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Sucking habits in childhood and the effects on the primary dentition: findings of the Avon Longitudinal Study of Pregnancy and Childhood

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Introduction. Most previous research on non-nutritive sucking habits has been cross-sectional in nature. This study determined the prevalence of non-nutritive sucking habits and the effects on the developing dentition within a longitudinal observational cohort.
Methods. The Children in Focus group of the Avon Longitudinal Study of Pregnancy and Childhood study was studied. Questionnaire data on non-nutritive sucking habits were collected on the children at 15 months, 24 months, and 36 months of age. Dental examinations were performed on the same children at 31 months, 43 months, and 61 months of age.
Results. At 15 months, 63.2% of children had a sucking habit, 37.6% used just a dummy, and 22.8% used a digit. By 36 months, sucking had reduced to 40%, with similar prevalence of dummy and digit sucking. Both habits had effects on the developing dentition, most notably in upper labial segment alignment and the development of anterior open bites and posterior crossbites.
Conclusions. The majority of children had non-nutritive sucking habits up until 24 months of age. Both digit and dummy sucking were associated with observed anomalies in the developing dentition, but dummy-sucking habits had the most profound influence on the anterior and posterior occlusions of the children.

Introduction

The prevalence of non-nutritive sucking habits in children has been estimated to be between 61% and 90%[1–4]. It is thought to provide the child with a sense of security and comfort[5] and can include the sucking of a dummy (or pacifier), one or more digits, or less commonly toys or part of a blanket. Nowak *et al.*[6] reported that although 81% of children had non-nutritive sucking habits at the age of 6 months, by 20 months this had declined to around 59%. The prevalence of pacifier use has been reported to decrease from 40% to 1% over the first 5 years of life, and that of digit sucking from 31% at 12 months of age to just 12% in 4-year-olds[7]. Therefore, the majority of children with a non-nutritive habit at 4 years of age are likely to be digit suckers[8].

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Social background also influences the prevalence and duration of non-nutritive sucking habits. Children from higher socioeconomic groups appear to have an increased prevalence of digit sucking[9]. Older mothers, a higher level of maternal education, and having no older siblings are also factors associated with prolonged non-nutritive sucking habits.

The influence of non-nutritive sucking habits on dental arch characteristics and development has long been recognized[1,2,4,8–19]. These include a decreased overbite or anterior open bite, an increased overjet, and a higher incidence of class II canines and molars. Such habits are also associated with narrowing of the maxillary arch and increased mandibular arch width, leading to an increased likelihood of developing a posterior crossbite[14,15]. The prevalence of posterior crossbite in children with these habits can be as high as 22%[16]. The effect on the occlusion differs according to the type, frequency, and duration of the habit. Open bite establishes itself earlier in dummy suckers than digit suckers[17]. It tends to be symmetrical when

a dummy is sucked and asymmetric when a digit is sucked, with the site related to the digit position[20].

Posterior crossbites are thought to arise in sucking habits as a result of the tongue being pushed down out of contact with the upper arch. At the same time, the upper and lower teeth are held out of occlusion and the cheeks are sucked inwards. This leads to a reduction in upper arch width, the maintenance or even widening of the lower arch width, and a consequent disturbance in the posterior occlusion. The resulting posterior crossbite is associated with a displacement on closing into centric occlusion. In the primary dentition, dummy sucking rather than digit sucking is thought more likely to cause the creation of such a posterior crossbite[7,8,17].

Whereas a digit habit of 48 months duration is associated with a greater increase in overjet, a pacifier habit of the same duration is associated with a greater incidence of posterior crossbite[7,14]. The prevalence of anterior open bite does not appear to differ between those with pacifier and digit-sucking habits[7,8].

As might be expected, the duration of the habit is an important factor in occlusal disturbance, but this has been addressed by relatively few studies. Warren *et al*.[8] compared children who had ceased their habit by 12 months of age with those who still had a habit at 36 months. Perhaps not surprisingly, it was found that increased mandibular intercanine width, maxillary canine, and molar arch depth and overjet were associated with increased duration of the sucking habit. Even in those children where the habit had ceased at between 24 months and 36 months of age, there was increased risk of developing a posterior crossbite when compared with those whose habit had stopped by 12 months. If the habit continued beyond 48 months, it was associated with a reduced maxillary arch width, a further increase in overjet, and reduction in overbite, as well as an increased prevalence of posterior crossbite. These dental changes do not necessarily rectify themselves once the habit has stopped. Bowden[19] examined a group of children aged between 2 years and 8 years, and found that increased overjet, reduced overbite, and maxillary arch width persisted between 2 years and 5 years after cessation of the habit.

