



Effects of current and former pacifier use on the dentition of 24- to 59-month-old children

Steven M. Adair, DDS, MS Michael Milano, DMD Isabel Lorenzo, DMD Carl Russell, DMD, MS, PhD

Abstract

Two hundred eighteen children ages 24–59 months participated in a study to examine the effects of pacifier use on the occlusion of the primary dentition. A questionnaire was used to gain information on habit history. Eighty-two children were current or former users of functional exercisers, 38 had a history of conventional pacifier use, and 98 had no history of oral habits. Compared to children with no habit, those with a history of pacifier use had a significantly larger mean overjet ($P < 0.001$), as well as significantly higher occurrences of Class II primary canines ($P = 0.015$), distal step molars ($P = 0.014$), openbite ($P = 0.001$), and posterior crossbite ($P = 0.025$). Compared to users of conventional pacifiers, users of functional exercisers had a significantly higher occurrence of Class II primary canines ($P = 0.013$) and distal step molars ($P = 0.037$). Pacifier use time in months was significantly higher for children with openbite ($P = 0.02$) and posterior crossbite ($P = 0.019$). Compared to former pacifier users, those with current habits had a significantly higher prevalence of openbite ($P = 0.002$) and posterior crossbite ($P = 0.001$), and a greater mean openbite ($P = 0.019$). The reported number of hours use per day was not related to any aspect of the occlusion of pacifier users. African-American and European-American children began their habits at about the same age and used their pacifiers for an equivalent number of hours per day. Among those who had discontinued their habits, African-American children had maintained theirs for a significantly shorter period ($P < 0.001$), leading to a longer elapsed time between habit discontinuation and the examination. (*Pediatr Dent* 17:437–44, 1995)

The soothing effects on infants and young children of non-nutritive sucking have been apparent to their caretakers for centuries. Ravn¹ reported that reference to sucking objects appeared in the German medical literature in the late 15th and early 16th centuries. Winter² described an 1801 report of a linen “sucking bag” containing milk, sugar, and bread used to feed and comfort children. The current prevalence of non-nutritive sucking habits at various ages has been

reported between 61 and 95%, and Larsson³ states that pacifier users are in the majority in Scandinavia.

Pacifier use has been associated with malocclusions in all three planes of space. The prevalence of malocclusions among children with the habit has been reported to be 38–94%.⁴ Anterior openbites have been reported in as many as 74%.⁵ Posterior crossbites have been described in pacifier users as young as 24 months,⁶ while others have described a prevalence of 5 to 19%.^{4, 5, 7–9} Increased overjet (≥ 4 mm) has been noted in 17 to 79% of pacifier users.^{5, 10} An increased prevalence of Class II canines and distal step primary molars also has been reported.^{7, 10}

Manufacturers have devised various designs of pacifiers and nursing bottle nipples to more closely imitate the shape of the mother’s breast in the infant’s mouth during feeding. The Nuk™ Functional Orthodontic Nursing Nipple and Orthodontic Pacifier/Exerciser, introduced in the U.S. in the late 1950s, has been promoted as allowing a more natural arch development because it encourages muscular movements that more closely imitate breast feeding. Adair et al.,¹¹ in a study of 54 pacifier users and 25 controls, found no clinically significant differences in the occlusions of 2- to 5-year-old children with a history of conventional pacifier or functional exerciser use.

The purposes of this study were to compare:

1. The occlusions of 24- to 59-month-old current and former pacifier users to children of the same age with no non-nutritive sucking habit
2. The effects on the occlusion of conventional pacifiers and functional exercisers
3. The effects of pacifier use time (hours per day, total months used) on the occlusion
4. Differences between current and former pacifier users, as well as the effects of differing lengths of pacifier discontinuation (months) on the dentition
5. Differences between the pacifier use patterns of European-Americans and African-Americans.

