Prediction of Malocclusion Development Based on the Evaluation of the Ethiologic Factors

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SUMMARY

The increase in the number of malocclusion and the change in the goals of modern orthodontics resulted in the improvement of the prevention methods and the elimination of etiological factors of malocclusion in deciduous and early mixed dentition. The purpose of the study was to determine the most informative etiological criteria of the malocclusion development. 1463 7-15 year-old children in three randomly selected Kaunas city schools were examined . The study included interview of children , questionnaire-based interview of parents, and clinical examination. The study showed that the following malocclusions were most common among the studied 1463 7-15 year-old children: malposition of upper (40.3 %), and lower incisors (39.4 %). The analysis of occlusion showed that 21.1 % of children had increased overjet greater than 3.5 mm; distribution of the occlusal relationships of the first permanent molars according to Angle classification was the following: Class I – 69.2 % of subjects, Class II – 27.9 %, Class III – 1.6 % of children; open bite was found in 4 % of subjects, and posterior crossbite was detected in 9.5 % of children. Applying the method of the multivariation logistic regression, the following etiological factors causing development of malocclusion in the studied contingent were determined: mouth breathing, family history of malocclusion, prolonged sucking of a pacifier and adenoids. The multivariation logistic regression method enables to predict the probability of some malocclusion (malposition of upper incisors, increased overjet greater than 3.5 mm, malocclusal relationship of the first permanent molars according to Angle classification Class II, posterior crossbite) development according to the etiological criteria.

Key words: maloccusion, etiological factors, prediction.

Malocclusion are common in the contemporary society, according to the data published by various authors, prevalence of malocclusion during mixed dentition was estimated as 50% to 95% [1, 2]. At present, researchers recognize that the etiological factors of malocclusion can be differentiated into two groups – the genetically determined factors and the environmental factors [3, 4, 5, 6, 7, 8]. The interaction between these two kinds of factors during the development of a child is highly individual.

There are a number of publications that prove the influence of genes on the development of dentofacial system [1]. Genes determine dental size and shape, supernumerary teeth and adentia, the time of eruption, etc. [9]. The environmental factors include forces and pressures from soft tissues and muscles surrounding the dental arches, various habits (thumb sucking, nail-biting, etc.), and the effect of orthodontic appliances [4, 5, 8]. The dentofacial system is also influenced by the forces resulting from mastication [6, 8]. Therefore, although the majority of the etiological factors are clear,

malocclusion are one of the most urgent stomatological problems. Their treatment lasts for 2-3 years, is expensive and not always effective. The necessary precondition of successful orthodontic treatment is early diagnostics and the selection of the appropriate treatment method. Even more efficiency can be attained through the prevention of malocclusion and elimination of the etiological factors during the periods of deciduous and early mixed dentition. Is it possible to foresee and prognosticate the development of orthodontic anomalies? Literature provides only scarce data that is of little value in clinical practice.

The aim of the study: to determine the most informative factors for the prediction of the most common malocclusion, such as malposition of the anterior teeth, overjet greater than 3.5 mm, occlusal relationship of the first molars according to Angle class II, and posterior cross-bite.

MATERIAL AND METHODS

According to the designed study protocol and questionnaire, 1463 children aged 7-15 years from three randomly selected Kaunas city schools were examined. 611 children (41.76%) had mixed dentition, and 852 (58.24%) – permanent dentition. The mean age of the subjects was 11.5±2.3 years.

Dependence of the period of dentition on age was evaluated using the cluster analysis method and three age groups were formed: 7-9 years, 10-12 years, and

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13-15 years. Permanent dentition in the age group of 7-9 years was found in 4.11% of subjects, in the age group of 10-12 years – in 59.72% of subjects, and in the age group of 13-15 years – in 95.35% of subjects. The study included 710 girls and 753 boys; the distribution of subjects by age and sex is presented in fig. 1.