The aim of this study was to investigate the prevalence of non-nutritive sucking habits and associated dental effects on the primary dentition in children within a UK population.

Materials and methods

The Avon Longitudinal Study of Parents and Children (ALSPAC) is a prospective study which has been described in detail elsewhere[21]. Briefly, 14 541 pregnant women living in one of three Bristol-based health districts in the former County of Avon with an expected delivery date between April 1991 and December 1992 were enrolled in the study. Detailed information has been collected using self-administered questionnaires, data extraction from medical notes, linkage to routine information systems, and at research clinics. Ethical approval for the study was obtained from the ALSPAC Law and Ethics Committee and Local Research Ethics Committees.

Within the ALSPAC study, a randomly selected cohort of children is known as Children in Focus (CiF), and these children have been monitored periodically via further extensive questionnaires and clinic visits. This group comprised between 994 and 1314 children over the initial 61 months of the study. For this non-nutritive habits study, questionnaires were completed at 15 months, 24 months, and 36 months, and included data on both digit and dummy sucking. A total of 891, 852, and 880 questionnaires, respectively, had information on non-nutritive habits completed by the parents. Specifically, the questionnaire asked, 'Does your child suck a dummy, thumb, or finger? In addition to the questionnaires, dental data were collected at clinical examinations from the CiF when they attended clinics at 31 months, 43 months, and 61 months of age. The primary examiner (K.D.) was the same throughout the study. The other eight examiners were non-dental personnel whose availability differed between clinics. However, the primary examiner was accepted as the standard setter, and just prior to the time of each clinic, a reproducibility study was performed. In total, 867 children attended all three clinics (31 months, 43 months, and 61 months of age). Data were collected on the different aspects of

the occlusion on fewer children than this, dependant on the stage of dental development. Data were collected on the following aspects of dental development: i) Upper labial segment teeth – well-aligned/crowded/spaced, ii) Lower labial segment teeth – well-aligned/crowded/spaced, iii) Anterior occlusion – positive overbite/edge-to-edge incisors/anterior open bite, iv) Posterior occlusion – no crossbite/crossbite.

As there was more than one dental examiner, in this second part of the study, the measurement of interoperator agreement (reproducibility of the examiners) was determined using the non-weighted kappa statistic.

Results

The results of the questionnaires on non-nutritive sucking habits are illustrated in Table 1, and indicate that at 15 months of age, 63.2% of children had a reported sucking habit, which reduced to 40% by the age of 36 months; 37.6% of children used just a dummy compared with 22.8% who used a digit and 2.8% who used both. By 36 months of age, however, the figures were comparable (18.3% just used a dummy and 18.9% just a digit). The decline in the use of a dummy was therefore more rapid than the decline in digit sucking over this 21-month study period.

The interoperator agreement using the non-weighted kappa statistic produced a measurement of agreement for the majority of variables of 1.00, apart from measurements of the upper labial segment (kappa value of 0.93, 95% confidence interval 0.81–1.06), lower labial segment (0.87, 95% confidence interval 0.69–1.04), and right posterior occlusion (0.78, 95% confidence interval 0.37–1.19). Nevertheless, this still represented either good or very good agreement[22]. Summary data from the dental examinations at 31 months, 43 months, and 61 months are

Table 1. Proportion of children at each age with reported sucking habit.

Age (months)	*n*	Dummy	Digit	Both	Neither
15	867	310 (37.6%)	188 (22.8%)	24 (2.8%)	369 (42.6%)
24	867	269 (34.6%)	153 (21.2%)	8 (1.2%)	422 (48.6%)
36	867	140 (18.3%)	144 (18.9%)	13 (1.8%)	583 (67.2%)

Table 2. Dental characteristics recorded at each time interval 31 months, 43 months, and 61 months.

	31 Months		43 Months		61 Months	
	n	%	*n*	%	*n*	%
Upper labial segment (U)						
Well-aligned	549	65.4	501	59.2	421	49.9
Crowded	29	3.5	57	6.7	43	5.1
Spaced	261	31.1	288	34.0	379	45.0
Upper median diastema	141	16.8	170	20.0	116	13.5
Lower labial segment (L)						
Well-aligned	424	50.9	369	43.6	291	34.2
Crowded	77	9.2	87	10.3	110	12.9
Spaced	332	39.9	391	46.2	449	52.8
Lower median diastema	28	3.4	43	5.1	47	5.5
Anterior open bite						
Symmetrical	128	15.7	141	16.8	87	10.2
Unilateral on right	29	3.5	16	1.9	2	0.2
Unilateral on left	18	2.2	7	0.8	3	0.3
Posterior occlusion						
Right crossbite	60	7.8	60	7.2	59	7.0
Left crossbite	55	7.2	48	5.8	51	6.0
Unilateral (right or left)	80	10.5	89	10.8	98	11.6
Bilateral (right and left)	17	2.2	9	1.1	6	0.7
Open bite and crossbite	102	12.6	118	14.2	65	7.6