Methods and materials

Examiner calibration

Before children were examined, the reliability of the examiners was assessed. Each examiner evaluated 23 sets of diagnostic casts made from children in the primary or early mixed dentition. A variety of occlusal patterns was represented. Each of the three examiners evaluated each set of casts twice, on occasions separated by at least 1 week. Good reliability was taken as evidence that examiners were well calibrated on the following criteria for evaluation:

1. Primary canine relationships, recorded as Class I, II, or III on the right and left sides
2. Terminal plane relationships of the primary second molars, recorded as flush, distal step, or mesial step on each side
3. Degree of overbite, recorded as $\leq 50\%$, or $> 50\%$ overlap of the lower incisor clinical crowns
4. Presence of anterior openbite, measured in millimeters
5. Presence of posterior crossbite, recorded as unilateral or bilateral. Unilateral posterior crossbites were diagnosed as reverse buccal overjet on one side of the mouth with or without a midline shift. Thus, crossbites created by bilateral maxillary constriction and by unilateral maxillary asymmetry were recorded. Bilateral posterior crossbite was diagnosed as reverse buccal overjet in both posterior segments.
6. Amount of overjet in millimeters, measured from the lingual surface of the mesial corner of the most erupted maxillary incisor to the facial surface of the ipsilateral mandibular incisor.

These data were evaluated for percent agreement and Cohen's unweighted kappa statistic as measures of inter- and intraexaminer agreement.

Examination of children

This study was conducted in Augusta, Georgia, and Rochester, New York. In both cities children were recruited from local daycare centers and dental clinics based on the following criteria:

1. Informed parental consent for the child's participation
2. Age 24–59 months
3. Good general health and age-appropriate cognitive development
4. Presence of 20 primary teeth
5. Parental ability to recall the child's oral habits and type of pacifier used, if any
6. Completion of a questionnaire by the parent regarding the child's pacifier use
7. Absence of digit sucking habit
8. No history of orthodontic treatment.

Examinations were performed using a dental light, metal millimeter ruler, and mouth mirror. Each examiner was blind to the child's pacifier history and to the data on the questionnaire. The clinical examinations were conducted to determine the same parameters of occlusion as those in the calibration study. When necessary, the child was gently guided into centric occlusion by asking him/her to "bite on your back teeth" with the examiner's fingers placed on the facial surface of the maxillary second molars. If required, the mandible was gently manipulated into centric occlusion. None of the children had extensively restored dentitions.

The questionnaire contained the following items:

1. Date of birth, gender, and racial/ethnic background
2. Drawings to assist the parent in identifying the type of pacifier used, if any
3. Ages at which pacifier use was begun and, if appropriate, ended
4. Hours per day of pacifier use, and verification that the pacifier was used in the intended manner (right side up, lip shield outside lips)
5. Presence of finger- or thumb-sucking habit.

No data were collected on current nursing bottle use by the participants. In the study population, however, bottle use after 24 months was uncommon.

Statistical analysis

Summary statistics were determined for each continuous variable across pacifier groups (functional exercisers and conventional pacifiers) and various subgroups. Frequencies or percentages were determined for each categorical variable across groups and assessed by chi-square analysis. Analysis of variance (ANOVA) and two-sample *t*-tests were used to evaluate differences in means across groups. An alpha level of 0.05 was established *a priori* as the level of significance.

Differences in occlusion were assessed between pacifier users and habit-free children, as well as between the two pacifier groups. Comparisons also were made between current and former pacifier users; further comparisons were made between current users and those whose habits stopped within the median of 26.5 months of the examination (recent discontinuation), and those who discontinued the habit ≥ 26.5 months prior to the examination (early discontinuation). We assessed the effects on the occlusion of the reported months of use and hours of use per day. We also compared the occlusions of those children who reportedly used their pacifiers for less than the median of 15.5 months with those who used them ≥ 15.5 months, as well as those reporting < 7 or ≥ 7 hr of use per day.

Results

Examiner calibration

In general the level of intra- and interexaminer

TABLE 1. AGE, GENDER, AND RACIAL DISTRIBUTION AMONG THE THREE HABIT GROUPS

Group	N	Mean Age (SD)(months)	Range	Percent Male	Percent European-American	Percent African-American	Other Ethnic Groups
Functional exerciser	82	44.4 (8.9)	24-59	47.6	50.0	45.1	4.9
Conventional pacifier	38	42.0 (9.6)	24-59	55.3	50.0	47.4	2.6
Habit-free	98	44.2 (9.1)	26-59	46.0	34.7	58.2	7.1

agreement was high, indicating that the three examiners were using the same criteria to define the occlusion. Intraexaminer agreement ranged from 83-100%; the range of Kappa statistics were 0.72-1.0. Interexaminer percent agreement across the three possible pairings of examiners generally ranged from 76-100%. Interexaminer Kappa scores typically ranged from 0.59-1.0. Overjet measurements had a limited range (-2-9 mm) and were measured to the nearest millimeter. Thus, the Kappa statistic was deemed a reasonable measure of inter- and intraexaminer reliability for this variable. Differences between examiners revealed by the calibration exercise were discussed and rectified prior to examination of the participants.