The questionnaire-based study was used to perform children's inquiry (whether orthodontic treatment was/ is applied, whether there are complaints of disturbed nose breathing) and parents' inquiry (family history of malocclusion, data on the child's breathing pattern, adenoidectomy, tonsillectomy, past traumas and surgery of dentofacial system, breast feeding and its duration, pacifier sucking and its duration, and bottle feeding and its duration).

During the clinical examination we evaluated :
• Malposition of the anterior teeth (labial and lingual position, rotation).
• Overjet (OJ, horizontal overlap of the incisors) – the distance between the edge of the upper central incisor and the labial surface of the lower central incisor, measured in parallel to the occlusal plane and central occlusion of the mandible [10]. The measurements were performed using the Vernier calipers with the precision of ±0.1 mm. All subjects were distributed into two groups – OJ from 0 to 3.5 mm, and OJ greater than 3.5 mm.
• The occlusal relationship of the first permanent molars was evaluated according to Angle classification: class I – the mesiobuccal cusp of the first upper molar occludes into the buccal groove of the first lower molar; class II – lower molar distally positioned relative to upper molar; class III – lower molar mesially positioned relative to upper molar [1, 12, 13, 14].
• Overbite (OB, vetical overlap of the incisors) – the distance between the edge of the lower central incisor and the projection of the biting edge of the upper central incisor on the lower central incisor in the central occlusion. The measurements were performed using the Vernier calipers with the precision of ±0.1 mm according to the technique proposed by Proffit. The subjects were distributed into two groups: normal overbite (OB >= 0 mm), and open bite (OB < 0 mm) [1].

• The occlusion at the region of premolars and molars in the transversal direction was evaluated as normal or posterior cross-bite. Normal occlusion in the group of posterior teeth was considered to be the relationship between the teeth when, in central occlusion, the buccal cusps of the lower premolars and molars occludes in the grooves of the respective upper premolars and molars. Posterior cross-bite was diagnosed in case when the one or several upper premolar's or molar's buccal cusp occludes in the grooves of the respective lower premolars and molars [12].
• Breathing pattern: nasal breathing as normal pattern ; mouth breathing was diagnosed when at rest the child's mouth is open, and deep breathing with the lip closure results in the straining of the perioral muscles. The last feature indicates that the nose breathing is difficult, and the child more frequently breathes through the mouth [15]. When evaluating the breathing pattern, only the cases that corresponded to the above-mentioned clinical criteria and were confirmed during the parents' inquiry were considered to be mouth breathing.

Statistical analysis. During the study, measured and categorized indications were determined. Statistical analysis was used to evaluate the means and standard deviations of the measured parameters. In order to evaluate the dependent variable with relation to the influencing factors, multivariation logistic regression analysis was used. The means of the measured indications were compared using Student's (t) criterion. The interdependence of the categorized indications was measured using the χ^2 criterion. In order to determine the precision of the logistic regression model, G^2 criterion was used. All calculations were performed using the software package STATISTICA 5.0.