shown in Table 2, and were analysed using the chi-squared test (χ^2) with a predetermined level of significance of 0.05. Complete data for the upper labial segment alignment at 31 months, 43 months, and 61 months were available for 797 children. At 31 months, 39% of children had a spaced upper labial segment, increasing to 45% at 43 months and 47.8% at 61 months. These differences were statistically significantly different between each time period ($P < 0.001$; Tables 3–5). Data for the lower labial segment alignment were available for 799 children. Spacing in the lower arch increased significantly with time ($P < 0.001$; Tables 6–8) with 41.2% spaced at 31 months, 49.9% at 43 months, and 55.2% at 61 months. At 31 months, 27.7% of the children were spaced in both arches, and this similarly increased to 33.3% at 43 months and 38.4% at 61 months ($P < 0.001$).

Data for anterior open bite were available for 799 children at 31 months, 43 months, and 61 months. The open bite had a tendency to close with time. At 31 months, 21.5% of children had an anterior open bite, decreasing to 19.3% at 43 months and 10.5% at 61 months. Only 26.8% of those who had an open bite at 31 months still had an open bite at 61 months.

There was a highly statistically significant association between posterior crossbite at each of the three time intervals 31 months, 43 months,

Table 3. Proportion of children with a spaced upper labial segment at 31 months (U 31) by proportion with a spaced upper labial segment at 43 months (U 43).

***n* = 797** **100%**	**U 43 not spaced** **438** **55%**	**U 43 spaced** **359** **45%**	χ^2	***P* value**
U 31 not spaced				
486	368	118		
61%	75.7%	24.3%	217	< 0.001
U 31 spaced				
311	70	241		
39%	22.5%	77.5%		

Table 4. Proportion of children with a spaced upper labial segment at 31 months (U 31) by proportion with a spaced upper labial segment at 61 months (U 61).

***n* = 797** **100%**	**U 61not spaced** **416** **52.2%**	**U 61 spaced** **381** **47.8%**	χ^2	***P* value**
U 31 not spaced				
486	347	139		
61%	71.4%	28.6%	184	< 0.001
U 31 spaced				
311	69	242		
39%	22.2%	77.8%		

Table 5. Proportion of children with a spaced upper labial segment at 43 months (U 43) by proportion with a spaced upper labial segment at 61 months (U61).

***n* = 797** **100%**	**U 61 not spaced** **416** **52.2%**	**U 61 spaced** **381** **47.8%**	χ^2	***P* value**
U 43 not spaced				
438	342	96		
55%	78.1%	21.9%	261	< 0.001
U 43 spaced				
359	74	285		
45%	20.6%	79.4%		

Table 6. Proportion of children with a spaced lower labial segment at 31 months (L 31) by proportion with a spaced lower labial segment at 43 months (L 43).

	L 43 not spaced	L 43 spaced		
***n* = 799**	**400**	**399**		
100%	**50.1%**	**49.9%**	**χ^2**	***P* value**
L 31 not spaced				
470	328	42		
58.8%	69.8%	30.2%	178	< 0.001
L 31 spaced				
329	72	257		
41.2%	21.9%	78.1%		

Table 7. Proportion of children with a spaced lower labial segment at 31 months (L 31) by proportion with a spaced lower labial segment at 61 months (L 61).

	L 61 not spaced	L 61 spaced		
***n* = 799**	**353**	**446**		
100%	**44.2%**	**55.8%**	**χ^2**	***P* value**
L 31 not spaced				
470	296	174		
58.8%	63.0%	37.0%	164	< 0.001
L 31 spaced				
329	57	272		
41.2%	17.3%	82.7%		

Table 8. Proportion of children with a spaced lower labial segment at 43 months (L 43) by proportion with a spaced lower labial segment at 61 months (L 61).

	L 61 not spaced	L 61 spaced		
***n* = 799**	**353**	**446**		
100%	**44.2%**	**55.8%**	**χ^2**	***P* value**
L 43 not spaced				
400	293	107		
50.1%	73.3%	26.7%	274	< 0.001
L 43 spaced				
399	60	339		
49.9%	15.0%	85.0%		

and 61 months ($P < 0.001$; Tables 9–11). The proportion of children with posterior crossbite was markedly similar at all three time periods (12%).

