REVIEWS

Dent. Med. Probl. 2016, 53, 4, 510–523
DOI: 10.17219/dmp/64077

© Copyright by Wrocław Medical University and Polish Dental Society
ISSN 1644-387X

PAULA PIEKOSZEWSKA-ZIĘTEK^{A-D}, ANNA TURSKA-SZYBKA^{A, E, F},
DOROTA OLCZAK-KOWALCZYK^{E, F}

State of Dentition Among Twins Considering the Influence of Genetic and Environmental Factors: The Systematic Review of the Literature

Systematyczny przegląd piśmiennictwa dotyczącego stanu uzębienia u bliźniąt z uwzględnieniem wpływu czynników genetycznych i środowiskowych

Department of Pediatric Dentistry, Medical University of Warsaw, Warsaw, Poland

A – research concept and design; B – collection and/or assembly of data; C – data analysis and interpretation; D – writing the article; E – critical revision of the article; F – final approval of article

Abstract

Twin pregnancies, the most common among multiple pregnancies, currently occur more frequently than 1 out of 100 cases. The studies of twins have a great significance, because they allow us to determine the influence of genetic and environmental factors in many physical and behavioral features or abnormalities. This is possible because monozygotic twins share 100% of their genome, while dizygotic twins share only a part of it, but they usually have a common developmental environment. Better concordance of a specific feature presence among monozygotic twins may provide a bigger influence of the genetic component. On the other hand, no significant difference between mono- and dizygotic twins suggests the influence of the environmental component. The systematic review of the following articles presents issues of oral health in twins, taking the possible genetic and environmental factors into account. Thirty-three original papers, concerning children and teenagers, as well as adults, were included in the review. The article presents the issues of mineralized tissues diseases – caries, erosions, hypoplasia, problems of occlusion development and occlusion defects, periodontal issues, parafunctions (**Dent. Med. Probl. 2016, 53, 4, 510–523**).

Key words: twins, oral hygiene, caries, teeth erosion, periodontal diseases.

Słowa kluczowe: bliźnięta, higiena jamy ustnej, próchnica, erozje zębów, choroby przyzębia.

According to the current reports, 1 out of 100 pregnancies is a multiple pregnancy, which means that during one labor more than one child is delivered [1]. The frequency of twin pregnancies, which is the most common among multiple pregnancies, differs depending on the population. The percentage of their occurrence may differ among races. As Szukalski [1] claims, they are rare among representatives of the Mongoloid race (approximately 0.7% of pregnancies), slightly more often among the white race (1.2% of pregnancies), and the most often among the Negroid race (2% of pregnancies, whereas in some African regions the percentage reaches even 4.5–5%).

In the European population, including Poland, an increase in the frequency of twin pregnancies has been observed [2]. A probable cause of this phenomenon is the use of hormonal therapy against infertility as well as artificial fertilization methods (an *in vitro* technique during which the number of implanted embryos is increased in order to enhance the chance for method's success) [3]. Another factor may be the increase of the average age of mothers, as they decide to have offspring later [1]. Researches on twins has substantial meaning because they allow us to determine the participation of genetic as well as environmental factors in many physical and behavioral features

or abnormalities [4]. The proportion between identical and fraternal twins is about 1 : 2 [5]. Identical twins (monozygotic) are characterized by the genetic material shared in 100%, and consequently, the variability of features among individual pairs arises from diverse influences of the environment. Fraternal twins (dizygotic) share a set of genes derived from parents only partially, but they used to have a common environment in terms of birth delivered in the same time and place [6, 7]. The most significant and known research of that type, which touches upon the biggest number of dental issues, is the project conducted for over 30 years by Australian researchers from the Medical University in Adelaide [4]. The aim of the review of the literature is to analyze the state of dentition among twins, taking into account the possible influence of genetic and environmental factors.

Materials and Methods

Pubmed/Medline databases have been reviewed in order to find academic literature concerning some research associated with the dental aspects related to twins. The following key words have been used: “twins dentistry”, “twins caries”, “twins teeth”, “twins oral hygiene”, “twins dentition”, “twins dental erosion”, “twins teeth eruption”, “twins dental habits”, “twins oral health”,

“twins orthodontics”. The titles of the articles have been verified and repetitions excluded, essential abstracts have been chosen and then the articles have been downloaded in full text. Research conducted with the participation of twins which focus on the state of dentition have been enclosed in the review. Enclosure criteria: original papers, published after the year 2000, written in Polish or English, concerning children, teenagers and/or adults’ dentition, in which dental caries, periodontal diseases, morphological conditions, enamel disorders, tooth emergence timing, occlusal abnormalities and habits, taking into account the possible influence of genetic and environmental factors, have been assessed. Case descriptions, object works, literature reviews as well as questionnaire surveys and articles not connected to the possible influence of genetic and environmental factors have been excluded.

Results

From among 1494 records, 33 articles have been qualified to revision. A schema of the qualifying process is presented by PRISMA flow diagram (Fig. 1).

A characteristic of researches included in the systematic review is presented in Table 1.

The overview of included results is compiled in Tables 2–8.

Table 1. Characteristics of studies included in systematic review

Authors/Country, Year/ Reference No.	Number of twins investigated	Type of study	Examined parameters
Kurushima Y. et al./ Japan, 2014/[6]	116 monozygotic pairs 16 dizygotic pairs	cross-sectional study	caries lesions, periodontium state, bone resorption, width of dental arches, stimulated saliva flow, occlusal force
Lovelina F.D. et al./ India, 2012/[7]	9 monizygotic pairs 21 dizygotic pairs	cross-sectional study	dietary and hygienic habits, caries lesions, restoration presence, calcullus presence, bleeding on probing, clinical attachment loss
Bretz W.A. et al./ USA, 2005/[8]	142 monozygotic pairs 246 dizygotic pairs	cross-sectional study	caries lesions, cariogenic bacteria acid production
Ooi G. et al./ Australia, 2014/[10]	17 monozygotic pairs 25 dizygotic pairs	the classical twin study	caries lesions, enamel hypoplasia/opacities, quantity of <i>Streptococcus mutans</i> and <i>Lactobacillus</i> bacteria
Bockmann M.R. et al./ Australia, 2011/[11]	151 monozygotic pairs	cohort study	tooth emergence order, <i>S. mutans</i> bacteria presence
Corby P.M. et al./ USA, 2005/[12]	48 monozygotic pairs 54 dizygotic pairs	cross-sectional study	<i>S. mutans</i> quantity in saliva
Corby P.M. et al./ USA, 2007/[13]	40 monozygotic pairs 62 dizygotic pairs	cross-sectional study	white spot lesions, caries lesions, bacteria species in plaque
Opydo-Szymaczek J. et al./ Poland, 2007/[14]	20 twin pairs (mono- and dizygotic)	case-control study	pregnancy and labour course, birth weight, dietary and hygienic habits, first dental appointment term, No. of teeth, caries intensity

Table 1. Characteristics of studies included in systematic review – cont.