TABLE 2. DIFFERENCES IN OCCLUSION BETWEEN CHILDREN WITH A HISTORY OF PACIFIER USE (N = 120) AND THOSE WITH NO REPORTED HABIT (N = 98)

Parameter	Pacifier Group	Habit-Free Group	Significance (P)
Overjet, mm mean (SD)	2.4 (1.5)	1.7 (1.4)	< 0.001*
Occurrence (%) with overjet ≥ 4 mm	20.0	10.2	0.048†
Occurrence (%) of one or two Class II primary canines	17.7	9.3	0.015‡
Occurrence (%) of one or two distal step primary molars	9.6	3.6	0.014‡
Occurrence (%) of openbite	16.7	3.1	0.001‡
Openbite, mm mean (SD)	2.8 (1.6) (N = 20)	2.0 (1.0) (N = 3)	0.33*
Occurrence (%) of posterior crossbite	15	5.1	0.025‡

Statistical tests:

* t-test for independent groups.

† Chi-square test.

‡ Fischer's exact test.

Examinations

Two hundred eighteen children were examined for the study, 79 in Rochester and 139 in Augusta. The major characteristics of the three habit groups are shown in Table 1. The mean age of all children was 43.9 months (9.09 SD). Almost half (48.2%) were males; 43.1% were of European-American descent and 51.4% were of African-American descent (self-described). There were no significant differences among the habit groups in mean age or in the distribution of sex or race. There were also no significant differences between the Rochester and Augusta children in these parameters.

There were no significant differences among the habit groups in mean age or in the distribution of sex or race. There were also no significant differences between the Rochester and Augusta children in these parameters.

Habit Groups

Table 2 lists the major findings in habit-free children and those with a history of pacifier use. There was no significant difference in age or the distribution of sexes between the combined pacifier group and the habit-free group. Children with a history of pacifier use had a mean overjet that was significantly greater than that of habit-free children. Children with overjets ≥ 4 mm constituted 20% of the pacifier group and 10.2% of the no-habit group; this difference was statistically significant (P = 0.048) by chi-square analysis. Class II primary canine relationships on one or both sides were significantly more common among the pacifier group; the differences occurred primarily on the left side. The same was true of distal step primary molar relationships. Only 10 children in the entire sample had bilateral Class II primary

TABLE 3. SUMMARY STATISTICS OF PACIFIER USE

Parameter	Functional Exerciser Group (N = 82)	Conventional Pacifier Group (N = 38)	Significance (t-test)
Age at start of pacifier use, months mean (SD)	2.9 (8.9)	2.9 (2.4)	0.10
Use per day, hours mean (SD)	6.7 (4.3)	6.5 (2.7)	0.74
Among those who had discontinued their habits	N = 68	N = 30	
Duration of use, months mean (SD)	15.4 (10.6)	19.8 (10.6)	0.059
Age discontinued, months mean (SD)	17.5 (10.8)	22.5 (11.0)	0.037
Time elapsed between discontinuation and exam, months mean (SD)	28.2 (14.4)	21.6 (12.5)	0.035

TABLE 4. COMPARISON OF OCCLUSIONS BETWEEN FUNCTIONAL EXERCISER GROUP (N = 82) AND CONVENTIONAL PACIFIER GROUP (N = 38)

Parameter	Functional Exerciser Group	Conventional Pacifier Group	Significance (P)
Overjet, mm mean (SD)	2.5 (1.7)	2.2 (1.1)	0.295*
Occurrence (%) with overjet \geq 4 mm	23.2	13.2	0.231 [†]
Occurrence (%) of one or two Class II primary canines	26.8	5.3	0.013 [†]
Occurrence (%) of one or two distal step primary molars	15.9	2.6	0.037 [†]
Occurrence (%) of openbite	13.4	23.7	0.191 [†]
Openbite, mm mean (SD)	2.9 (1.2) (N = 11)	2.6 (2.0) (N = 9)	0.633*
Occurrence (%) of posterior crossbite	15.9	13.2	0.790 [†]

Statistical tests:

* t-test for independent groups.

[†] Fischer's exact test.

canines and bilateral distal step primary molars; seven of these had a history of pacifier use.

