ORIGINAL ARTICLE

# Duration of nutritive and nonnutritive sucking behaviors and their effects on the dental arches in the primary dentition

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The purpose of this study was to determine the association between the duration of nutritive and nonnutritive sucking behaviors and various occlusal characteristics in the primary dentition. Sucking behavior data were collected on 372 children followed longitudinally from birth by using periodic questionnaires completed by parents. Study models were obtained from the children at 4 to 5 years of age and assessed for posterior crossbite, anterior open bite, and overjet. Dental arch parameters including arch widths, arch lengths, and arch depths were measured directly from the models. The subjects were grouped according to type of habit (pacifier or digit) and duration of nonnutritive sucking behaviors (less than 12, 12 to 24, 24 to 36, 36 to 48, and more than 48 months). Children with nonnutritive sucking of less than 12 months were further grouped according to the duration of breast-feeding. The dental arch and the occlusal characteristics were then compared among these groups. The results indicated no relationship between duration of breast-feeding during the first year of life and any dental arch or occlusal parameters. The study found that prolonged pacifier habits resulted in changes to the dental arches and the occlusal parameters that were different from the effects of digit sucking. In addition, some changes in the dental arch parameters and occlusal characteristics (eg, prevalence of posterior crossbite and increased amount of overjet) persisted well beyond the cessation of the pacifier or digit habit. Although further study is needed to determine the effects of nonnutritive sucking behavior in the mixed dentition, the results suggest that current recommendations for discontinuing these habits may not be optimal in preventing habit-related malocclusions. (Am J Orthod Dentofacial Orthop 2002;121:347-56)

Sucking behaviors have long been recognized to affect occlusion and dental arch characteristics. As early as the 1870s, Campbell[1] and Chandler[2] recognized that prolonged finger or thumb sucking habits had deleterious effects on certain occlusal traits. More recently, it has been suggested that longer breast-feeding may be associated with fewer occlusal abnormalities. However, these suggestions are based on very few studies of the effects of infant feeding method on dental arch development, and 2 of these studies relied on parental reporting of malocclusions rather than on actual clinical assessment. For example, a case-control study of 454 Massachusetts children from 10 to 12 years of age found a weak association between bottle-feeding and malocclusion that was not statistically significant.[3] This study relied on interview questions posed to parents regarding orthodontic treatment as its primary means of assessing the presence of a malocclusion.

A study using data from the 1981 United States National Health Interview Survey (NHIS) revealed that longer breast-feeding was associated with a lower proportion of malocclusion among children 3 to 18 years of age.[4] However, this study asked parents whether orthodontic treatment had ever been performed or recommended for their child as an indirect measure of malocclusion. Furthermore, breast-feeding data were obtained from retrospective interview questions. By contrast, an earlier longitudinal study of 122 Iowa infants found no significant differences in the dental arch dimensions among 6 groups with various feeding and sucking behaviors at 18 or 36 months of age.[5]

Relationships between nonnutritive sucking habits and occlusal abnormalities have been much more extensively studied.[6-18] These studies found that nonnutritive sucking habits were associated with certain malocclusions in the primary dentition, including anterior open bite, increased overjet, and Class II canine and molar relationships.[6-15] For example, Kohler and

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Holst[14] found that 4-year-old Swedish children with pacifier or finger sucking habits were significantly more likely to develop anterior open bite, excessive overjet, and posterior crossbite than children with no such history. A study of 218 children 2 to 4 years of age in the United States compared those with a history of pacifier use to those with no history of nonnutritive sucking.[6,7] The authors reported that those with a history of pacifier use had significantly greater mean overjet, a significantly higher prevalence of Class II primary canine and molar relationships, and a greater prevalence of open bite and posterior crossbite.[6,7]

Several studies have also reported the effects of prolonged nonnutritive sucking on certain dental arch measurements such as decreased maxillary arch width and increased lower arch width, with correspondingly higher prevalence of posterior crossbite.[6,7,10,12,14,16-18] For example, Ögaard et al.[16] examined posterior crossbite in 445 3-year-old children with and without previous or continued finger or pacifier sucking habits. They reported that pacifier use decreased maxillary intercanine arch width and increased mandibular intercanine arch width, resulting in crossbite. Analysis of covariance revealed that a pacifier habit of 2 years or longer was necessary to cause decreased maxillary arch width, and a pacifier habit of 3 years duration was significantly associated with increased mandibular arch width.