When the anterior and posterior occlusions were compared, 8.6% of children had both an anterior open bite and a posterior crossbite at 31 months, which decreased to 5% at 43 months and to 3% at 61 months ($P < 0.001$).

The digit- and dummy-sucking habits at 15 months, 24 months, and 36 months were compared with the developing occlusion at 31 months, 43 months, and 61 months of age. Taking each in turn:

Non-nutritive sucking at 15 months of age and the effect on occlusal development

In those children with a digit-sucking habit at 15 months of age, there was a statistically significant association with spacing in the upper labial segment teeth at 43 months and 61 months ($P \leq 0.035$), but no association at 31 months ($P = 0.288$). For those children with a dummy-sucking habit, it was shown to be statistically significantly associated with a spaced upper labial segment only at 61 months ($P < 0.0001$). No other significant associations were detected ($P \geq 0.06$).

Table 9. Proportion of children with posterior crossbite at 31 months (Xbite 31) by proportion with posterior crossbite at 43 months (Xbite 43).

	Xbite 43 no crossbite 627 87.9%	Xbite 43 crossbite 861 2.1%	χ^2	*P* value
Xbite 31 no crossbite				
627	574	53		
87.9%	91.5%	8.5%	64	< 0.001
Xbite 31 crossbite				
86	53	33		
12.1%	61.6%	38.4%		

Table 10. Proportion of children with posterior crossbite at 43 months (Xbite 43) by proportion with posterior crossbite at 61 months (Xbite 61).

n = 713	Xbite 61 no crossbite 629 88.2%	Xbite 61 crossbite 841 1.8%	χ^2	*P* value
Xbite 43 no crossbite				
627	598	29		
87.9%	95.4%	4.6%	256	< 0.001
Xbite 43 crossbite				
86	31	55		
12.1%	36%	64%		

Table 11. Proportion of children with posterior crossbite at 31 months (Xbite 31) by proportion with posterior crossbite at 61 months (Xbite 61).

n = 713	Xbite 61 no crossbite 629 88.2%	Xbite 61 crossbite 841 1.8%	χ^2	*P* value
Xbite 31 no crossbite				
627	579	48		
87.9%	92.3%	7.7%	85	< 0.001
Xbite 31 crossbite				
86	50	36		
12.1%	58.1%	41.9%		

There was no association between the proportion of children with spaced lower labial segments at any age and digit sucking at 15 months ($P \geq 0.301$), similarly with dummy sucking and spacing at 43 months and 61 months ($P \geq 0.271$). There was, however, a statistically significant association between lower labial segment spacing at 31 months and dummy sucking at 15 months ($P < 0.001$). In this case, 48.8% of those who sucked had spaced arches compared with 35.6% of those who did not suck.

Although no associations existed between the children with a digit habit at 15 months and the presence of an anterior open bite at 31 months and 43 months ($P \geq 0.055$), there was an association between those children who had digit sucked and the presence of an open bite at 61 months ($P < 0.001$). At this age, 19.4% of digit suckers had an open bite compared with only 7.6% of non-suckers. With a dummy, there was a statistically significant association between sucking at 15 months and the presence of an open bite

at 31 months, 43 months, and 61 months ($P \leq 0.003$).

There was no statistically significant association between the presence of posterior crossbite at any age and a digit-sucking habit at 15 months ($P \geq 0.118$). With dummy sucking, there was a statistically significant association with a posterior crossbite ($P < 0.001$).

Non-nutritive sucking at 24 months of age and the effect on occlusal development

At 24 months of age, there was a statistically significant association between the alignment of the upper labial segment at all ages and a digit habit at 24 months ($P \leq 0.036$). Those who sucked have a greater tendency towards a spaced upper labial segment. Although dummy sucking at 24 months also demonstrated a statistically significant association with the alignment of the upper labial segment at 43 months and 61 months ($P \leq 0.012$), by contrast, the upper labial segment was less likely to be spaced in those who dummy sucked than those who did not.

No association could be demonstrated between digit sucking at 24 months and the alignment of the lower labial segment ($P \geq 0.424$) at any age. With dummy sucking, there was statistically significant association with lower labial segment alignment at 31 months ($P < 0.001$). Those who sucked were more likely to have a spaced lower labial segment than those who did not.