RESULTS AND DISCUSSION

Children's inquiry. The children's inquiry showed that orthodontic treatment was not applied in 85.47% of the children in the first age group, in 78.12% of children in the second age group and in 71.75% of the children in the third age group.
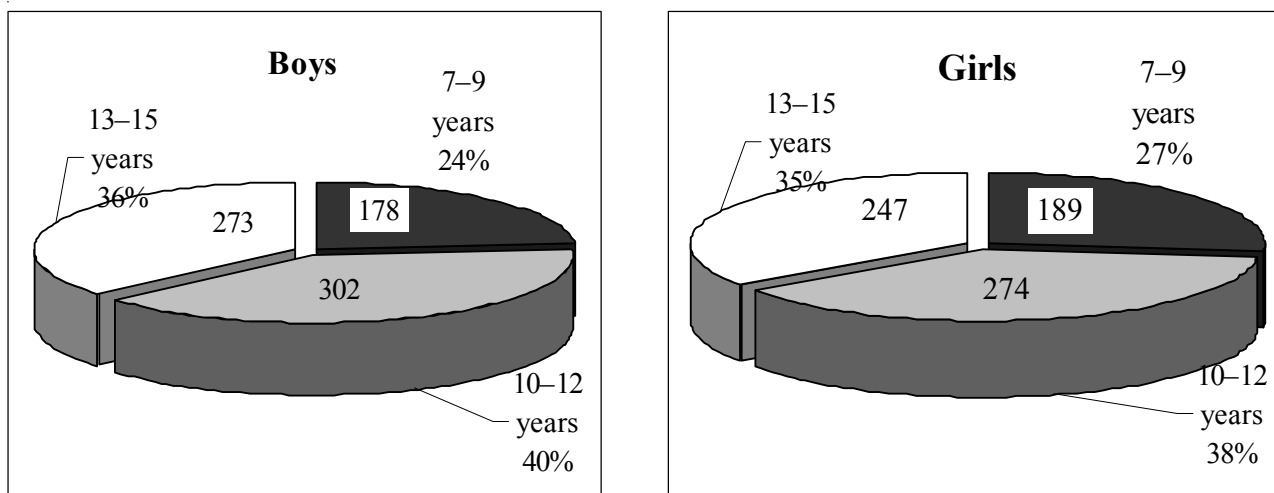

Figure 1. *The distribution of the contingent according to age and sex*

Parents' inquiry. 1396 parents (95.42%) participated in the inquiry. The parents indicated that the families of 670 children (47.95%) had malocclusions. Adenoidectomy had passed 340 children (24.4%), and 13 (0.93%) subjects had it undergone twice. 65 children had undergone tonsillectomy. 81.69% of children (1140 subjects) had been breast-fed, and 291 children (25.51%) had been breast-fed for more than six months. The parents indicated that 88.88% of children (1242 subjects) had been sucking the pacifier, of which 886 children (71.39%) – up to 1.5 years of age, 333 children (26.83%) – up to 3 years of age, and 23 children (1.77%) – longer than up to 3 years of age. Only 74 children (5.3%) had not been bottle-fed. 963 children (72.88%) had been bottle-fed up to 1.5 years of age, and 359 children (27.11%) had been fed longer than up to 1.5 years of age.

Clinical examination. 224 children (15.31%) had normal occlusion; 44 of them had undergone orthodontic treatment. Malposition of the upper incisors was detected in 40.33% of the studied children, and 16.71% of children had malposition of canines. Malposition of the lower incisor was detected in 39.37% of the studied children, and 12.98% of children had malposition of canines.

The greatest overjet in the studied contingent was 11 mm, and the greatest reverse overjet – 3 mm. The general mean of OJ was 2.44±1.75 mm. The mean of OJ among children aged 7-9 years was 2.56±1.85 mm, among those aged 10-12 years – 2.67±1.80 mm, and among subjects aged 13-15 years – 2.11±1.57 mm. Reverse overjet was detected in 6 children (0.41%). OJ, according to the size, was differentiated into two groups: I group – 0-3.5 mm, and II group – greater than 3.5 mm. OJ was age-dependent – the older age groups had less children with increased OJ (greater than 3.5 mm), compared to the group of younger children, p<0.001 (table 1).

The occlusal relationship of the first permanent molars according to Angle classification: in 1012 children (69.17%) Angle class I was determined, in 409 children (27.95%) – Angle class II, and in 23 subjects (1.57%) – Angle class III (in 19 cases the occlusal relationship of the first permanent molars according to Angle classification was impossible to determine for various reasons).