A significantly higher percentage of children with a history of pacifier use had openbites, compared with those with no habit ($P = 0.001$). The mean openbite in the pacifier group was larger than that of habit-free children. This difference, while clinically significant, did not reach statistical significance.

Twenty-three children (10.5% of the total) exhibited posterior crossbites, of which 17 were unilateral. Posterior crossbites were seen among 15% of the pacifier group and only 5.1% of the habit-free children. This difference in distribution was significant ($P = 0.025$).

Pacifier groups

Table 3 lists summary statistics of pacifier use for the two pacifier groups. Pacifier use was reported to begin at a mean age of 2.9 months (7.5 SD). The median starting age was 1.5 months, and the 25th–75th percentile age range was 1–3 months. Pacifiers were reportedly used a mean of 6.7 hr/day (3.9 SD); the median was 7 and the 25th–75th percentile range was 4–8.75 months. Among those who had discontinued pacifier use, habits were maintained a mean of 16.7 months (10.7 SD); the median was 15.5 months and the 25th–75th percentile range was 7–24 months. Pacifier habits were discontinued at a mean age of 19.0 months (11.1 SD). The median time elapsed since discontinuation was 26.5 months; the mean was 26.2 months (14.3 SD). Users of conventional pacifiers maintained their habits some-

TABLE 5. COMPARISON OF OCCLUSIONS BETWEEN CURRENT (N = 22) AND FORMER (N = 98) PACIFIER USERS

Parameter	Current Users	Former Users	Significance (P)
Overjet, mm mean (SD)	2.9 (1.4)	2.5 (1.6)	0.139*
Occurrence (%) of overjet \geq 4 mm	22.7	21.6	0.77 [†]
Occurrence (%) of one or two Class II canines	31.8	20.4	0.265 [†]
Occurrence (%) of one or two distal step primary molars	22.7	9.2	0.132 [†]
Occurrence (%) with openbite	40.9	11.2	0.002 [†]
Openbite, mm mean (SD)	3.6 (1.7) (N = 9)	2.1 (1.1) (N = 10)	0.019*
Occurrence (%) with posterior crossbite	40.9	9.2	0.001 [†]

Statistical tests:

* t-test for independent groups.

[†] Fischer's exact test.

what longer and discontinued their pacifier use at a significantly older age. Thus, significantly less time had elapsed between discontinuation and examination for that group. No differences were found between the Rochester and Augusta groups.

Table 4 displays the differences in occlusion between the users of functional exercisers and conventional pacifiers. There was no difference in mean overjet, nor in the percentage of children in each group with overjets \geq 4 mm. The occurrences of Class II primary canines and distal step molars were statistically significantly greater among the users of functional exercisers. The occurrence of openbite, while higher among users of conventional pacifiers, was not significantly different. Among those with openbite, the mean measurement was equivalent in the two groups. The occurrence of posterior crossbites also did not differ between the two pacifier groups.

Effect of hours of use per day

Differences in reported hours of use per day were not related to any of the aspects of occlusion among pacifier users.

Effect of months of use

The reported number of months of pacifier use was not related to sagittal measures of occlusion (overjet, molar and canine relationships). ANOVA indicated that the mean pacifier use time in months was significantly higher ($P = 0.02$) for children with openbites (26.8

months, 11.7 SD) than those with shallow (18.4 months, 12.0 SD) or deep (19.2 months, 12.2 SD) bites. The mean number of months of use was significantly higher among pacifier users with posterior crossbite (26.1 months, 12.1 SD) than those without posterior crossbite (18.8 months, 12.0 SD, $P = 0.019$).

There were no differences in vertical or sagittal measures of occlusion between those who had used their pacifiers < 15.5 or ≥ 15.5 months. There was, however, a significantly higher percentage of posterior crossbites (21.1%) among those who had used their pacifiers ≥ 15.5 months compared with those whose habits ended < 15.5 months (6.1%, $P = 0.035$).

Effect of discontinuation and time since discontinuation

A comparison of current users versus children who had discontinued pacifier use revealed no significant differences in the age at which habits were started, or in the hours per day of pacifier use. However, there was a significant difference between current and former users in the mean number of months of pacifier use. Current users had sustained their habits for 34.2 (7.5 SD) months, compared with 16.7 (10.7 SD) months for those who had discontinued their habits ($P < 0.001$).