Although these studies document the consequences of prolonged nonnutritive sucking habits on the primary dentition, most of them relied on cross-sectional designs, so that the relationship between duration of nonnutritive sucking behaviors and malocclusion is difficult to assess. The purpose of this study was to assess the effects of the duration of breast-feeding and pacifier and digit sucking habits on the dental arch and the occlusal characteristics among a birth cohort of children in the primary dentition assessed at 5 years of age.

## MATERIAL AND METHODS

### Subjects and questionnaires

The sample was drawn from a large prospective cohort study of nearly 700 children as described previously.[19-21] Mothers of the children in the study were recruited in hospital postpartum wards in Iowa from March 1992 to January 1995. The mothers were asked to complete a series of mailed questionnaires that included items regarding both nutritive and nonnutritive sucking behaviors at 3, 6, 9, 12, 16, and 20 months of age. Questions about nonnutritive sucking behaviors continued to 24 months and then yearly thereafter. Specifically, the questions asked about breast-feeding and bottle-feeding and whether the child regularly sucked on pacifiers, thumb, finger, or other objects during the preceding period since they were last contacted.

Nonnutritive sucking behaviors were categorized for each child as either primarily pacifier or primarily digit sucking, based on the last report of that sucking behavior. For 45 children, this determination was not possible, or the mother reported both digit and pacifier habits simultaneously. The duration of nonnutritive sucking behaviors was determined based on the previously collected questionnaire responses, and the behaviors were categorized based on either a digit or a pacifier habit at 12, 24, 36, and 48 months. The categories included (1) those whose habit ceased before 12 months of age; (2) those whose habit continued at 12 months but ceased by 24 months; (3) those whose habit continued at 24 months but ceased by 36 months; (4) those whose habit continued at 36 months but ceased by 48 months; and (5) those whose habit continued to 48 months or longer. To investigate the relationship between nutritive sucking duration and the dental arches, those ($n = 119$) with minimal nonnutritive sucking habits (less than 12 months) were further categorized by duration of breast-feeding: (1) no breast-feeding, (2) breast-feeding less than 6 months, (3) breast-feeding 6 to 12 months, and (3) breast-feeding more than 12 months.

### Dental arch evaluations

Children were clinically examined at 4-and-a-half to 5 years of age, and alginate impressions of the maxillary and mandibular arches and wax bite registrations were obtained for each of the 547 participating children. The impressions were poured in yellow stone, with the casts subsequently trimmed and articulated. Children with at least 1 permanent tooth present or in eruption ($n = 98$) were excluded to limit the analysis to the primary dentition. An additional 56 children were excluded because their parents did not provide sufficient data to categorize their behavior. Thus, 372 children were included in the present analyses.

All models were assessed for occlusal relationships by 1 examiner (J.J.W.). The assessments included classification of primary canine relationship (Angle classification), and presence or absence of anterior crossbite, posterior crossbite, and anterior open bite. Another examiner (S.E.B.) identified and marked the landmarks for each model. Measurements were then made directly from the casts in millimeters with calipers accurate to 0.05 mm (Mitutoyo Corporation, Tokyo, Japan). Arch parameters were measured a minimum of twice by 2 different examiners, and individual measurements that differed by more than 0.5 mm were

measured a third time to resolve the discrepancies. The following parameters were measured: arch widths in the maxillary and mandibular arches were measured as intercanine arch widths from cusp tip to cusp tip, and intermolar arch widths were measured between the mesiobuccal cusp tips of the right and left second primary molars (Fig 1).

Total maxillary and mandibular arch lengths were measured as segments on the right and left sides as follows: the anterior segment, from the contact area of the central incisors to the contact area between the canine and the first primary molar, and the posterior segment, from the contact between the canine and the first primary molar to the most distal point of the primary second molar. The segment lengths for the right and left sides for each arch were summed to determine total length for each arch (Fig 2).

Arch depth for both the maxillary and mandibular arches was measured at 2 levels: anterior arch depth was defined as the length of a line running perpendicularly from the midpoint between the central incisors to a line connecting the distal contact points of the right and left canines, and posterior arch depth was defined as the length of a line running perpendicularly from the midpoint between the 2 central incisors to a line connecting the most distal points of the right and left second primary molars (Fig 3).

