) were reduced in the DS group and compared to the non-DS group. ($p>0.05$).

Table 2: Age and Gender of Participants in the Digit sucking and Non-Digit sucking group

Variable	DS group (n=30)	Non-DS group (n=30)	Total N=60	$\chi 2$	p-value
Age group (Years)	freq(%)	freq(%)	Freq(%)		
4-6	9(30.0)	8(26.7)	17(28.3)	0.424	0.809
7-9	16(53.3)	15(50.0)	31(51.6)		
10-12	5(16.7)	7(23.3)	12(20.0)		
Gender					
Male	16(53.3)	16(53.3)	32(53.3)	0.000	1.000
Female	14(46.7)	14(46.7)	28(46.7)		

Table 3. Comparison of the mean masseter muscle (MM) thickness in the DS and non-DS groups, in their contracted and relaxed states

Masseter Muscle(MM) thickness	DS group Mean±SD (mm)	Non-DS group Mean±SD (mm)	Overall Mean±SD (mm)	t-value	p-value
Right MM thickness (relaxation)	11.97±2.1	11.18±1.2	11.58±1.7	1.787	0.079
Left MM thickness (relaxation)	11.34±2.1	11.00±1.3	11.17±1.8	0.747	0.458
Right MM thickness (clench)	13.58±2.1	12.76±1.3	13.17±1.8	1.845	0.070
Left MM thickness (clench)	13.09±2.2	12.31±1.6	12.71±1.9	1.573	0.121

Independent sample t test

Table 4. Comparison of the mean upper airway dimensions in the DS and non-DS groups

Upper Airway Dimension	DSgroup Mean±SD (mm)	Non-DS group Mean±SD (mm)	Overall Mean±SD (mm)	t-value	p-value
Nasopharynx (P1)	19.17±5.8	22.57±4.5	20.87±5.2	-2.535	0.014*
Oropharynx (P2)	16.50±5.8	15.07±3.4	15.78±4.8	1.165	0.249
Hypopharynx (P3)	11.97±3.5	10.83±2.3	11.40±3.0	1.479	0.145
Soft palate length (PNS-U1)	16.63±5.5	18.97±7.3	17.80±6.5	-1.395	0.168
MPT	6.37±1.7	6.97±1.3	6.67±1.5	-1.529	0.132
PNS-Ba	53.10±5.6	54.57±5.8	53.84±5.7	-0.868	0.389

*Independent sample t test, *= Statistically significant*

DISCUSSION

This study aimed to explore the potential influence of digit-sucking habits on muscle thickness and upper airway dimensions among Nigerian children aged 4 to 12. The findings of this investigation provide novel insights into the relationship between digit-sucking behaviors and various craniofacial parameters, shedding light on potential implications for dental, craniofacial, and airway development in children. The persistence of digit sucking beyond the age of three years has been known to cause occlusal deformation, and the permanence of this deformation increases significantly if the habit is continued.[30-32] The study employed ultrasonography to assess the masseter muscle thickness in both relaxed and clenched states among children with and without digit-sucking habits, as it is a radiation-free, inexpensive, repeatable, and quick imaging method. This is similar to the method of measurement of masseter muscle thickness used in previous studies.[17, 20,25]

Interestingly, the results revealed that children in the digit-sucking (DS) group exhibited a trend towards increased masseter muscle thickness in comparison to those in the non-digit-sucking (non-DS) group. However, it is important to note that these differences did not attain statistical significance. This observation aligns with the existing understanding that prolonged digit sucking can lead to the hyperactivity of the masseter muscle due to the continuous mechanical stimulus. [33] This potentially contributes to the muscle's adaptive response by increasing its thickness.[33] Nonetheless, the lack of statistical significance in our study might be attributed to factors such as the age range of the participants and the variations in the intensity and duration of digit-sucking habits. Furthermore, our study did not explore the potential association between increased masseter muscle thickness and vertical craniofacial morphology, which remains a pertinent avenue for future research. It is noteworthy that our findings differ from those of Otaren[20] and Agnihotri et al [19], who reported statistically significant differences in masseter muscle thickness among DS groups in their studies. One possible explanation for these disparities could be the variation in the age ranges of participants. Our study included a wider age range, spanning from 4 to 12 years, while Otaren[20] included 7 to 12-year-olds and Agnihotri et al[19] included 9 to 11-year-olds. The age-related changes in muscle development and the duration and intensity of digit-sucking habits may explain these discrepancies.

Beyond investigating the influence of digit sucking on masseter muscle thickness, our study extended its focus to upper airway dimensions using lateral cephalometric X-rays. Notably, the results indicated a statistically significant reduction in the width of the nasopharynx (P1) among children in the DS group when compared to their non-DS counterparts. This outcome suggests a potential narrowing of the nasopharyngeal region, which could have implications for upper airway patency, oral breathing, and even obstructive sleep apnea.[13,34-35] Although this significant difference in nasopharyngeal width was observed, the precise reasons underlying this phenomenon remain speculative, as the study did not delve into the mechanisms responsible for this change. Nonetheless, this finding is in line with the results reported by Salazar-Arboleda et al[13] in their study, emphasizing the need for further research to unravel the underlying causes of nasopharyngeal narrowing associated with digit-sucking habits. Our study did not observe statistically significant differences in the width of the oropharynx, hypopharynx, posterior bony boundary of the nasopharynx (PNS-Ba), soft palate length (PNS-U1), and thickness (MPT) between the DS and non-DS groups. However, it is worth considering that the observed trends toward wider oropharynx and hypopharynx measurements in the DS group could suggest potential adaptations in tongue posture due to digit-sucking habits. Yet, these trends did not reach statistical significance and require further exploration.

CONCLUSION

This study contributes valuable insights into the potential influence of digit-sucking habits on masseter muscle thickness and upper airway dimensions among Nigerian children aged 4 to 12 years. While the findings indicate trends towards increased masseter muscle thickness and alterations in upper airway dimensions in the DS group, the lack of statistical significance in some instances underscores the complexity of these relationships. This study therefore highlights the need for larger sample sizes and more comprehensive assessments to fully understand the effects of digit sucking habits on craniofacial and airway development. The implications of these findings can guide future research, prevention, and treatment strategies to address the long-term consequences of digit-sucking behaviors on children's oral health, facial morphology, and airway function.

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