Authors/Country, Year/ Reference No.	Number of twins investigated	Type of study	Examined parameters
Michalowicz B.S. et al./ USA, 2000/[15]	64 monozygotic pairs 53 dizygotic pairs	cross-sectional study	pocket depth, clinical attachment loss, plaque presence, gingiva state
Kurushima Y. et al./ Japan, 2014/[16]	91 monozygotic pairs 15 dizygotic pairs	cross-sectional study	pocket depth, No. of extracted teeth, masticatory performance, carotid intima-media complex thickness
Bockmann M.R. et al./ Australia, 2010/[17]	94 monozygotic pairs 125 dizygotic pairs	cohort study	tooth emergence timing
Mihailidis S. et al./ Australia, 2009/[18]	131 twin pairs	cohort study	asymmetry of tooth emergence
Sharma K./ India, 2014/[19]	111 twin pairs	chronogenetic study	permanent teething timing
Krzywańska-Karolewska M. et al./ Poland, 2009/[20]	35 twin pairs	cross-sectional study	tempo of permanent teething
Kabban M et al./ Great Britain, 2001/[21]	22 monozygotic pairs 12 dizygotic pairs	cross-sectional study	mesio-distal and bucco-lingual crown dimension, occlusal topography
Hughes T. et al./ Australia, 2000/[22]	99 monozygotic pairs 122 dizygotic pairs	cross-sectional study	mesio-distal and bucco-lingual dimensions of deciduous teeth
Ribeiro D.C. et al./ Australia, 2013/[23]	52 monozygotic pairs 82 dizygotic pairs	cross-sectional study	mesio-distal, bucco-lingual and intercuspidal dimensions, height of crowns
Apps M.V. et al./ Australia, 2004/[24]	218 twin pairs	cross-sectional study	mesio-distal dimension of central incisors in deciduous and permanent dentition
Su C.Y. et al./ USA, 2008/ [25]	9 monozygotic pairs 12 dizygotic pairs	cross-sectional study	occlusal topography of first permanent molars
Liu M.T. et al./ USA, 2014/[26]	147 monozygotic pairs	case-control study	facial features, habits evaluation
Spielman A.I. et al./ USA, 2011/[27]	6 monozygotic pairs 3 dizygotic pairs	picture-matching study	tongue morphology
Śmiech-Słomkowska G. et al./ Poland, 2006/[28]	35 twin pairs	cross-sectional study	permanent teething advancement, occlusion
Condo R. et al./ Italy, 2010/[29]	1 monozygotic pair	clinical trial	therapeutic effect of 2 different removable braces
Kot M. et al./ Poland, 2005/[30]	6 monozygotic pairs 18 dizygotic pairs	cross-sectional study	cleft lip/palate occurrence
Tessler A.Y. et al./ USA, 2011/[31]	19 monozygotes 10 dizygotes	cross-sectional study	viscerocranium features
Taji S.S. et al./Australia, 2010/[33]	31 monozygotic pairs 50 dizygotic pairs	cross-sectional study	dental erosions, dietary and hygienic habits
Dooland K.V. et al./ Australia, 2006/[34]	116 monozygotic pairs 124 dizygotic pairs	cross-sectional study	incisal edge attrition, occlusion
Taji S.S. et al./Australia, 2000/[35]	181 twin pairs	cross-sectional study	enamel loss on labial surfaces of extracted canines, diagnostics models analysis
Taji S.S. et al./Australia, 2011/[36]	88 twins	cross-sectional study	enamel hypoplasia/opacities
Biesbrock A. et al./ USA, 2006/[37]	51 twin pairs	clinical trial	effect of flossing as additional hygienic method
Corby P.M. et al./ USA, 2008/[38]	51 twin pairs	clinical trial	effect of flossing on interproximal plaque
Wasmer C. et al./ Switzerland, 2008/[39]	21 monozygotic pairs 31 dizygotic pairs	cross-sectional study	frequency and circumstances of dental and facial trauma
Corby P.M. et al./ USA, 2014/[40]	42 monozygotic pairs 43 dizygotic pairs	clinical trial	effect of bleaching with 10% hydrogen peroxide

Table 2. Results overview – caries studies

Authors/Country, Year/Reference No.	No. of patients	Average age (years)	Examined parameters	Average values/results (in groups)	Statistical significance
Kurushima Y. et al./ Japan, 2014/[6]	264	66.1	% of decayed, missing, filled teeth	67.1% (MZ) 72.4% (DZ)	not significant
Lovelina F.D. et al./ India, 2012/[7]	60	18.5	correlation of caries presence in twin pairs	88.9% (MZ) 9.5% (DZ)	not significant
Bretz W.A. et al./ USA, 2005/[8]	776	5.2	SB-CPR (surface based caries prevalence rate)	MZ DZ 0 24% 22% 0–2 5% 6% 2–5 14% 15% > 5 56% 57%	not significant
Bretz W.A. et al./ USA, 2005/[8]	776	5.2	LSI (lesion severity index)	0.22 (MZ) 0.21 (DZ)	not significant
Bretz W.A. et al./ USA, 2005/[8]	776	5.2	bacterial acid production	10% low 17% medium 73% high (MZ) 4.5% low 17.5% medium 78% high (DZ)	not significant
Ooi G. et al./ Australia, 2014/[10]	84	5.1	dmft (including white spot lesions)	0.6 (MZ) 1.5 (DZ)	p = 0.015 statistical significance
Ooi G. et al./ Australia, 2014/[10]	84	5.1	dmfs (including white spot lesions)	0.6 (MZ) 2.7 (DZ)	not significant
Bockmann M.R. et al./ Australia, 2011/[11]	302	No data	time of <i>S. mutans</i> colonization	15% – pair concordance (PRE) 64% – pair concordance (AFT) 21% – pair discordance	statistical significance
Opydo-Szymaczek J. et al./ Poland, 2007/[14]	40	5.4	dmft	5.7 (LBW) 4.9 (HBW)	not significant
Opydo-Szymaczek J. et al./ Poland, 2007/[14]	40	5.4	dmft + DMFT	5.9 (LBW) 5.6 (HBW)	not significant

MZ – monozygotic twins; DZ – dizygotic twins; LBW – low birth weight; HBW – high birth weight; PRE – before first tooth emergence; AFT – after first tooth emergence.