Palatal depth was measured as the length of a line from the deepest point in the palate to a line connecting the mesiolingual cusp tips of the primary second molars (Fig 4).

Overjet was measured as the distance along a horizontal plane between the incisal edge of the labial surface of the mandibular central incisor and the incisal edge of the labial surface of the most labially positioned maxillary central incisor (Fig 5).

Overbite was measured as the vertical distance between the incisal edge of the maxillary central incisor and the incisal edge of the mandibular central incisor. For normal overbite, this measurement was facilitated by scribing a pencil line on the buccal surface of the mandibular central incisor corresponding to the position of the incisal edge of the maxillary central incisor. For open bite, the vertical distance between the incisal edges of the maxillary and mandibular central incisors was recorded (Fig 5).

### Data management and statistical analysis

Questionnaire data were double entered and verified with spreadsheet software and analyzed with SAS.[22] Dental arch data were entered with SPSS Data Entry[23] and analyzed with the SPSS statistical program.[24] The questionnaire and dental arch data were then combined and analyzed with SPSS software. The breast-feeding duration categories were compared with a 1-way analysis of variance (ANOVA). Similarly, the sucking habit duration categories for those with pacifier habits and those with digit habits were also analyzed with ANOVA. Chi-square analysis was used to compare prevalence of occlusal traits among the breast-feeding and nonnutritive sucking behavior groups. Significance was predetermined at $P < .05$.

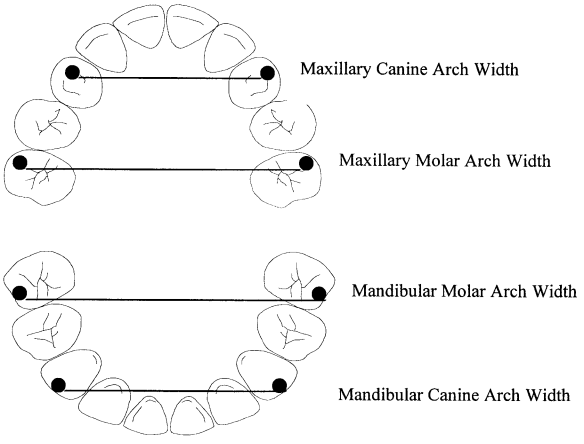


**Fig 1.** Arch widths.

## RESULTS

Comparisons of the dental parameters of children grouped according to the 4 breast-feeding duration categories and nonnutritive sucking less than 12 months are presented in Table I. There were no statistically significant differences between these groups in any of the parameters compared. Comparisons of selected occlusal characteristics between the same 4 groups (Table II) indicated no significant differences in the prevalence of dental arch abnormalities.

ANOVA indicated that children with pacifier habits of 36 to 48 months duration had significantly greater mandibular arch widths (Table III). Consistent with this finding and as presented in Table IV, there was a statistically significant increase in the prevalence of posterior crossbite with pacifier habits longer than 24 months. In addition, overbite and palatal depths were significantly decreased among children with pacifier habits longer than 48 months and 36 months, respectively (Table III). The prevalence of anterior open bite was significantly higher among children with pacifier habits of 48 months or longer (Table IV).

Comparisons of the mean dental arch measurements among different groups based on the duration of digit-sucking habits were performed with ANOVA. Children who sustained their digit habits to 48 months of age or