There was also no association between the children with open bite at 31 months and digit sucking at 24 months ($P = 0.559$). However, statistically significant associations were seen at 43 months and 61 months ($P \leq 0.002$) and 25% of those who sucked had an open bite at 43 months, compared with 14% of those who did not suck. At 61 months, 21% of digit suckers had an open bite compared with 6% of those with no digit habit. There was no association between the children who did and did not suck a digit at 24 months and the presence of posterior crossbite at any age ($P \geq 0.066$). Statistically significant associations were demonstrated between a dummy-sucking habit at 24 months and presence of open bite and posterior crossbite at all ages ($P < 0.001$). In each case, those who sucked a dummy were more likely to have affected occlusions.

Non-nutritive sucking at 36 months of age and the effect on occlusal development

A statistically significant association was seen between digit sucking at this age and the alignment of the upper labial segment at 43 months ($P = 0.022$), but not at 61 months ($P = 0.363$). In each case, however, a greater proportion of the children who sucked a digit had a spaced upper labial segment than those who did not, although the majority of the children who were spaced were not digit suckers. With dummy sucking, there was a highly statistically significant association between a sucking habit at 36 months and the upper labial segment alignment at 61 months ($P < 0.001$). Those who sucked a dummy being less likely to have spacing in the upper labial segment.

No association could be demonstrated between digit sucking at 36 months and the alignment of the lower labial segment at either age ($P \geq 0.918$). Dummy sucking showed a statistically significant association between sucking at 36 months and the lower labial segment alignment at 43 months ($P < 0.001$). A greater proportion of those who sucked a dummy had spaced lower labial segments than those who did not. Although no association was seen with the lower segment at 61 months ($P = 0.907$), there was still a tendency for more children to have a spaced lower labial segment if they had a history of dummy sucking at 36 months.

A statistically significant association was demonstrated between a history of digit sucking at 36 months and an anterior open bite at 43 months and 61 months ($P < 0.001$). Of those with a sucking habit, 28% had an open bite at 43 months compared with 14% of those without a habit. At 61 months, 23% of digit suckers had an open bite compared with 6.5% of non-suckers.

A statistically significant association was demonstrated between digit sucking at 36 months and the proportion of children with a posterior crossbite at both ages ($P \leq 0.029$). At 43 months, 17% of digit suckers had a posterior crossbite compared with 10% of non-suckers, and at 61 months, 19% of suckers had a crossbite compared with 10% of those who did not.

A statistically significant association was also found between dummy sucking at 36 months

and the presence of both an anterior open bite and a posterior crossbite at 43 months and 61 months ($P < 0.001$). In all cases, those who sucked a dummy at 36 months were more likely to have an open bite or posterior crossbite than those who did not suck at 36 months. Interestingly, 74% of dummy suckers at 43 months had an affected anterior occlusion compared with 27% at 61 months.

The occlusal effects of persistent non-nutritive sucking habits

Persistent sucking was denoted as sucking being recorded at two or more of the questionnaire time intervals. Around 15% of the children sucked a digit and 34% of children sucked a dummy at two or more time points, 15 months, 24 months, or 36 months. The occlusal features of those children at 43 months and 61 months were compared with the sucking habit using the chi-squared test (χ^2) for trend.

At both 43 months and 61 months, around 59% of persistent digit suckers had spaced upper labial segments ($P \leq 0.013$) compared with around 45% of less persistent suckers. There was also a statistically significant association between a persistent dummy-sucking habit and the upper labial segment alignment at both 43 months and 61 months ($P \leq 0.032$). Nevertheless, there was a trend for the majority of children with spacing to fall within the group who were less persistent suckers.

As already highlighted, digit sucking had little effect on lower labial segment alignment and there was very little difference in the proportion of children with lower labial spacing in either the persistent digit-sucking or non-persistent digit-sucking groups ($P \geq 0.204$). Again, there were no associations between lower labial segment alignment and a persistent dummy-sucking habit ($P \geq 0.263$).

Although associations were seen between the proportion of persistent digit suckers with an anterior open bite at 43 months and 61 months ($P \leq 0.029$), the majority of open bites were seen in children who did not have a persistent digit habit. However, a greater proportion of those who were persistent digit suckers had an open bite than those who were not. There was a statistically significant association between a persistent dummy-sucking habit and the presence of an anterior open bite at both 43 months and 61 months ($P < 0.001$). In both cases, more children with an open bite were in the persistent sucking group. At 43 months, 51.6% of persistent suckers had an anterior open bite compared with only 4.5% of less persistent suckers. At 61 months, 16.9% of persistent suckers had open bite compared with 5.6% of less persistent suckers.