Table 5 compares the occlusions of current and former pacifier users. Sagittal measures of occlusion did not differ significantly between the two groups. Significant differences were found for the mean openbite and the percentage of children in each group with openbite; both findings were greater among current users. The findings on openbite were supported by a significant ($P < 0.001$) negative correlation between openbite measurement and the time elapsed since discontinuation. In addition, current pacifier users comprised significantly more shallow bite cases ($\leq 50\%$ overlap) than did children who had discontinued their pacifier habits ($P = 0.008$). There also was a significantly higher percentage of current users with posterior crossbites.

Twenty-two children were active pacifier users at the time of examination. Forty-nine had discontinued its use within the median of 26.5 months of the examination (recent discontinuers), and 49 had discontinued the habit ≥ 26.5 months prior to examination (early discontinuers). There were no significant differences between pacifier groups in the distribution of current users, early discontinuers, and recent discontinuers. ANOVA and chi-square analyses indicated no differences in mean overjet or distribution of canine and molar relationships between current users and those who discontinued the habit recently or early. Of current pacifier users, 40.9% exhibited openbites compared with 16.3% of recent and 6.1% of early discontinuers ($P = 0.001$). Mean openbite was greater in current pacifier users (3.6 mm, 1.7 SD) than recent (2.0 mm, 1.1 SD) or early (2.2 mm, 1.2 SD) discontinuers of pacifier use, though these differences were not statistically significant.

As with current versus former users, we found a significant ($P = 0.001$) difference in the distribution of crossbites among current users, recent discontinuers, and early discontinuers of pacifiers. Current users constituted 50% of all crossbite cases, while recent and early discontinuers made up 27.7% and 22.2% of crossbite cases, respectively. The mean number of months elapsed since pacifier discontinuation was significantly lower for children with crossbite (9.5 months, 16.0 SD) than for those without crossbite (23.3 months, 16.0 SD, $P < 0.001$).

Effect of race

The differences between European-Americans and African-Americans are summarized in Table 6. There was no significant difference in the ages at which the two groups of children began pacifier use, nor in the

TABLE 6. DIFFERENCES IN PACIFIER USE AND OCCLUSION BETWEEN AFRICAN-AMERICANS (N = 55) AND EUROPEAN-AMERICANS (N = 60)

Parameter	African-Americans	European-Americans	Significance (P)
Mean age at start of habit months (SD)	2.4 (2.4)	2.3 (2.8)	0.924 [†]
Mean use per day hours (SD)	6.5 (4.3)	6.7 (3.5)	0.739 [†]
Mean duration of use months (SD)*	15.1 (10.9)	23.7 (11.5)	< 0.001 [†]
Mean time since discontinuation months (SD)*	24.5 (16.6)	18.4 (16.0)	0.047 [†]
Overjet, mm mean (SD)	2.1 (1.5)	2.7 (1.5)	0.019 [†]
Occurrence (%) of overjet ≥ 4 mm	16.4	21.7	0.644 [‡]
Occurrence (%) of openbite	10.9	21.7	0.139 [‡]
Openbite, mm mean (SD)	2.8 (1.9) (N = 6)	2.8 (1.5) (N = 13)	0.939 [†]
Occurrence (%) of one or two Class II canines	16.2	19.7	0.600 [‡]
Occurrence (%) of distal step molars	4.5	15.0	0.009 [‡]
Occurrence (%) of posterior crossbite	5.5	23.3	0.008 [‡]

* Among those who had discontinued habit: African-American N = 47, European-American N = 48.

Statistical tests:

[†] t-test of independent groups.

[‡] Fisher's exact test.

hours of pacifier use per day. Among those who had discontinued their habits, European-American children maintained their habits for a significantly greater number of months ($P < 0.001$) and had discontinued their habits more recently than African-American children. About two-thirds of each group were current or former users of functional exercisers. Among children with reported habits, the overjet of European-Americans (2.7 mm, 1.5 SD) was significantly greater than that of African-Americans (2.1 mm, 1.5 SD, $P = 0.019$). Neither the mean openbite nor the percentage occurrence of children with openbites differed significantly between groups. There was no difference between pacifier users of the two racial groups in the distribution of canine relationships, but European-Americans comprised a significantly larger percentage of children with one or two distal step molars. However, the number of children with distal step molars on either side was small ($N = 14$). A significantly higher percentage of European-American pacifier users exhibited posterior crossbites.