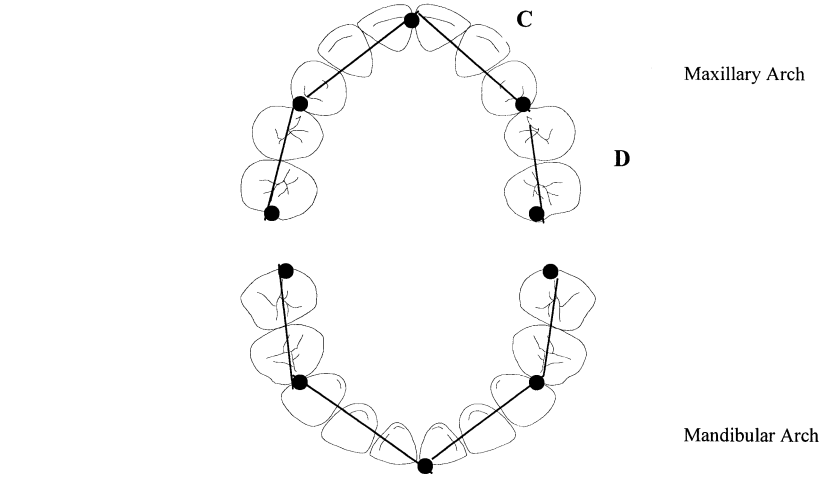


**Fig 2.** Arch lengths.

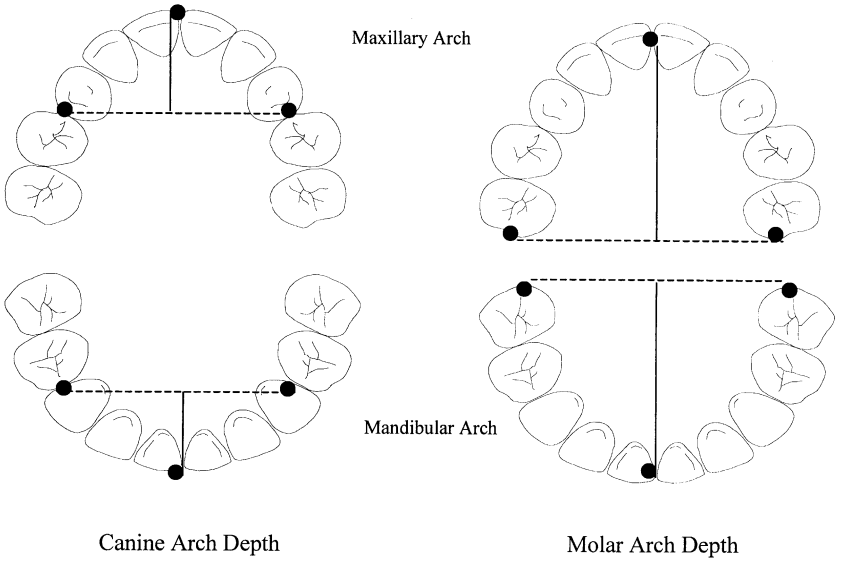


**Fig 3.** Arch depths.

longer had significantly narrower maxillary canine and molar arch widths and greater maxillary canine and molar arch depths (Table V). In addition, overjet was significantly greater among children with habits of 36 months or longer compared with the other groups. Overbite was significantly less in children with digit habits persisting to 48 months of age or older. As presented in Table VI, the prevalence of anterior open bite and excessive overjet increased as the duration of digit sucking habits increased, but the prevalence of posterior crossbite did not differ significantly among the groups.

Comparisons between groups of children with pacifier and digit habits of the same duration were performed with *t* tests and chi-square analysis. Children with pacifier habits of 36 to 48 months had significantly ($P = .013$, *t* test) greater mandibular arch widths than did children with digit habits of the same length. Children with digit habits of 48 months had significantly ($P = .001$, *t* test) greater overjet than did children with pacifier habits of the same duration. Consistent with these findings, children with pacifier habits of 24 to 36 months and 48 months or longer had significantly ($P = .034$ and .044, respectively, chi-

square) higher prevalence of posterior crossbite than did children with the same duration of digit habits. Children with digit habits continuing to 48 months of age or older had significantly ($P = .012$, chi-square) higher prevalence of overjet of 4 mm or greater than did children with pacifier habits of the same duration.

## DISCUSSION AND CLINICAL IMPLICATIONS

The effects of breast-feeding on dental arch development is difficult to assess because it is not easy to separate these effects from those of nonnutritive sucking behaviors. This is because most breast-fed children also engaged in at least some nonnutritive sucking. In the present study, we identified a relatively large group of children who engaged in minimal (less than 12 months) nonnutritive sucking, and we used this group to investigate the effect of different lengths of breast-feeding on dental arch measurements and occlusal characteristics, thus partially controlling for nonnutritive sucking effects. With this approach, the results indicated no statistically significant differences between the subgroups divided according to the duration of breast-feeding (Table I). Furthermore, there were no discernable trends in either the dental arch measurements or the prevalence of occlusal traits based on breast-feeding length. Although we cannot exclude the possibility that more prolonged breast-feeding (perhaps 2 years or longer) might have effects on either the dental arch parameters or the occlusal characteristics, it appears that the more typical breast-feeding patterns experienced in the present population have little effect on these parameters.