Table 3. Results overview – periodontological issues

Authors/Country, Year/Reference No.	Number of patients	Average age (years)	Examined parameter	Average values/results (in groups)	Statistical significance
Kurushima Y. et al./ Japan, 2014/[6]	264	66.1	PD (Pocket Depth)	5.9 mm (MZ) 6.2 mm (DZ)	not significant
Lovelina F.D. et al./ India, 2012/[7]	60	18.5	correlation of periodontitis features in twin pairs	77.8% (MZ) 23.8% (DZ)	statistical significance in case of monozygotes p = 0.001
Kurushima Y. et al./ Japan, 2014/[16]	212	67.4	PD (Pocket Depth)	2.8 mm (MZ) 2.8 mm (DZ)	not significant
Kurushima Y. et al./ Japan, 2014/[16]	212	67.4	No. of teeth remaining in oral cavity	21.1 (MZ) 20.1 (DZ)	not significant

MZ – monozygotic twins; DZ – dizygotic twins.

Table 4. Results overview – tooth emergence timing

Authors/Country, Year/Reference No.	Number of patients	Age range (years)	Examined parameter	Average values/results (in groups)		Statistical significance
Bockmann M.R. et al./Australia, 2010/[17]	438	2–6	order of teeth emergence in twin pairs	average age of first tooth emergence: 9 months average age of last tooth emergence: 28 months (MZ, DZ)		statistical significance depends on teeth group
Mihailidis S. et al./ Australia, 2009/[18]	262	2–6	asymmetry of teeth emergence	earlier emergence on the left side of dental arch (MZ, DZ)		not significant
Sharma K./ India, 2014/[19]	223	5–25	permanent teeth emergence	average age of first tooth emergence		statistical significance depends on teeth group
				5.9 years (M) (MZ)	5.96 years (M) (DZ)	
				6 years (W) (MZ)	5.72 years (W) (DZ)	
				average age of last tooth emergence		
				17.9 years (M) (DZ) 17.35 years (W) (MZ)	19.17 years (M) (DZ) 18.75 years (W) (DZ)	
Krzywańska-Karolewska M. et al./ Poland, 2009/[20]	70	6.5–7.5	influence of labour time on teeth emergence	late teeth emergence in children born prematurely (MZ, DZ)		no analysis
Śmiech-Słomkowska G. et al./ Poland, 2006/[28]	270	7	tempo of permanent teething	later permanent teething in twins (MZ, DZ, control)		no analysis

MZ – monozygotic twins; DZ – dizygotic twins; W – women; M – men.

Table 5. Results overview – tooth dimensions

Authors/ Country, Year/ Reference No.	Number of patients	Average age/ age range (years)	Examined parameter	Average values/results (in groups)	Statistical significance
Kabban M et al./ Great Britain, 2001/[21]	68	13.1	squared difference of mesio-distal dimensions	permanent dentition 0.16 (MZ and DZ) 0.73 (control)	p < 0.001 statistical significance
				deciduous dentition 0.08 (MZ and DZ) 0.33 (control)	p < 0.001 statistical significance
Kabban M et al./ Great Britain, 2001/[21]	68	13.1	squared difference of bucco-lingual dimensions	permanent dentition 0.35 (MZ and DZ) 1.13 (control)	p < 0.001 statistical significance
				deciduous dentition 0.09 (MZ and DZ) 0.28 (control)	p < 0.001 statistical significance
Kabban M et al./ Great Britain, 2001/[21]	68	13.1	difference of mesio-distal dimensions	0.02 (MZ) 0.10 (DZ)	p = 0.01 statistical significance
Kabban M et al./ Great Britain, 2001/[21]	68	13.1	difference of bucco-lingual dimensions	0.07 (MZ) 0.15 (DZ)	p = 0.23 not significant

Table 5. Results overview – tooth dimensions – cont.

Authors/ Country, Year/ Reference No.	Number of patients	Average age/ age range (years)	Examined parameter	Average values/results (in groups)	Statistical significance
Hughes T. et al./ Australia, 2000/[22]	602	4–7	correlation of mesio-distal and bucco- -lingual crown dimensions	mesio-distal dimension correlation range: 0.28–0.93 (average 0.47) bucco-lingual dimension correlation range: 0.23–0.93 (average 0.47)	statistical significance in both genders
Ribeiro D.C. et al./Australia, 2013/[23]	134	4–16	squared ave- rage of mesio- -distal, bucco- -lingual, inter- cuspidal dimensions and crown height	highest average values in case of DZOS Similar average values in case of MZ and DZSS	statistical significance in both dentitions (MZ and DZOS) statistical significance in both dentitions except mesio-distal dimensions (DZSS and DZOS)
Su C.Y. et al./ USA, 2008/[25]	42	4–7	difference of occlusal surface dimensions	tooth 46 – 0.0135 mm (MZ) tooth 36 – 0.0783 mm (MZ)	p = 0.168 not significant
				tooth 46 – 0.0450 mm (DZ) tooth 36 – 0.0125 mm (DZ)	p = 0.37 not significant

MZ – monozygotic twins; DZ – dizygotic twins; DZSS – dizygotic same-sex twins; DZOS – dizygotic opposite-sex twins.