Discussion

This study confirms the findings of others that, compared to habit-free children, children with a history of pacifier use have a significantly higher occurrence of increased overjet,^{4, 6, 12} a greater mean overjet,¹³ and reduced overbite.¹³ As in other reports, the prevalences of posterior crossbites^{4, 5, 14} and openbites^{4, 6, 12} were also higher among children with a habit history. The mean overjet of children in the pacifier groups of this study was 2.4 mm, which is less than the mean of 4.13 reported by Larsson¹³ for children with a 4-year pacifier habit, and slightly less than the 2.6–3.0 mm reported by Adair et al.¹¹ Twenty percent of the pacifier group in this study had overjets ≥ 4 mm. This compares well with Svedmyr's⁶ finding of a 25% occurrence in a group of children who had discontinued their pacifier habits, but it is less than the 47% prevalence she found in children with continuing habits. Ravn⁵ found overjets of 4–6 mm in 7.1–31.2% of children with pacifier habits of 12 or more months' duration. Our technique of measuring overjet from the facial surface of the lower incisor to the lingual surface of the upper incisor may account for the slightly lower overjet findings in our study.

A significantly higher percentage of pacifier users than nonusers in this study had evidence of distocclusion by virtue of the presence of at least one Class II primary canine relationship or at least one distal step primary molar relationship. However, only 15 children exhibited at least one of each relationship. Eleven of these children were users of functional exercisers, and four were children with no reported habit. Though statistically significant, it is difficult to draw a firm conclusion regarding the effect of pacifier use on the development of Class II malocclusions based on what may be chance distributions in the sample. Some studies have suggested that pacifier use may lead to such malocclusions.^{4, 7, 10, 15} while others have found no relationship.⁵

Openbites were five times as common among the pacifier group. The prevalence found in this study, 16.7%, is less than that reported by Järvinen and Lehtinen¹² (49.5%), but greater than the figure reported by Ravn⁵ for all groups except those whose habits were of 36 months' duration.

Posterior crossbites were three times as common among pacifier users. The prevalence in our sample, 15%, is within the range of 5–22% reported in the literature for children with pacifier habits.^{4, 5, 11, 13, 14, 16–18} Øgaard et al.¹⁸ suggested that at least 2 years of pacifier use are required to produce a significant narrowing of the maxillary arch. Our data support this notion. The prevalence of posterior crossbites was 40.9% among current users, whose mean use time was 34.2 months. The prevalence of posterior crossbites was 9.2% among former pacifier users, whose mean use time was 16.7 months.

Comparison of the two pacifier groups does not support the purported advantages of functional exercisers over conventional pacifiers. No significant differences were found for mean overjet, mean openbite, occurrence of openbite, or occurrence of posterior crossbite. These findings generally are in agreement with those of Adair et al.,¹¹ who concluded that no clinically significant differences existed between users of the two types of pacifiers. Bishara et al.¹⁹ found no differences in arch dimensions in 18-month-old infants who employed different types of feeding and non-nutritive sucking habits. Our study did find, however, a significant difference in the distribution of children with Class II primary canines and distal step primary molar occlusion. As noted above, the numbers of such children were small, and the findings may be a result of chance distributions. There were no users of conventional pacifiers with both a Class II canine and a distal step molar relationship.

The occurrence of openbite was higher among users of conventional pacifiers, but the difference was not statistically significant. This is in agreement with Adair et al.,¹¹ though their analysis also included a group of habit-free children.

There was no difference between the two pacifier groups in the occurrence of posterior crossbites. This same finding was reported by Adair et al.¹¹ Similarly, Bishara et al.¹⁹ found no differences in arch width at 18 months among several groups of infants, including those who used functional exercisers and conventional pacifiers and bottle nipples.

It must be noted that former users of functional exercisers maintained their habits for a substantially shorter time. Also, the mean time elapsed between habit discontinuation and examination for former users of functional exercisers was significantly longer than for former users of conventional pacifiers. These differences may have prevented development of some clinically significant malocclusions or allowed for their spontaneous correction in users of functional exercisers. Thus, nonsignificant differences between the groups at the time of examinations may have been sig-

nificant at an earlier age. The number of current pacifier users, 22, was too small for meaningful comparisons of the two types of pacifiers.