Prolonged pacifier habits resulted in significant changes to dental arch parameters and occlusal traits (eg, increased mandibular arch width and greater prevalence of posterior crossbite and anterior open bite). The increase in the prevalence of posterior crossbites with pacifier habits is the result of the combination of a significant increase in mandibular arch width and a tendency for a decrease in maxillary arch width (Tables III and IV). Some of these changes persisted well beyond the cessation of the pacifier habits.

Prolonged digit habits were also associated with significant changes to dental arch parameters and occlusal traits including greater overjet, greater maxillary arch depth, and greater prevalence of anterior open bite (Tables V and VI). As with children with pacifier habits, many changes persisted well beyond the cessation of the digit habits.

The finding that pacifier and digit habits have different effects on dental arch and occlusal characteristics has been reported previously, and the results of the present study were generally consistent with those

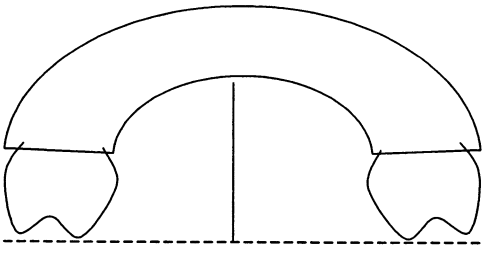

**Fig 4.** Palatal depth.

earlier studies.[13,16,25,26] Specifically, both the pacifier and the digit habits were associated with anterior open bite. In addition, pacifier habits were strongly associated with the development of posterior crossbite, increased mandibular arch width, and shallower palatal depths, while digit habits were associated with increased overjet, narrowed maxillary arch widths, and elongated maxillary arch depths.

Figure 6 presents a case typical of children with prolonged pacifier habits. This child continued a pacifer habit beyond 48 months of age and presents with a slight anterior open bite and a unilateral posterior crossbite. Overjet was 1.5 mm. In comparison, Figure 7 presents a case typical of children with prolonged digit habits. This child continued a thumb sucking habit beyond 48 months of age and presents with an anterior open bite, a Class II canine relationship, and an overjet of 10 mm. A further observation from the study is depicted in Figure 8. This child had a thumb sucking habit persisting beyond 48 months of age and presents with an asymmetrical anterior open bite. Children with digit habits often have anterior open bites, and it is not unusual for these open bites to be asymmetrical, corresponding to the child's right or left hand. Children with prolonged pacifier habits have open bites that tend to be more symmetric, probably because the design of pacifiers somewhat limits their positioning.

Perhaps more importantly, the study found that pacifier habits 24 to 36 months long resulted in an increased prevalence of posterior crossbite at age 5 compared with shorter pacifier habits or no nonnutritive sucking. Similarly, digit habits that ceased between 36 and 48 months of age resulted in greater prevalence of anterior open bite and greater overjet at age 5 compared with children with a shorter habit duration or no habit history. Although these findings in the primary dentition are interesting, from a clinical perspective, they are important only to the degree they can be related to the occlusal characteristics in the mixed and permanent dentitions. Thus, the key clinical question is whether, and to what degree, these changes persist into the