Table 6. Results overview – orthodontic issues

Authors/Country, Year/Reference No.	Number of patients	Average age (years)	Examined parameter	Average value/results (in groups)	Statistical significance
Śmiech-Słomkow- ska G. et al./ Poland, 2006/[28]	270	7	malocclusion	63% (MZ and DZ) 55% (control)	no analysis
Condo R. et al./ Italy, 2010/[29]	2	11.3	effect of class II group 2 tre- atment	significant clinical conditions improve- ment in both braces ("Twin block" due to Clark and "Occlus-o-guide" due to Bergensen)	no analysis
Kot M. et al./ Poland, 2005/[30]	42	no data	cleft lip/palate presence	50% concordance in pairs; 50% discor- dance in pairs (MZ)	no analysis
				27% – concordance in pairs; 73% – discordance in pairs (DZ)	
Tessler A.Y. et al./ USA, 2011/[31]	29	8.5	viscerocra- nium features	96.2% – moderate level of morpholo- gical similarity in pairs discordant for unilateral cleft lip/palate (MZ)	not signifi- cant
				56.2% – moderate level of morpholo- gical similarity in pairs discordant for unilateral cleft lip/palate (DZ)	

MZ – monozygotic twins DZ – dizygotic twins

Table 7. Results overview – erosions and enamel defects

Authors/Country, Year/Reference No.	Number of patients	Average age/ age range (years)	Examined para- meter	Average value/results (in groups)	Statistical significance
Taji S.S. et al./ Australia, 2010/[33]	128	2.9	erosion occurrence	77% (MZ) 74% (DZ) 75% (control)	not signifi- cant
Dooland K.V. et al./ Australia, 2006/[34]	480	no data	erosion concor- dance in twin pairs	86% (MZ) 81% (DZ)	not signifi- cant

Table 7. Results overview – erosions and enamel defects – cont.

Authors/Country, Year/Reference No.	Number of patients	Average age/ age range (years)	Examined parameter	Average value/results (in groups)	Statistical significance
Taji S.S. et al./ Australia, 2000/[35]	699	3–10	enamel hypoplasia concordance in twin pairs	at least 1 lesion present: 55% (MZ) 73% (DZ)	no analysis
				No. of teeth with lesions: 43% (MZ) 54% (DZ)	
				lesions in vertical position: 42% (MZ) 30% (DZ)	
				lesions in horizontal position: 53% (MZ) 48% (DZ)	
Taji S.S. et al./ Australia, 2011/[36]	128	3	enamel hypoplasia concordance in twin pairs	labial surface of left lower canine 86.7% (MZ) 60% (DZ)	not significant
				labial surface of right lower canine 80% (MZ) 44% (DZ)	statistical significance

MZ – monozygotic twins; DZ – dizygotic twins.

Table 8. Results overview – other studies

Authors/Country, Year/Reference No.	Number of patients	Average age/ age range (years)	Examined parameter	Average values/results (in groups)	Statistical significance
Liu M.T. et al./ USA, 2014/[26]	294	42	face asymmetry due to extractions	lean of occlusal surface up to 0.31 degree after each tooth extraction	p = 0.043 statistical significance
Liu M.T. et al./ USA, 2014/[26]	294	42	face asymmetry due to prosthodontic treatment	average nasal midline deviation in patients using dentures = 3.4 mm average asymmetry of mouth angles in patients using dentures = 9 mm	p = 0.032 statistical significance p = 0.007 statistical significance
Spielman A.I. et al./ USA, 2011/[27]	18	18	tongue morphology	60% correct matches (MZ) 31% correct matches (DZ)	no analysis
Dooland K.V. et al./ Australia, 2006/[34]	480	No data	teeth gnashing side	33.8% discordance (MZ) 16.8% discordance (DZ)	statistical significance
Biesbrock A. et al./ USA, 2006/[37]	102	12–21	PBS (papillary bleeding score)	41.5% decrease in PBS index (B + F) no change in PBS index (B)	p < 0.001 statistical significance
Corby P.M. et al./ USA, 2008/[38]	102	12–21	plaque flora	decrease in quantity of bacteria causing caries and periodontitis (B + F)	no analysis
Wasmer C. et al./ Switzerland, 2008/[39]	104	23.4	dental or facial injuries in twin pairs	dental trauma 66.7% (MZ) 58.1% (DZ)	not significant
				facial trauma 52.4% (MZ) 58.1% (DZ)	
Corby P.M. et al./ USA, 2014/[40]	170	12–29	“L” teeth colour parameter change (light/dark)	$\Delta L = 2.81$ (DZ) $\Delta L = 3.64$ (MZ)	not significant
Corby P.M. et al./ USA, 2014/[40]	170	12–29	“b” teeth colour parameter change (yellow/blue)	$\Delta b = 5.59$ (DZ) $\Delta b = 5.03$ (MZ)	statistical significance
Corby P.M. et al./ USA, 2014/[40]	170	12–29	“a” teeth colour parameter change (red/green)	$\Delta a = 0.61$ (DZ) $\Delta a = 0.81$ (MZ)	statistical significance

MZ – monozygotic twins; DZ – dizygotic twins; B + F – teeth brushing + flossing; B – teeth brushing.

Fig. 1. PRISMA flow diagram

Discussion

Caries and Periodontal Diseases

Susceptibility to caries, the colonization by cariogenic bacteria, the incidence of gingival and periodontal diseases were aspects undertaken most frequently by scientists who conducted studies on twins considering the possible influence of genetic and environmental factors. The researched works confirmed that a genetic component has an influence on the appearance of multifactorial diseases, such as teeth caries [7, 8] or periodontitis [7, 9]. However, they are not excluded from environmental factors, the importance of which was proved by Ooi et al. [10] and Kurushima et al. [6].

Other researchers continued to focus on cariogenic bacteria colonization timing among identical twins. Bockmann et al. [11] were collecting data on the time that deciduous teeth and *Streptococcus mutans* bacteria appear among monozygotic twins. In 25% of cases, the colonization appeared even before the first teeth in the oral cavity. The time of colonization among 21% of twins (before or after the emergence of the first tooth) varied, which was statistically significant and allowed us to draw a conclusion about the influence of the environmental factor. The studies have been confirmed by Ooi et al. [10], who checked the compliance of *Streptococcus mutans* (SM) and *Lactobacillus acidophilus* (LB) bacteria occurrence among pairs of twins. They achieved this compliance in the case of 71% of identical pairs and 68% of fraternal pairs in terms of SM and 65% of identical pairs and 72% of fraternal pairs for LB.

Minimal differences between proportions allowed us to conclude that there exists an inconsiderable influence of the genetic component on bacterial colonization. Other results were obtained by Corby et al. [12], who defined that SM appearance depends on heritability in 52%, whereas on environmental factors in 48%. Two years later, Corby et al. [13] conducted research, whose main aim was to check if microorganism species living in the oral cavity are hereditary. Samples with biofilm were taken from the surface of healthy teeth from 118 twins free from dental caries, as well as from healthy teeth and those with caries from 86 twins with active caries. A statistically significant difference was obtained in the level of 20 species of bacteria between healthy patients and those with caries (with the majority in the healthy population). Most of these bacteria are related to the protective functions of the oral cavity (for example *S. salivarius*, *S. sanguinis*, *S. mitis/oralis*). Heritability for these species was estimated on a level of 56–80%, which means that genetic factors have a crucial influence on the colonization of potentially non-cariogenic bacteria among twins free from caries. An opposite result was obtained in the case of *S. mutans* cariogenic bacteria. Here, a higher level of heritability was estimated in the case of patients with active dental caries.