The reported number of hours per day of pacifier use, termed "intensity" in some studies, has been positively correlated with the presence of posterior crossbite.^{8,14} We found no relationship between hours use per day and any aspect of malocclusion. This study did not address the muscular force used by the child when sucking the pacifier. The number of reported months of pacifier use, however, was significantly related to vertical and transverse malocclusions. This is in agreement with Lindner and Mod er⁸ for posterior crossbites and openbite, as well as with Ravn,⁵ who found that openbites were "very evidently related to" the duration of the habit. Sagittal measures of occlusion have not been related to habit duration in the literature. Differences in the number of months of use accounted for much of the differences in occlusion between current and former pacifier users.

Comparisons of pacifier use patterns by race indicated that African-American and European-American children began their habits at the same age and used their pacifiers an equal number of hours per day. African-American children discontinued their habit earlier, however, and consequently more time had elapsed between habit discontinuation and examination. This latter factor might explain the lower mean overjet and lower occurrences of posterior crossbite and distal step molars in that group. About two-thirds of each group were users of functional exercisers.

The no-habit group demonstrated occlusion characteristics that were in agreement with other descriptions in the literature. The mean overjet, 1.7 (1.4 SD) mm, corresponds well with Moyers²⁰ description of minimal overjet in the primary dentition, and Foster and Hamilton's²¹ description of ideal overjet being 0–2 mm. Overbite is also described in the literature as predominately "slight" to "medium."²² Nanda et al.²³ found the lower primary incisor overlap to be $\leq 80\%$ for the majority of 2- to 3-year-olds, and $\leq 60\%$ for the majority of children ages 5–6. In the no-habit group, overbite of $\leq 50\%$ occurred in 60% of the children, and overbite $> 50\%$ occurred in 37%. Bowden²⁴ found that among children without sucking habits, overjet was < 2 mm for ages 3–6 years, and overbite was 2–3 mm for ages 3–5 years. The prevalence of posterior crossbite in our no-habit group, 5.1%, compares well with 7.1% in a group of similar children⁷, but is greater than K hler and Holst's⁴ finding of 1.4% in their control group.

Examiner calibration in this study was deemed generally high. The use of plaster casts for calibration was necessitated by the distance between the study sites. The use of casts also facilitated measurement of intra-examiner reliability. Early in the study, examiners confirmed their clinical findings by duplicating the examinations. Duplicate clinical examinations were also conducted between examiners SMA-MM and SMA-IL as a further means of ensuring consistency.

The effects of habit discontinuation and other findings must be interpreted with caution. First, the data are cross-sectional. Spontaneous changes in the occlusion following pacifier discontinuation are suggested, but longitudinal studies are needed to demonstrate them directly. Second, current users had maintained their habits longer, on average, than those who had quit. Thus, the differences noted may be simply a reflection of shorter usage times rather than any ameliorating effects of habit discontinuation. Nevertheless, our finding of a significantly larger mean openbite among current pacifier users is in agreement with Ravn⁵ and Bowden.⁷ Third, the data on pacifier usage were derived from parental questionnaires. The reliability of the parents as historians may be questioned, though they were reporting relatively recent or current events in their children's lives. Fourth, the sample of children examined in this study was not randomly chosen, but represented a convenience sample of self-selected children in the 24- to 59-month-old age range. There were, however, no clinically or statistically significant differences between the samples chosen in the two locations.

Conclusions

1. Compared to children without habits, children with a history of pacifier use were significantly more likely to demonstrate overjet ≥ 4 mm, openbite, and posterior crossbite. They also demonstrated a greater mean overjet.
2. There appeared to be no advantage to functional exercisers over conventional pacifiers.
3. Longer pacifier use time in months was associated with anterior openbite and posterior crossbite.
4. Pacifier use patterns were similar for European-American and African-American children, except for a significantly shorter duration of the habit in the latter group.

This study was supported in part by a grant from the Medical College of Georgia Dental Foundation.

Dr. Adair is associate professor and chair, Department of Pediatric Dentistry, and Dr. Russell is associate professor, Office of Biostatistics and Department of Oral Diagnosis and Patient Services, both of the Medical College of Georgia, Augusta. Drs. Milano and Lorenzo are in the private practice pediatric dentistry in Danbury, Connecticut, and Manila, The Philippines, respectively.