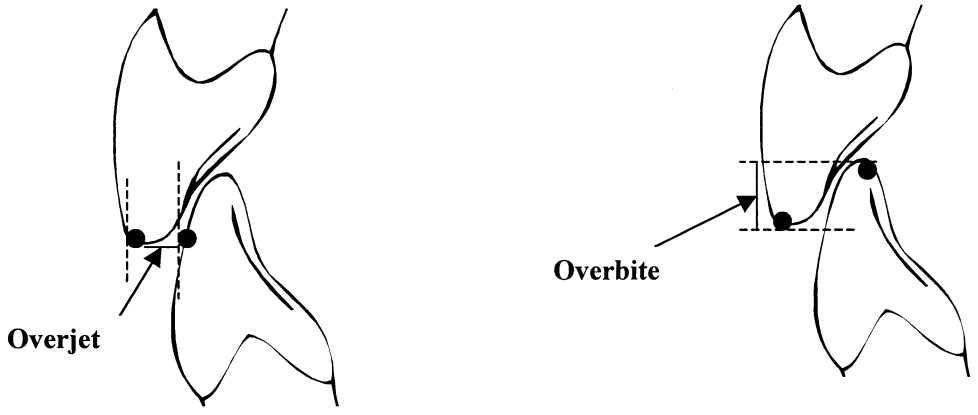


**Fig 5.** Overjet and overbite.

**Table I.** Comparison of mean dental arch measurements (mm) by breast-feeding duration group with ANOVA

| *Measurement* | *Group 1 No breast-feeding (n = 48)* | *Group 2 Less than 6 months (n = 25)* | *Group 3 6-12 months (n = 33)* | *Group 4 Longer than 12 months (n = 13)* | P *value* |
|---|---|---|---|---|---|
| Maxillary canine arch width | 28.7 | 28.9 | 29.1 | 28.1 | .447 |
| Maxillary molar arch width | 41.6 | 41.4 | 41.6 | 41.2 | .906 |
| Mandibular canine arch width | 22.5 | 22.4 | 22.6 | 22.1 | .821 |
| Mandibular molar arch width | 35.7 | 35.3 | 35.6 | 35.3 | .803 |
| Maxillary canine arch depth | 10.0 | 10.1 | 10.1 | 9.7 | .850 |
| Maxillary molar arch depth | 25.9 | 26.1 | 25.7 | 25.4 | .656 |
| Mandibular canine arch depth | 6.8 | 6.8 | 7.1 | 6.5 | .304 |
| Mandibular molar arch depth | 23.2 | 23.2 | 23.4 | 22.7 | .643 |
| Total maxillary arch length | 70.9 | 70.9 | 70.5 | 70.2 | .866 |
| Maxillary anterior arch length | 38.2 | 38.5 | 38.3 | 37.8 | .884 |
| Total mandibular arch length | 64.3 | 63.8 | 64.0 | 63.5 | .792 |
| Mandibular anterior arch length | 29.2 | 29.0 | 29.5 | 28.8 | .527 |
| Overjet | 2.4 | 2.3 | 2.3 | 2.4 | .969 |
| Overbite | 1.8 | 2.2 | 2.0 | 1.4 | .345 |
| Palatal depth | 14.7 | 14.9 | 15.1 | 14.4 | .423 |

*P*, probability; *n*, sample size.

**Table II.** Comparison of the prevalence of occlusal characteristics (percentages) by breast-feeding duration group with chi-square analysis

| *Characteristic* | *Group 1 No breast-feeding (n = 48)* | *Group 2 Less than 6 months (n = 25)* | *Group 3 6-12 months (n = 33)* | *Group 4 Longer than 12 months (n = 13)* | P *value* |
|---|---|---|---|---|---|
| Anterior open bite | 2.1 | 0 | 6.1 | 15.4 | .114 |
| Posterior crossbite | 6.3 | 8.0 | 0 | 15.4 | .222 |
| Excessive overjet (≥4 mm) | 4.2 | 12.0 | 6.1 | 0 | .430 |
| One or more of the above | 12.5 | 20.0 | 9.1 | 23.1 | .505 |
| Any Class II canine relationship | 35.4 | 24.0 | 36.4 | 15.4 | .402 |

*P*, probability; *n*, sample size.