In Poland, observations concerning the appearance of caries among twins were carried by researchers from the Poznan University of Medical Sciences [14]. The research took into consideration data such as the course of pregnancy, birth weight, hygienic and dietary habits, as well as the term of the first dental appointment. The clinical examination has been carried out, which considered the intensity of dental caries on the basis of dmft, DMFT or dmft + DMFT indexes, depending on the type of dentition. Any statistically significant differences in the appearance of caries among twins with diverse birth weight have not been revealed. The incidence of unfavorable habits among most children who took part in the experiment has been noted, which helped us draw conclusions concerning the necessity of intensifying educational activities that create a proper health-promoting attitude.

Bretz et al. [8] in their studies on 388 pairs of twins aged 1.5–8 assessed the influence of genetic and environmental factors on the incidence of caries and bacterial acids production. The clinical part of the experiment involved the examination with a visual-tactile method as well as the transillumination method, with the use of DI-FOTI (Digital Fibre-Optic Transillumination). Production of bacterial acids was measured with ClinproCario-L-Pop test, which collected a biofilm sample from

the tongue with the use of particular carrier. Any change of color of the carrier meant that lactic acid was produced and the production intensity was assessed according to a scale attached to the set. The research results suggested considerable influence of genetic factors on dental caries prevalence and environmental factors on bacterial acids production, however differences were not statistically significant. Similar results were achieved by Lovelina et al. [7], who in their studies of 9 pairs of identical twins and 21 pairs of fraternal twins revealed a higher correlation of occurrence of dental caries and periodontal diseases in the case of the first group of subjects. Different results were achieved by Kurushima et al. [6], probably because of the relatively higher age of patients, and as a consequence, a higher influence of the environmental component, which was defined as the main component connected with the periodontium and coexisting with genetic component – in the case of dental caries.

Michalowicz et al. [15] looked closer at assessing the health condition of the periodontium among twins. In their studies, the presence of dental plaque, features of gingivitis, depth of gingival pockets and clinical attachment loss (CAL) were evaluated among 117 pairs of adult mono- and dizygotic twins. The level of periodontitis advancement among patients was assessed, taking into consideration maximal CAL values and the amount of teeth that are enveloped by the process. Higher conformity for all measured parameters was obtained in the case of monozygotes. The influence of genetic factors on the appearance of periodontitis was estimated at 50%. However, the authors paid a lot of attention to smoking and insufficient hygiene of the oral cavity as the most important of the environmental factors, significant in etiopathogenesis of the disease. Kurushima et al. [16] emphasized the influence of pathogenic processes occurring in periodontium on other systemic diseases. The relation between periodontitis and the occurrence of atherosclerosis among pairs of twins above 50 years old was evaluated. In the clinical study, a number of teeth in the oral cavity, the depth of gingival pockets, masticatory performance and the thickness of carotid intima-media complex were assessed. Bacteraemia connected with chronic inflammation of the periodontium is an environmental factor that contributes to the development of atherosclerosis.

Emergence Timing

Bockmann et al. [17] determined the influence of hereditary and environmental factors on the variability during the appearance of deciduous

teeth. The research group consisted of 125 pairs of fraternal and 94 pairs of identical twins. Parents in a specially prepared form noted the emergence of particular teeth and the data was verified during appointments. Heritability in teeth emergence timing was generally estimated at 90%; however, in the case of some teeth (lower canines, lower right lateral incisors), the value was significantly lower, reaching about 50%. The research confirmed a strong impact of the genetic factor. Mihailidis et al. [18] were interested in similar issues as they were checking the genetic basics of asymmetry in teeth appearance. Permanent teeth emergence times among 111 pairs of Indian twins was taken into account by Sharma [19]. Permanent teeth appeared earlier among girls. Significant differences between mono- and dizygotes were noticed only in the case of 37% of patients. The influence of heritability on the rate of emergence was more noticeable in the case of the maxilla rather than the mandible. Differences in heredity between genders were observed – a more significant contribution of genetic factors was estimated among girls rather than boys. Heredity contribution was estimated at 60% in terms of the length of the break between two phases of permanent teething (after the emergence of incisors and before the emergence of canines or premolars). In Poland, similar research was conducted by Krzywańska-Karolewska and Śmiech-Słomkowska [20]. The group consisted of 35 pairs of twins (6.5–7.5 years old). The aim of this work was to assess the influence of premature labor (< 37th week of pregnancy) on permanent teething time. The average term of labor was calculated on 35th week of pregnancy. The tempo of emergence was assessed on the basis of the appearance of particular groups of permanent teeth (incisors and premolars) in the oral cavity. The process of emergence in the study group was delayed in contrast to norms for children at a particular age.

Morphology of Teeth/Soft Tissues

A comparison of teeth dimensions was the topic of studies conducted by scientists in order to assess the influence and the role of genetic and environmental factors in the process of the development of deciduous as well as permanent dentition [21, 22]. The traditional examination of the size and shape of teeth is based on measurements of chosen variables (for example – a measurement of mesiodistal, bucco-lingual or intercuspidal distance) and, on the basis of them, calculation of chosen indexes, which allows us to inspect the differences between populations or genders. Along with the