When posterior crossbite was considered with respect to a persistent digit-sucking habit, a statistically significant association was seen at 61 months ($P = 0.044$), but not at 43 months ($P = 0.347$). In both cases, however, the majority of children with a sucking habit had no posterior crossbite, although within the persistent sucking group, a larger proportion had crossbite than those who were less persistent suckers. In the case of dummy suckers, the presence of a posterior crossbite was strongly associated with a persistent habit at both 43 months and 61 months ($P < 0.001$), with 23% of persistent suckers having a posterior crossbite, compared with only 6% of less persistent suckers having a posterior crossbite at both ages.

Discussion

Previous studies on non-nutritive sucking habits have shown a variation in prevalence between 20% and 87% at 36 months of age[2,23,24]. The results of the present longitudinal study sit in the middle of this range, being 39% in children of the same age. It is known that non-nutritive sucking habits develop during the first few months of life, reportedly reaching a peak at around 12 months of age[25]. Although the level of digit sucking has been reported to remain at a fairly constant level, possibly until 7 years of age, dummy sucking is thought to decrease until around 4 years of age, when the remaining dummy suckers are likely to stop as contact with other children increases. Certainly, in this study at 15 months of age, 60% of children had a sucking habit compared with 39% at 36 months, and the reduction in dummy sucking over this time period was much greater than the fall in the level of digit sucking. This may relate to the fact that dummies can be taken away from the child to eradicate

the habit. Perversely, this may encourage a digit habit if the dummy is taken away before the child is willing, or able, to cease non-nutritive sucking[4]. The results of this study do not substantiate or refute this hypothesis.

As was the case in previous studies, dummy sucking was found to be more prevalent than digit sucking in younger children, in this case at 15 months and 24 months[25,26]. Children also seem to most frequently choose either a dummy or a digit to suck and much less often both, which supports the findings of previous work[27].

Sucking habits are known to affect the developing occlusion in various ways, and the disturbances recorded in this study bear similarities to those recorded elsewhere. Unlike other studies, overjet, skeletal pattern, and inclination of the incisors were not considered, and so a direct comparison of the apparent effect of sucking habits on the labial segment alignment is not possible. However, a significant association was seen between digit sucking and spaced upper labial segments at both 43 months and 61 months. Certainly, prolonged sucking habits are known to be associated with maxillary proclination[28]. In this study, digit sucking appeared to have little effect on the lower labial segment.

Although dummy sucking had a significant effect on the upper labial segment at 61 months, the trend was for the labial segment to have no spacing. There was some evidence of increased spacing in the lower segment at 31 months and 43 months, which may have been because of fanning of the lower incisors, as a result of proclination. The lack of upper incisor spacing might be explained by the position of the digit or dummy during sucking. In the case of digit sucking, the degree of proclination may differ for each incisor, as the digit is not usually centrally placed in the mouth, resulting in uneven spacing. A dummy, on the other hand, tends to be placed more centrally in the mouth and the open bite formed is usually elliptical. This suggests that the incisors may move together as a block and remain unspaced, so that all four may be proclined and with any spacing present being distal to the incisor segment.

Evidence suggests that prolonged digit sucking is associated with an increased overjet[12,26]. Although Ravn[10] found that the majority of digit suckers did not have an increased overjet, if present, then it was likely to be greater than 6 mm, presumably linked to duration. It is unfortunate that this cannot be substantiated in this study.

Prolonged dummy sucking causes more profound effects on the anterior and posterior occlusions than digit sucking[17,28]. However, because a dummy habit is usually given up earlier than a digit habit, the long-term effects of digit sucking can be more damaging to the occlusion.

In this study, dummy sucking had the most consistent and convincing effect on both the anterior and posterior occlusions at 31 months, 43 months, and 61 months, and was associated with an anterior open bite and a posterior crossbite in each case. These findings support the work of Svedmyr[28] and Paunio *et al.*[29]. The effects of digit sucking, although less marked, were noticeable when being sucked persistently and particularly if still being sucked at 36 months. It was associated with an anterior open bite at 43 months and 61 months, and a posterior crossbite at 61 months. Other workers have found an association between digit sucking and the presence of a crossbite[9]. There is evidence, however, that when the digit habit ceases and an anterior open bite may spontaneously correct itself[10,30], a posterior crossbite is not self-correcting[9]. This is also true in the case of prolonged dummy sucking[28].

In this study, a larger proportion of children with a posterior crossbite were dummy suckers than were digit suckers, and although this is similar to the findings of Modéer *et al.*[25], it is at odds with those of Svedmyr[28]. Non-suckers, as might be expected, had a lower prevalence of crossbite, which is in agreement with Øgaard *et al.*[14] Approximately 12% of the children had a crossbite, and this figure remained the same throughout the study, which is in agreement with other studies[31,32].