**Table III.** Comparison of mean dental arch measurements (mm) by duration of pacifier habit with ANOVA

| *Measurement* | *Group 1 <12 months (n = 91)* | *Group 2 12-24 months (n = 44)* | *Group 3 24-36 months (n = 43)* | *Group 4 36-48 months (n = 18)* | *Group 5 48+ months (n = 12)* | P *value* |
|---|---|---|---|---|---|---|
| Maxillary canine arch width | 28.8 | 28.6 | 28.3 | 28.7 | 27.5 | .221 |
| Maxillary molar arch width | 41.5 | 41.9 | 41.2 | 42.2 | 40.1 | .121 |
| Mandibular canine arch width | 22.6[a] | 22.6[a] | 22.5[a] | 23.6[b] | 23.4[a,b] | .041* |
| Mandibular molar arch width | 35.7 | 35.5 | 35.6 | 36.9 | 35.5 | .137 |
| Maxillary canine arch depth | 10.0 | 10.3 | 10.3 | 10.3 | 10.6 | .343 |
| Maxillary molar arch depth | 25.8 | 26.2 | 26.1 | 25.9 | 26.9 | .302 |
| Mandibular canine arch depth | 6.9 | 6.8 | 7.0 | 6.8 | 7.1 | .827 |
| Mandibular molar arch depth | 22.2 | 23.3 | 23.3 | 23.4 | 23.8 | .728 |
| Total maxillary arch length | 70.8 | 71.0 | 70.4 | 71.3 | 70.4 | .862 |
| Maxillary anterior arch length | 38.3 | 38.3 | 38.0 | 38.8 | 37.9 | .765 |
| Total mandibular arch length | 64.2 | 64.3 | 64.1 | 65.6 | 65.4 | .226 |
| Mandibular anterior arch length | 29.3 | 29.2 | 29.4 | 30.4 | 29.7 | .193 |
| Overjet | 2.4 | 2.4 | 2.3 | 2.5 | 2.1 | .683 |
| Overbite | 1.9[a] | 2.1[a] | 2.0[a] | 1.7[a] | 0.4[b] | .007* |
| Palatal depth | 14.8[a] | 14.3[a,b] | 14.3[a,b] | 13.9[b,c] | 13.3[c] | <.001* |

*P*, probability; *n*, sample size.
*Groups with same letters are not significantly different from each other.

**Table IV.** Comparison of prevalence of occlusal characteristics (percentages) by duration of pacifier habit with chi-square analysis

| *Characteristic* | *Group 1 <12 months (n = 91)* | *Group 2 12-24 months (n = 44)* | *Group 3 24-36 months (n = 43)* | *Group 4 36-48 months (n = 18)* | *Group 5 48+ months (n = 12)* | P *value* |
|---|---|---|---|---|---|---|
| Anterior open bite | 5.5 | 4.5 | 0 | 0 | 25.0 | .008 |
| Posterior crossbite | 6.6 | 4.5 | 16.3 | 22.2 | 41.7 | .001 |
| Excessive overjet (≥4 mm) | 6.6 | 6.8 | 4.7 | 11.1 | 0 | .794 |
| One or more of the above | 16.5 | 15.9 | 18.6 | 33.3 | 66.7 | .001 |
| Any Class II canine relationship | 33.0 | 20.5 | 34.9 | 44.4 | 50.0 | .210 |

*P*, probability; *n*, sample size.

**Table V.** Comparison of mean dental arch measurements (mm) by duration of digit habit using 1-way ANOVA

| *Measurement* | *Group 1 <12 months (n = 91)* | *Group 2 12-24 months (n = 36)* | *Group 3 24-36 months (n = 24)* | *Group 4 36-48 months (n = 13)* | *Group 5 48+ months (n = 46)* | P *value* |
|---|---|---|---|---|---|---|
| Maxillary canine arch width | 28.8[a] | 29.2[a] | 29.0[a] | 29.0[a] | 27.8[b] | .009* |
| Maxillary molar arch width | 41.5[a,b] | 42.0[a] | 42.1[a] | 41.2[a,b] | 40.5[b] | .037* |
| Mandibular canine arch width | 22.6 | 22.9 | 22.7 | 22.8 | 23.3 | .272 |
| Mandibular molar arch width | 35.7 | 36.0 | 35.3 | 35.4 | 35.6 | .733 |
| Maxillary canine arch depth | 10.0[a] | 10.4[a,b] | 10.0[a] | 10.8[b,c] | 11.2[c] | <.001* |
| Maxillary molar arch depth | 25.8[a] | 26.5[a,b] | 25.7[a] | 27.0[b] | 27.0[b] | .003* |
| Mandibular canine arch depth | 6.9 | 6.9 | 6.7 | 6.7 | 6.9 | .893 |
| Mandibular molar arch depth | 23.2 | 23.7 | 23.1 | 23.3 | 23.2 | .533 |
| Total maxillary arch length | 70.8 | 71.7 | 70.3 | 71.8 | 71.0 | .543 |
| Maxillary anterior arch length | 38.3 | 38.9 | 38.1 | 38.9 | 38.8 | .648 |
| Total mandibular arch length | 64.2 | 64.6 | 63.9 | 64.3 | 64.0 | .930 |
| Mandibular anterior arch length | 29.3 | 29.5 | 29.1 | 28.9 | 29.5 | .845 |
| Overjet | 2.4[a] | 2.3[a] | 2.2[a] | 3.2[b] | 3.7[b] | <.001* |
| Overbite | 1.9[a] | 2.0[a] | 2.1[a] | 1.6[a,b] | 0.6[b] | .006* |
| Palatal depth | 14.8[a] | 14.8[a] | 14.0[b] | 14.5[a,b] | 14.2[a,b] | .030* |

*P*, probability; *n*, sample size.
*Groups with same letters are not significantly different from each other.