development of technology, new methods of shape and size analysis became possible. Currently, new systems of three-dimensional scanning are used, which makes registration of numerous teeth phenotypes possible, combined together with the significant progress in methods of data analysis [21, 22]. The research on twins revealed that the influence of genetic factors on morphological teeth features is significant; however, environmental factors may also play a role. Kabban et al. [21] were measuring mesio-distal and bucco-lingual teeth dimensions among 34 pairs of twins. Additionally, among 9 pairs of teeth, they carried out scans of the occlusal surface using a measuring device supplied with a contactless laser probe. The results revealed a higher concordance of both measured parameters between twin pairs than mixed pairs (one of one pair of twins and second from other pair). What is more, monozygotic twins reached a higher, statistically significant concordance in the case of mesio-distal dimension of permanent teeth than fraternal twins. Hughes et al. [22] conducted similar studies, on the basis of which they estimated the heritability of crown dimensions in deciduous dentition at 62–91%, which confirms the importance of the genetic component, as it is similarly noticeable in permanent dentition. However, the authors paid attention to the necessity of conducting further studies in order to state if basic mechanisms of heredity are the same in both types of dentition. In 2013, studies of another type involving twins were carried out by Ribeiro et al. [23], who focused on the influence of intrauterine male hormones on teeth dimensions. In their studies, 134 female children, monozygotic, dizygotic same-sex and dizygotic opposite-sex took part. Mesio-distal, intercuspidal dimensions and the height of crowns of all deciduous and permanent teeth were measured. The data analysis revealed that the measurements of teeth crowns among girls from dizygotic opposite-sex pregnancies are statistically higher, especially in the case of the height of the crown. Intrauterine male hormones influence teeth sizes and contribute to teeth dimorphism depending on the gender. Apps et al. [24] became interested in the influence of birth weight on both deciduous and permanent teeth dimensions among Australian twins. Two research groups were selected: the first group included children with a birth weight > 2500 g, and the second < 2500 g. The maximum mesio-distal size of the central incisor in deciduous and permanent dentition was measured. Little positive correlation was discovered between the birth weight and teeth size, larger in the case of girls than boys (size difference was about 2–3%). The research indicated that during the prenatal and postnatal

period, tooth buds are protected from factors that disrupt their development. Su et al. [25] examined the heredity influence on morphology of the occlusal surface of permanent molars of the mandible. In order to do this, they used a digital, three-dimensional scanner, which allowed them to analyze a picture of the occlusal surface of the teeth. The occlusal surface shape showed a larger diversity in the case of fraternal twins. It was estimated that genetic factors have a strong impact on the discussed issue.

The issue of morphological diversity of soft tissues among twins was taken up by researchers from Cleveland, Ohio [26]. They checked the potential influence of environmental factors on the differences in face symmetry among adult monozygotes. The pictures taken were measured and analyzed with the use of computer software. The research revealed that external factors, such as sleeping on the stomach, teeth extractions, the use of dentures or smoking may cause disorders in symmetry. Spielman et al. [27], on the basis of nine pairs of twins, tried to assess if it is possible to estimate the relationship between two people taking into consideration the appearance of their tongue. The appearance, shape and surface of the tongue may be influenced by environmental factors. Thirty independent people were asked to assign pictures of twins tongues (6 pairs were identical and 3 – fraternal twins). In case of monozygotic twins, correct matches reached 60%, whereas dizygotic – 31%. Both percentages were higher than expected by the authors (the possibility of an accidental match of 18 illustrations gives 3060 options; it was expected that correct matches would reach 22%). It appears that the tongues of people related to each other are similar, especially in the case of identical twins.

Orthodontic Disorders

Orthodontic disorders at the developmental age concern a significant part of patients. It is believed that more than half of the population suffers from dental and occlusal disorders [28]. Śmiech-Słomkowska and Krzywańska-Karolewska [28] analyzed the occlusion features among children born from single and twin pregnancies. The research group consisted of 35 twin pairs who were 7 years old, and a control group – 200 children from single pregnancies. Among 70 examined twins, occlusal abnormalities appeared in 44 cases, and the most frequent were lateral cross-bite and open bite. Occlusal disorders appeared among twins more frequently than in children from single pregnancies. Condo et al. [29] checked the effectiveness of interceptive

treatment of class II, group 2, with an increased overbite with the use of two different removable braces for the twins during the adolescence period. The researchers were comparing skeletal, dental and dento-alveolar changes after applying "Twin block" braces according to Clark and "Occluso-guide" braces according to Bergensen. The experiment showed that the second method may be used independently, while the first method should still be treated as one of the stages of treatment, because further procedures connected with proper intercuspitation and optimization of the overbite and overjet must be undertaken.

Cleft lip and palate are one of the most common developmental disorders of viscerocranium. Etiopathogenesis of this disorder has not been fully explained. It is believed that both genetic and environmental factors between 4 and 12 week of embryonic and foetal life have an influence on the appearance of defects [30]. Kot and Kruk-Jeronim [30] investigated the frequency of cleft lip and/or cleft palate occurrence among identical and fraternal twins (21 pairs of twins). They revealed that children from a twin pregnancy are at a higher risk of cleft defect development than children from single pregnancies. What is more, monozygotic twins are more likely to develop cleft defects as well. The researchers stated that identical twins usually do not have the same type of cleft defect, and it sometimes concerns only one of the twins, which may be explained with isolated gene mutations, diverse gene expression or other intrauterine conditions. Tessler et al. [31] compared the differences in the viscerocranium development, in cases of twins discordant for one-sided cleft lip and cleft palate appearance. Zygosity impact on the shape and dimension of facial skeleton was checked with the use of a mathematical-geometric program of data analysis. Affected children were surgically treated. A morphometric analysis revealed that plastic surgery of cleft lip and cleft palate does not cause statistically significant differences in facial features among both mono- and dizygotes.

Erosions/Enamel Defects

Tooth erosion is a progressive and irreversible loss of mineralized tooth tissues caused by chemical factors without bacteria participation. Recently an increase in the number of patients suffering from erosions has been noticed both in the adult and pediatric population. The erosions lead to numerous clinical implications, such as oversensitivity, occlusal disorders, pulp exposure or deterioration of aesthetic look [32]. Taji et al. [33] examined deciduous teeth of twins and only children aged 2–4 years, in terms of erosion appearance,

taking into consideration the influence of the diet and the medical history. The occurrence of erosions in the case of monozygotic, dizygotic twins and single children was assessed respectively as 77, 74 and 75%. Erosions were more advanced among older children (difference is statistically significant). Significant differences between identical and fraternal twins were not revealed. On the basis of the study it was concluded that the genetic factor is not important in terms of the appearance of tooth erosion. Dooland et al. [34], while analyzing the appearance of parafunctions among twins, noticed the presence of tooth erosion in almost 91% (only teeth within maxilla were assessed), without stating the crucial difference between mono- and dizygotic twins.

Enamel defects, such as hypoplasia or opacities, may be acquired or inborn. They manifest themselves in the form of grooves, furrows, dimples, overall or partial lack of enamel, differently colored – from chalky to dark brown. Such changes may have a diverse level of intensity and appear in several forms on different surfaces of one tooth. The problem was taken up by researchers from Australia in 2000 and 2011. In their first work [35] the concordance between hypoplastic changes on labial surfaces of deciduous canines was checked. The concordance was slightly higher in the case of identical twins, which allowed them to suggest the existence of genetic predispositions to the occurrence of enamel hypoplasia; however, the environment has a key meaning for feature expression. In another research [36], 88 twins and 40 only children aged 2–4 years took part. Results allowed the researchers to formulate a conclusion about the common influence of genetic and environmental factors on the presence of enamel hypoplasia, with a larger participation of the environment in the occurrence of defects.