The majority of studies share a common conclusion that non-nutritive sucking habits should be broken early because of the detrimental effects on the dentition. Some suggest that discontinuing habits at 24 months will reduce unwanted effects on the dentition, although limited damage will occur if the habit persists until 36 months[8,13]. Some workers

suggest that dummies should be given to small children who have a tendency to digit suck, on the pretext that the dummy habit will be broken earlier than the digit-sucking habit[33]. The present report provides good evidence that digit sucking is a preferable habit to dummy sucking with regard to effects on the dental arch characteristics. This may be of interest to manufacturers of pacifiers; possibly a design to mimic a digit would have lesser effects on the occlusion than the current forms available.

This study had the intrinsic advantage over many previous reports of being longitudinal in nature, observing changing patterns in the same group of children with time. Data collection using the questionnaires was ongoing, reducing parental anamnestic recall, and improving reporting accuracy. This study is also an observational cohort, comprising individuals who are not necessarily seeking treatment and are therefore more representative of the general population. There is a paucity of such longitudinal studies[8], with the majority of studies being cross-sectional in nature. Although these are valuable, they do not give the same degree of information on the progress of individual developing occlusions[9,16,18]. The ALSPAC study is a valuable resource of longitudinal information on the growth and development of 14 000 children. Longitudinal studies are difficult to instigate, requiring significant resource and a commitment on the part of both participants and researchers. The ALSPAC study is anticipated to continue for the foreseeable future, and as sequential questionnaire data become available, it will allow further investigation into the mixed dentition and beyond.

Conclusions

The following conclusions can be drawn from this part of the ALSPAC study on non-nutritive sucking and dental development: i) Digit-sucking habits were associated with variations in the dental development of the children examined at 31 months, 43 months, and 61 months, and in particular with the upper labial segment at 43 months ($P \leq 0.035$) and anterior occlusion at 61 months. ii) The persistent digit-sucking habit, if still present at 36 months, had the strongest associations with the presence of a posterior crossbite at 43 months and 61 months. In these cases, the digit habit was associated with a spaced upper labial segment, an anterior open bite, and a posterior crossbite. iii) No associations were found between a digit-sucking habit and lower labial segment alignment at any age. iv) Dummy-sucking habits had the most profound influence on the anterior and posterior occlusions of the children at all ages. Whether the habit was considered at each time point or as a confirmed persistent habit, it was strongly associated with the presence of an anterior open bite and posterior crossbite at 31 months, 43 months, and 61 months. A persistent dummy-sucking habit and dummy sucking at 24 months were associated with no spacing in upper labial segments at 43 months and 61 months. v) Persistent digit- and dummy-sucking habits were associated with effects on the alignment of the upper labial segment and the anterior and posterior occlusion at 61 months.

What this paper adds

- Clear evidence from a longitudinal cohort study that dummy-sucking habits have greater effect on the developing occlusion than digit sucking.
- Persistent non-nutritive sucking habits have significant effects on the developing dentition.

Why this paper is important to paediatric dentists

- This introduces an ongoing longitudinal life course study (ALSPAC) which will yield significant data on oral health.
- Paediatric dentists are monitors of the developing occlusion in the early years. This provides predictive data on the effects of non-nutritive sucking on the developing occlusion.