1. Ravn JJ: The prevalence of dummy and finger sucking habits in Copenhagen children under the age of 3 years. *Community Dent Oral Epidemiol* 2:316–22, 1974.
2. Winter GB: Problems involved with the use of comforters. *Int Dent J* 30:28–38, 1980.
3. Larsson EF, Dahlin KG: The prevalence and the etiology of the initial dummy- and finger-sucking habit. *Am J Orthod* 87:432–35, 1985.
4. Kohler L, Hoist K: Malocclusion and sucking habits of four year-old children. *Acta Paediatr Scand* 62:373–79, 1973.
5. Ravn JJ: Sucking habits and occlusion in 3-year-old children. *Scand J Dent Res* 84:204–9, 1976.

6. Svedmyr B: Dummy sucking. A study of its prevalence, duration and malocclusion consequences. *Swed Dent J* 3:205-10, 1979.
7. Bowden BD: A longitudinal study of the effects of digital and dummy-sucking. *Am J Orthod* 52:887-901, 1966.
8. Lindner A, Modéer T: Relation between sucking habits and dental characteristics in preschool children with unilateral crossbite. *Scand J Dent Res* 97:278-83, 1989.
9. Larson E: The effect of finger sucking on the occlusion: a review. *Eur J Orthod* 9:279-82, 1987.
10. Helle A, Haavikko K: Prevalence of earlier sucking habits revealed by anamnestic data and their consequences for occlusion at the age of eleven. *Proc Finn Dent Soc* 70:191-96, 1974.
11. Adair SM, Milano M, Dushku JC: Evaluation of the effects of orthodontic pacifiers on the primary dentitions of 24- to 59-month old children: preliminary study. *Pediatr Dent* 14: 13-18, 1992.
12. Järvinen S, Lehtinen L: Malocclusion in 3-year-old Finnish children. Prevalence and need for treatment. *Proc Finn Dent Soc* 73: 162-66, 1977.
13. Larson E: Dummy- and finger-sucking habits with special attention to their significance for facial growth and occlusion. 4. Effect on facial growth and occlusion. *Sven Tandlak Tidsskr* 65:605-34, 1972.
14. Modéer T, Odenrick L, Lindner A: Sucking habits and their relation to posterior cross-bite in 4-year-old children. *Scand J Dent Res* 90:323-38, 1982.
15. Humphreys HF, Leighton BC: Survey of antero-posterior abnormalities of the jaws in children between the ages of two and five and one-half years of age. *Brit Dent J* 88:3-7, 1950.
16. Larsson E: Prevalence of crossbite among children with prolonged dummy- and fingersucking habit. *Swed Dent J* 7:115-19, 1983.
17. Larsson E: The effect of dummy-sucking on the occlusion: a review. *Eur J Orthod* 8:127-30, 1986.
18. Ogaard B, Larsson E, Lindsten R: The effect of sucking habits, cohort, sex, intercanine arch widths, and breast or bottle feeding on posterior crossbite in Norwegian and Swedish 3-year-old children. *Am J Orthod Dentofac Orthop* 106:161-66, 1994.
19. Bishara SF, Nowak AJ, Kohaut FJ, Heckert DA, Hogan MM: Influence of feeding and non-nutritive sucking methods on the development of the dental arches: longitudinal study of the first 18 months of life. *Pediatr Dent* 9:13-21, 1987.
20. Moyers RE: *Handbook of Orthodontics*, 4th ed. Chicago: Year Book Medical Publishers, 1988.
21. Foster TD, Hamilton MC: Occlusion in the primary dentition. Study of children at 2 and one-half to 3 years of age. *Brit Dent J* 126:76-79, 1969.
22. Arya BS, Savara BS, Thomas DR: Prediction of first molar occlusion. *Am J Orthod* 63:610-21, 1973.
23. Nanda RS, Khan I, Anand R: Age changes in the occlusal pattern of deciduous dentition. *J Dent Res* 52:221-24, 1973.
24. Bowden BD: The effects of digital and dummy sucking on arch widths, overbite, and overjet. A longitudinal study. *Aust Dent J* 11:396-404, 1966.

Pediatric Dentistry can now communicate on line!

Please direct questions, comments, or letters to the editor to:

Dr. Paul Casamassimo, Editor in Chief
casamassimo.1@osu.edu (*Internet*)

You may also send correspondence or questions about manuscript preparation or status to:

Sara Pullan Geimer, Managing Editor
75471.3203@compuserve.com (*Internet*)
75471,3203 (*Compuserve*)

We welcome your comments and questions. However, please follow the Instructions to Contributors on the inside cover of this journal for manuscript submission procedures.