Bruxism, i.e. gnashing of teeth, is rated among parafunctions, which are nonphysiological actions usually performed unconsciously. Dooland et al. [34] examined the appearance of this habit among twins. Attrition of deciduous canines was measured and left and right sides of dental arch compared in terms of preferences of grinding side. Attrition of incisal edgewear was noticed in 100% of patients who took part in the research, whereas one-sided gnashing – 59%. Monozygotes were more frequently discordant for preferred side of the habit (33.8% of incompatible pairs in comparison with 16.8% among dizygotes).

Other Issues

Dental patients may display different types of habits. Some of them affect the health condi-

tions of the oral cavity beneficially, other may be destructive. Proper hygienic habits allow us to keep the oral cavity in a good condition. Biesbrock et al. [37] examined the results of controlled hygienic regime among 51 pairs of twins aged 12–21 years who were divided into 2 subgroups; in the first group patients brushed only their teeth and tongue, in the second group they additionally flossed interproximal spaces. After two weeks, gingival bleeding was examined – PBS index (Papillary bleeding score) and the presence of unpleasant smell from mouth – a level of volatile sulphur compounds (VSC) was checked. At the beginning, PBS and VSC values were similar. After 2 weeks of therapy, the PBS index showed a statistically significant difference between the two groups – in favor of the flossing group (less gingiva bleeding during clinical examination). Both groups manifested a significant reduction of VSC indicator, whereas the difference between the groups was not significant. The same group of twins was asked to take part in the next research, which was supposed to measure the influence of flossing on the composition of bacterial flora in interdental plaque [38]. Both groups were given the same hygienic recommendations as previously. 26 species of bacteria taken from 6 interproximal spaces of each patient were marked. After two weeks, the quantity of microorganisms connected with periodontal disease/caries (*T. denticola*, *P. gingivalis*, *T. forsythia*, *P. intermedia*, *A. actinomycetemcomitans*, *S. mutans*) was higher in the group of patients who were not flossing their teeth, whereas the number of bacteria which are not connected with diseases mentioned above was similar in both groups.

Teeth injuries often appear among pediatric patients. Wasmer et al. [39] were wondering if there exist genetic predispositions to injuries. For this purpose, they conducted a study involving twins, in which they assessed the relationship between the occurrence of teeth and face injuries. Medical histories gathered information connected with the frequency of injuries and their circumstances as well as clinical tests of front teeth were carried out. 34.6% of children who took part in the research had experienced teeth injury at least once, whereas 51% experienced face injury. The compatibility among pairs between monozygotes and dizygotes reached respectively 66.7% and 58.1% (teeth injuries) and 52.4% and 58.1% (face injuries). The difference was not statistically significant. On the basis of the research results, it is not possible to draw conclusions about genetic predispositions to injuries.

In recent years, aesthetic dentistry is gaining more and more importance, because of the growing concern of patients in relation to the shape and

color of dentition. Corby et al. [40] checked the impact of heritability on the susceptibility to teeth whitening. For this purpose, two study groups were given whitening stripes with 10% hydrogen peroxide or placebo to use twice a day for 30 min, for 7 days. The effectiveness was assessed on the basis of the juxtaposition of dentition images taken during 1 and 8 day of the test. Three parameters of change of teeth color was compared via the computer (red/green; yellow/blue; dark/fair) on the basis of color standards calibrated and averaged due to the first images. Teeth susceptibility to whitening turned out to be hereditary in the case of the first two parameters, in terms of the third, bigger impact of environmental factors was estimated.

Summary

Monozygotic twins share 100% of genetic material, while dizygotic twins usually share about 50% of genes originated from parents [6]. If a significantly larger level of compatibility is reached in the case of identical twins, heredity of the given feature may be concluded. In the opposite situation, higher compatibility among the second group suggests stronger influence of environmental factors. The research results allow us to partially understand the mechanism of inheriting or acquiring certain features or diseases, which in the future may contribute to the anticipation, prevention and even later to formulate proper way of treatment. In dentistry, research of this type primarily concerned caries [6–8, 12, 14], periodontal diseases [9, 15], teeth morphology [21–24]. Less often, conducted studies were related to emergence timing, hard tissues or orthodontic issues. The main group of researchers dealing with the issue of twins in dentistry is the Craniofacial Biology Research Group from the University in Adelaide (the South Australia). The research of the teeth and face of Australian twins has been conducted for nearly 30 years, using three main cohorts recruited during this period, whereby observations included patients from 2 years old to adulthood. Conducted studies were cross-cutting, long-termed and allowed us to have a closer look at dental development among twins during different life periods (from infantile toothlessness, through deciduous dentition to permanent teeth). In some studies, people from the closest surrounding of twins were used – their parents or siblings, born from single pregnancies. Comparison of identical and fraternal twins let researchers to observe, how genetic and environmental factors influence diverse aspects of development or health of oral cavity [4].

A common feature of these studies concerning twins is the necessity of determining zygosity in order to make the comparison. In cited papers, there were different methods of its determining, including the history collected from parents, medical history or physical similarity. However, determining zygosity on the basis of genetic research seems to be the most precise method. For that purpose, the compatibility of several loci (6–10) on several chromosomes, characterized by particular changeability, was confirmed, with the use of DNA acquired from buccal swabs or blood samples [8, 27, 34, 40]. A very interesting observation noted during the studies involving twins was “mirror imaging” effect presented among monozygotes [4, 21]. This is a phenomenon, which may occur among even 25% of twins of this type [4]. Certain features that occur in certain pair of

opposite sides of a body, one of the twins seems to be the mirror image of the second. This phenomenon usually concerns tissues derived from the ectoderm, and less frequently from other tissues, for example one of the twins may be right-handed while the second left-handed. Fingerprints may also reveal the mirror imaging. The presence of this phenomenon was also observed during the research concerning the oral cavity in two papers included in the review. Kabban et al. [21] carried out the studies over teeth dimensions and morphology. Among 12 out of 34 pairs of twins the mirror imaging effect was observed. Dooland et al. [34], while analyzing preferences concerning the sides of teeth gnashing noticed a higher level of occurrence of this parafunction on opposite sides in the case of monozygotes rather than dizygotes, which may indicate the existence of phenomenon.