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References

1 Levine RS. Briefing paper: oral aspects of dummy and digit sucking. *Br Dent J* 1999; **186**: 108.
2 Ravn JJ. The prevalence of dummy and finger sucking habits in Copenhagen children until the age of 3 years. *Community Dent Oral Epidemiol* 1974; **2**: 316–322.
3 Warren JJ, Levy SM, Nowak AJ, Tang S. Non-nutritive sucking behaviours in pre-school children: a longitudinal study. *Paediatr Dent* 2000; **22**: 187–191.
4 Larsson E. Sucking, chewing and feeding habits and the development of crossbite: a longitudinal study of girls from birth to 3 years of age. *Angle Orthod* 2001; **71**: 116–119.
5 Larsson EF, Dahlin KG. The prevalence and the etiology of the initial dummy- and finger-sucking habit. *Am J Orthod* 1985; **89**: 432–435.
6 Nowak AJ, Levy SM, Kiritsy MC, Slager SL. Patterns of nutritive/non-nutritive sucking at 20 months. *J Dent Res* 1996; **75**: 1683.
7 Bishara SE, Warren JJ, Broffitt B, Levy SM. Changes in the prevalence of non-nutritive sucking patterns in the first 8 years of life. *Am J Orthod Dentofacial Orthop* 2006; **130**: 31–36.
8 Warren JJ, Bishara SE, Steinbock KL, Yonezu T, Nowak AJ. Effects of oral habits' duration on dental characteristics in the primary dentition. *J Am Dent Assoc* 2001; **132**: 1685–1693.
9 Infante PF. An epidemiologic study of finger habits in preschool children, as related to malocclusion, socioeconomic status, race, sex and size of community. *J Dent Child* 1976; **43**: 33–38.
10 Ravn JJ. Sucking habits and occlusion in 3-year-old children. *Scand J Dent Res* 1976; **84**: 204–209.
11 Adair SM, Milano M, Lorenzo I, Russell C. Effects of current and former pacifier use on the dentition of 24- to 59-month-old children. *Paediatr Dent* 1995; **17**: 437–444.
12 Fukuta O, Braham RL, Yokoi K, Kurosu K. Damage to the primary dentition resulting from thumb and finger (digit) sucking. *J Dent Child* 1996; **63**: 403–440.
13 Warren JJ, Bishara SE. Duration of nutritive and non-nutritive sucking behaviours and their effects on the dental arches in the primary dentition. *Am J Orthod Dentofacial Orthop* 2002; **121**: 347–356.
14 Øgaard 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 Dentofacial Orthop* 1994; **106**: 161–166.
15 Lindner A, Modéer T. Relation between sucking habits and dental characteristics in preschool children with unilateral cross-bite. *Scand J Dent Res* 1989; **97**: 278–283.
16 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* 1992; **14**: 13–18.
17 Larsson E. Artificial sucking habits: etiology, prevalence and effect on occlusion. *Int J Orofacial Myology* 1994; **20**: 10–21.
18 Nanda RS, Khan IK, Anand R. Effect of oral habits on the occlusion in preschool children. *J Dent Child* 1972; **39**: 449–452.
19 Bowden BD. A longitudinal study of the effects of digit- and dummy-sucking. *Am J Orthod* 1966; **52**: 887–910.
20 Editorial comment. Digit sucking. *Lancet* 1992; **339**: 963.
21 ALSPAC Study Team. *Avon Longitudinal Study of Pregnancy and Childhood: Aims and Study Design*, 6th edn of study protocol. [WWW document]. URL: http://alspac2.ich.bris.ac.uk/ALSPACext/MainProtocol/contents.htm (accessed: 27 October 2000).
22 Bland JM, Altman BG. Statistical methods for assessing agreement between two methods of clinical measurement. *Lancet* 1986; **i**: 307–310.
23 Cerny R. Thumb and finger sucking. *Aust Dent J* 1981; **26**: 167–171.
24 Wendt LK, Hallonsten AL, Koch G. Oral health in preschool children living in Sweden. Part II – A longitudinal study. Findings at three years of age. *Swed Dent J* 1992; **16**: 41–49.
25 Modéer T, Odenrick L, Lindner A. Sucking habits and their relation to posterior cross-bite in 4-year-old children. *Scand J Dent Res* 1982; **90**: 323–328.
26 Farsi NM, Salama FS. Sucking habits in Saudi children: prevalence, contributing factors and effects on the primary dentition. *Pediatr Dent* 1997; **19**: 28–33.
27 Zadik D, Stern N, Litner M. Thumb and pacifier sucking habits. *Am J Orthod* 1977; **71**: 197–201.
28 Svedmyr B. Dummy sucking. A study of its prevalence, duration and malocclusion consequences. *Swed Dent J* 1979; **3**: 205–210.
29 Paunio P, Rautava P, Sillanpää M. The Finnish Family Competence Study: the effects of living conditions on sucking habits in 3-year-old Finnish children and the association between these habits and dental occlusion. *Acta Odontol Scand* 1993; **51**: 23–29.
30 Moore GJ, McNeill RW, D'Anna JA. The effects of digit sucking on facial growth. *J Am Dent Assoc* 1972; **84**: 592–599.
31 Kutin G, Hawes RR. Posterior cross-bites in the deciduous and mixed dentitions. *Am J Orthod* 1969; **56**: 491–504.
32 Kisling E, Krebs G. Patterns of occlusion in 3-year-old Danish children. *Community Dent Oral Epidemiol* 1976; **4**: 152–159.
33 Baer PN, Lester M. The thumb, the pacifier, the erupting tooth and a beautiful smile. *J Pedod* 1987; **11**: 113–119.