The greatest overbite was 6 mm and the greatest open bite was 4 mm. The general mean of OB was 2.29±1.23 mm. This indicator did not differ significantly between age groups: in the age group of 7-9 years it was 2.24±1.32, in the age group of 10-12 years – 2.46±1.20 mm, and in the age group of 13-15 years – 2.14±1.29 mm. Open bite during clinical examination was detected in 58 children (3.98%): in the age group of 7-9 years – in 20 cases (5.52%), in the age group of 10-12 years – in 14 cases (2.43%), and in the age group of 13-15 years – in 24 cases (4.64%). Posterior cross-bite was found in 139 children (9.50%). Unilateral cross-bite was found in 96 children (6.56%), and bilateral cross-bite – in 43 children (2.94%).

Breathing pattern. On the basis of the data obtained from the parents' inquiry and children examination, nasal breathing was found in 1308 children (89.45%), and mouth breathing – in 155 children (10.55%).

During the study the influence of the etiological factors (age, period of the dentition, breathing pattern, adenoidectomy, family history of malocclusion, breast feeding and its duration, pacifier sucking and its duration, and bottle-feeding and its duration) was evaluated on the development of malocclusion (malposition of the upper incisors, occlusal relationship of the first permanent molars Angle class II, posterior cross-bite, and increased overjet (greater than 3.5 mm). The study included 1396 schoolchildren whose parents filled out the questionnaire (in 17 cases the occlusal relationship of the first permanent molars according to Angle classification was not determined). Method of multivariation logistic regression was applied in order to predict complex of etiological factors that influence the development of malocclusion. Logistic regression method was firstly used to identify the factors that significantly conditioned the development of malocclusion. The etiological factors that influenced the development of malocclusion, their risk for the onset of the anomaly, odds ratio (OR), confidence intervals (CI), and logistic model χ^2 criterion and its respective p value are given in table 2.

The development of malposition of the upper incisors is significantly influenced by mouth breathing, family history of malocclusion, the absence of breast feeding and pacifier sucking for longer than up to 18 months of age (p<0.05). Increased overjet is significantly dependent on age (up to 13 years), period of dentition (mixed), mouth breathing, family history of malocclusion, the presence of adenoids, and pacifier sucking for longer than 18 months of age (p<0.05). The formation of occlusal relationship of the first permanent molars Angle class II is significantly influenced by mouth breathing, family history of malocclusion, the presence of adenoids, and pacifier sucking for longer than 18 months of age (p<0.01). The formation of the posterior cross-bite is significantly influenced by mouth breathing, family history of malocclusion, and bottle feeding for longer than up to 18 months of age (p<0.05).

On the basis of the etiological factors that have a significant influence on the development of malocclusion, logistic models for the evaluation of the probability of the development of malocclusion were designed. The model included only those factors that reliably increased the probability function. The model coefficients and G^2 criterion and its respective p values are given in table 3.

When using the coefficients provided in the table and inserting the values of the factor that affects an individual into the multivariation logistic regression formula, the probability of the development of malocclusion (p) is determined. When applying the

Table 1. Overjet in different age groups *

Age	Overjet			
	0–3.5 mm		Greater than 3.5 mm	
	N	%	N	%
7–9 years	268	74.44	92	25.56
10–12 years	439	76.48	135	23.52
13–15 years	437	84.69	79	15.31
Total	**1144**	**78.89**	**306**	**21.11**

* in 6 children reverse overjet was detected in 7 children overjet was not measured

Table 2. *The etiological factors for the development of malocclusion determined on the basis of the logistic regression data.*