**Table VI.** Comparison of prevalence of occlusal characteristics (percentages) by duration of digit habit with chi-square analysis

| *Characteristic* | *Group 1 <12 months (n = 91)* | *Group 2 12-24 months (n = 36)* | *Group 3 24-36 months (n = 24)* | *Group 4 36-48 months (n = 13)* | *Group 5 48+ months (n = 46)* | P *value* |
|---|---|---|---|---|---|---|
| Anterior open bite | 5.5 | 0 | 0 | 15.4 | 37.0 | <.001 |
| Posterior crossbite | 6.6 | 13.9 | 0 | 0 | 15.2 | .099 |
| Excessive overjet (≥4 mm) | 6.6 | 0 | 8.7 | 15.4 | 39.1 | <.001 |
| One or more of the above | 16.5 | 13.9 | 8.7 | 23.1 | 71.7 | <.001 |
| Any Class II canine relationship | 33.0 | 27.8 | 33.3 | 15.4 | 47.8 | .161 |

*P*, probability; *n*, sample size.


**Fig 6.** Case typical of children with prolonged pacifier habits, with slight anterior open bite and unilateral posterior crossbite. Note fusion of left lateral and central incisors.


**Fig 7.** Case typical of children with prolonged digit habits. Note anterior open bite and large overjet.

**Fig 8.** Example of asymmetrical anterior open bite, common in children with prolonged digit habits.

mixed dentition. Unfortunately, the information from the available literature is limited but suggests that some characteristics, including increased overjet and reduced maxillary arch widths, do persist into the mixed dentition.[25-27]

Thus, although further study is needed, including continuing the present study, it appears that recommendations made by several professional organizations[28-31] may need to be modified to provide the best possible advice to parents to prevent habit-related malocclusions. More specifically, the current recommendations suggest that nonnutritive sucking habits are of little

concern unless they persist until the early mixed dentition stage.[28-31] Although these recommendations may help to reduce the severity of habit-related malocclusions, they may not reduce the prevalence of such malocclusions to the degree possible if earlier habit cessation is recommended. Moreover, even though nonnutritive sucking fulfills physiological needs during infancy and may comfort toddlers, persistence of these habits beyond 2 or 3 years of age significantly increases the probability of developing undesirable dental arch and occlusal traits at the end of the primary dentition stage.

The present study was unique because, through periodic questionnaires, longitudinal nutritive and nonnutritive sucking behavior data were collected. This approach has advantages over cross-sectional data collection relying on retrospective questionnaires that are more prone to recall bias. Although the study design was a strength, it had several limitations: the sample did not represent any defined population (ie, it did not represent all children in Iowa), and it included very few nonwhite subjects. Furthermore, the sucking behavior data were reported by parents and could not be directly validated. Finally, the sample had a relatively small number of subjects engaged in certain behaviors such as breast-feeding longer than 12 months and pacifier use of 48 months or more.

## CONCLUSIONS

From the results of the present study, the following conclusions can be made:

1. Among children with minimal nonnutritive sucking habits, those who breast-fed longer had similar dental arch parameters and occlusal characteristics as those with shorter duration of breast-feeding or no breast-feeding.
2. The durations of pacifier and digit habits were each positively related to the prevalence of certain malocclusions, but these malocclusions were different for pacifier and digit behaviors. Both behaviors were associated with increased prevalence of anterior open bite and reduced overbite; pacifier habits were associated with increased prevalence of posterior crossbite, while digit habits were associated with greater overjet, greater maxillary arch depths, and smaller maxillary arch widths.
3. More importantly from a clinical perspective, some changes in dental arch parameters and changes in prevalence of certain occlusal traits persisted well beyond the cessation of pacifier or digit habits.
4. The results suggest that current recommendations for discontinuing nonnutritive sucking habits may not be optimal in preventing habit-related malocclusions at the end of the primary dentition stage.

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