Etiological factor	Indication	Anomaly present		OR	CI	χ²	p
		N	%				
Malposition of the upper incisors							
Breathing pattern	Nasal	520	39.8	1		16.25	0.0006
	Mouth	88	56.8	1.99	[1.4–2.83]		
Family history of malocclusion	Present	308	47.7	1.7	[1.36–2.13]	22.87	0.000017
	Absent	244	34.9	1			
Breast feeding	No	115	46.9	1.33	[1.0–1.77]	4.68	0.027
	Yes	435	39.9	1			
Duration of pacifier sucking	Up to 18 months	226	37.4	1		7.51	0.006
	19–36 months	107	47.1	1.5	[1.09–2.06]		
	More than 36 months	8	53.3	1.92	[0.62–5.95]		
Overjet greater than 3.5 mm							
Age groups	7–9 years	92	25.6	1.9	[1.34–2.7]	20.6	0.000058
	10–12 years	135	23.5	1.7	[1.24–2.35]		
	13–15 years	79	15.3	1			
Breathing pattern	Nasal	197	15.2	1		203.87	0.00001
	Mouth	109	70.8	13.53	[9.11–20.1]		
Period of dentition	Mixed	152	25.5	1.57	[1.21–2.05]	12.13	0.0005
	Permanent	151	17.9	1			
Family history of malocclusion	Present	161	25.2	1.63	[1.24–2.15]	13.2	0.00028
	Absent	119	17.1	1			
Adenoids	Do not have	139	16.4	1		22.06	0.000027
	Have/operated	80	26.7	1.92	[1.35–3.19]		
Duration of pacifier sucking	Up to 18 months	113	18.9	1		3.88	0.049
	19–36 months	56	24.8	1.42	[0.97–2.07]		
	More than 36 months	4	28.6	1.72	[0.45–6.1]		
Occlusal relationship of the first permanent molars Angle class II							
Breathing pattern	Nasal	348	26.6	1		94.2	0.0001
	Mouth	103	66.5	5.46	[3.78–7.92]		
Family history of malocclusion	Present	244	37.8	1.79	[1.41–2.28]	24.4	0.00008
	Absent	177	25.3	1			
Adenoids	Do not have	230	26	1		16.42	0.00006
	Have/operated	119	37	1.77	[1.21–2.43]		
Duration of pacifier sucking	Up to 18 months	167	27.6	1		9.12	0.0025
	19–36 months	85	37.4	1.57	[1.12–2.20]		
	More than 36 months	7	46.7	2.29	[0.74–7.09]		
Posterior cross-bite							
Breathing pattern	Nasal	113	8.6	1		77.98	0.0001
	Mouth	57	36.8	6.15	[4.14–9.14]		
Family history of maloccusion	Present	59	8.4	1.9	[1.33–2.71]	13.7	0.0002
	Absent	96	14.9	1			
Duration of bottle feeding	Up to 18 months	73	11.9	1		6.98	0.008
	More than 18 months	36	15.8	1.39	[0.88–2.18]		
Adenoids	Do not have	77	9	1		8.84	0.003
	Have/operated	52	15.3	1.83	[1.23–2.71]		

logistic model, the set of the values of p was evaluated and, using the cluster analysis method with respect to the natural distribution of the probability, was differentiated into three groups. The 1st group may be considered a low-risk group for the formation of an anomaly, the 2nd – medium risk, and the 3rd – high risk group. The borders of the groups and the frequencies of anomalies among the risk groups are presented in table 4.

The group with a high risk for the formation of the malposition of the upper incisor position (p≥0.4) made up 38.2% of all the subjects. 49.1% of children in this group had anomalies. 9.4% of children were ascribed to the medium-risk group (probability p≥0.35-0.4). Pathology in this group was found in 39.5% of cases. 52.4% of children belonged to the low-risk group (p≤0.35). 30.0% of the subjects in this group had anomalies.

The risk of the formation of overjet greater than 3.5 mm was evaluated the following way: if the probability p is greater than 0.5, the subject is ascribed to the high-risk group (11.3% of subjects). Increased OJ was found in 72% of the subjects in this group. When the value of the probability is 0.015-0.5, the child is ascribed to the medium-risk group (41.4% of subjects). In this group, OJ >3.5 mm was found in 18% of children. If p<0.015, the subject is ascribed to the low-risk group (47.3% of subjects). In this group, increased OJ was found in 11.6% of children.

The risk of the formation of Angle class II occlusal relationship of the first permanent molars was evaluated in the following way: if the probability p exceeds 0.5, the child is ascribed to the high-risk group (12.5% of children, Angle class II found in 71.4% of subjects in this group). If the value of the probability is 0.25-0.5, the child is ascribed to the medium-risk group

Table 3. *The logistic models of the development of malocclusion: their coefficients, G² criterion and its respective p*

Indications	Model coefficients	G^2	p
Malposition of upper incisors			
β_0	0.21		
Breathing pattern	0.65		
Family history of malocclusion	-0.515	41.68	0.00001
Breast feeding	-0.29		
Overjet greater than 3.5 mm			
β_0	-2.66		
Age	-0.085		
Breathing pattern	2.45	173	0.000001
Family history of malocclusion	-0.38		
Occlusal relationship of the first permanent molars Angle class II			
β_0	-2.7		
Breathing pattern	1.97		
Family history of malocclusion	-0.6	106	0.0000001
Duration of pacifier sucking	0.386		
Posterior cross-bite			
β_0	-3.79		
Breathing pattern	1.95		
Family history of malocclusion	-0.8	79.4	0.000001
Duration of bottle feeding	0.033		

Table 4. *The frequency of malocclusion in different risk groups*

Risk group		N	%	N	%
Malposition of upper incisors					
		Present		Absent	
I (low)	$p \leq 0.35$	152	30.00	355	70.0
II (medium)	$0.35 < p < 0.4$	49	39.5	75	60.5
III (high)	$p \geq 0.4$	342	49.1	352	50.9
Overjet					
		OJ greater than 3.5 mm		OJ up to 3.5 mm	
I (low)	$p < 0.015$	73	11.6	558	88.4
II (medium)	$0.015 \leq p \leq 0.5$	99	18.0	453	82.0
III (high)	$p > 0.5$	108	72	42	28.0
Occlusal relationship of the first permanent molars Angle class II					
		Present		Absent	
I (low)	$p \leq 0.25$	73	19.6	300	80.4
II (medium)	$0.25 < p < 0.5$	108	30.00	252	70.0
III (high)	$p \geq 0.5$	75	71.4	30	28.6
Posterior cross-bite					
		Present		Absent	
I (low)	$p \leq 0.1$	25	6.54	357	93.46
II (medium)	$0.1 < p < 0.3$	36	10.75	299	89.25
III (high)	$p \geq 0.3$	40	41.7	56	58.3

(43.0% of subjects, 30.0% of Angle class II cases in this group). If $p \leq 0.25$, the child is ascribed to the low-risk group (44.5% of subjects, Angle class II found in 19.6% of children in this group).

The evaluation of the risk for the formation posterior cross-bite was the following: if the probability p is greater than 0.3, the child was ascribed to high-risk group (11.8% of the subjects; the incidence of cross-bite in this group was 41.7%). If the probability is 0.1-0.3, the child was ascribed to the medium-risk group (41.2% of subjects; in this group, cross-bite was found in 10.75% of cases). If $p \leq 0.1$, the child was ascribed to the low-risk group (47.0% of subjects; in this group, cross-bite was found in 6.54% of cases).

CONCLUSIONS

1. It was determined that in children aged 7-15 years the malposition of the upper (40.3%) and lower (39.4%) incisors was the most common pathology Overjet greater than 3.5 mm was found in 21.1% of children. Angle class II occlusal relationship of the the first permanent molars was found in 27.9% of cases, and Angle class III – in 1.6% of cases. Open bite was detected in 4% of the subjects, and posterior cross-bite – in 9.5% of children.

2. The most common etiological factors that predict the development of malocclusion are: mouth breathing, family history of malocclusion, long duration of pacifier sucking, and adenoids.

3. The multivariation logistic regression method allows to predict the probability of the development of some types of malocclusion (malposition of the upper incisors, greater than 3.5 mm overjet, Angle class II occlusal relationship of the first permanent molars and posterior cross-bite) on the basis of etiological factors (G^2 criterion p<0.001).

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