References

- [1] SZUKALSKI P.: Multiple births. Demografia i gerontologia społeczna – biuletyn informacyjny 2014, 10, 1–4 [in Polish].
- [2] LESZCZYŃSKA-GORZELAK B., OLESZCZUK J., KICZYŃSKA A., SAWULICKA-OLESZCZUK H., KEITH L.G.: Peculiarities of multiple pregnancy: Epidemiology. Gin. Pol. 2000, 71, 1327–1333 [in Polish].
- [3] KAMIŃSKI K., LESZCZYŃSKA-GORZELAK B., OLESZCZUK J.: The influence of infertility treatment and assisted reproduction techniques on multiple pregnancy rates. Gin. Pol. 2000, 71, 1352–1354 [in Polish].
- [4] HUGHES T.E., TOWNSEND G.C., PINKERTON S.K., BOCKMANN M.R., SEOW W.K., BROOK A.H., RICHARDS L.C., MIHAILIDIS S., RANJITKAR S., LEKKAS D.: The teeth and faces of twins: Providing insights into dentofacial development and oral health for practising oral health professionals. Aust. Dent J. 2014, 59, Suppl. 1, 101–116.
- [5] CARROLL S.G.: Is zygosity or chorionicity the main determinant of fetal outcome in twin pregnancies? Am. J. Obstet. Gynecol. 2005, 193, 757–761.
- [6] KURUSHIMA Y., IKEBE K., MATSUDA K., ENOKI K., OGATA S., YAMASHITA M., MURAKAMI S., HAYAKAWA K., MAEDA Y.: Influence of genetic and environmental factors on oral diseases and function in aged twins. J. Oral Rehabil. 2015, 42, 49–56.
- [7] LOVELINA F.D., SHASTRI S.M., KUMAR P.D.: Assessment of the oral health status of monozygotic and dizygotic twins – a comparative study. Oral Health Prev. Dent. 2012, 10, 135–139.
- [8] BRETZ W.A., CORBY P.M., HART T.C., COSTA S., COELHO M.Q., WEYANT R.J., ROBINSON M., SCHORK N.J.: Dental caries and microbial acid production in twins. Caries Res. 2005, 39, 168–172.
- [9] KINANE D.F., HART T.C.: Genes and gene polymorphisms associated with periodontal disease. Crit. Rev. Oral Biol. Med. 2003, 14, 430–449.
- [10] OOI G., TOWNSEND G., SEOW W.K.: Bacterial colonization, enamel defects and dental caries in 4–6-year-old mono- and dizygotic twins. Int. J. Paediatr. Dent. 2014, 24, 152–160.
- [11] BOCKMANN M.R., HARRIS A.V., BENNETT C.N., ODEH R., HUGHES T.E., TOWNSEND G.C.: Timing of colonization of caries-producing bacteria: An approach based on studying monozygotic twin pairs. Int. J. Dent. 2011 doi:10.1155/2011/571573.
- [12] CORBY P.M., BRETZ W.A., HART T.C., FILHO M.M., OLIVEIRA B., VANYUKOV M.: *Mutans streptococci* in preschool twins. Arch. Oral Biol. 2005, 50, 347–351.
- [13] CORBY P.M., BRETZ W.A., HART T.C., SCHORK N.J., WESSEL J., LYONS-WEISLER J., PASTER B.J.: Heritability of oral microbial species in caries-active and caries-free twins. Twin Res. Hum. Genet. 2007, 10, 821–828.
- [14] OPYDO-SZYMACEK J., PUACZ P., SPYCHAŁA A.: Dental caries in twins – own observations. Dent. Med. Probl. 2007, 44, 335–342 [in Polish].
- [15] MICHALOWICZ B.S., DIEHL S.R., GUNSOLLEY J.C., SPARKS B.S., BROOKS C.N., KOERTGE T.E., CALIFANO J.V., BURMEISTER J.A., SCHENKEIN H.A.: Evidence of a substantial genetic basis for risk of adult periodontitis. J. Periodontol. 2000, 71, 1699–1707.
- [16] KURUSHIMA Y., IKEBE K., MATSUDA K., ENOKI K., OGATA S., YAMASHITA M., MURAKAMI S., MAEDA Y.: Examinations of the relationship between oral health and arterial sclerosis without genetic confounding through the study of older Japanese twins. Plos One, 2015, 10, e0127642.
- [17] BOCKMANN M.R., HUGHES T.E., TOWNSEND G.C.: Genetic modeling of primary tooth emergence: A study of Australian twins. Twin Res. Hum. Genet. 2010, 13, 573–581.
- [18] MIHAILIDIS S., WOODROFFE S.N., HUGHES T.E., BOCKMANN M.R., TOWNSEND G.C.: Patterns of asymmetry in primary tooth emergence of Australian twins. Front Oral Biol. 2009, 13, 110–115.

- [19] SHARMA K.: Genetic determinants and dynamics of permanent teeth emergence in Northwest Indian twins: A chronogenetic study. *Homo*, 2014, 65, 450–463.
- [20] KRZYWAŃSKA-KAROLEWSKA M., ŚMIECH-SŁOMKOWSKA G.: Influence of the delivery term on the time of permanent teeth eruption in twins. *Czas. Stomatol.* 2009, 62, 293–297 [in Polish].
- [21] KABBAN M., FEARNE J., JOVANOVSKI V., ZOU L.: Tooth size and morphology in twins. *Int. J. Paediatr. Dent.* 2001, 11, 333–339.
- [22] HUGHES T., DEMPSEY P., RICHARDS L., TOWNSEND G.: Genetic analysis of deciduous tooth size in Australian twins. *Arch. Oral Biol.* 2000, 45, 997–1004.
- [23] RIBEIRO D.C., BROOK A.H., HUGHES T.E., SAMPSON W.J., TOWNSEND G.C.: Intrauterine hormone effects on tooth dimensions. *J. Dent. Res.* 2013, 92, 425–431.
- [24] APPS M.V., HUGHES T.E., TOWNSEND G.C.: The effect of birthweight on tooth-size variability in twins. *Twin Res.* 2004, 7, 415–420.
- [25] SU C.Y., CORBY P.M., ELLIOT M.A., STUDEN-PAVLOVICH D.A., RANALLI D.N., ROSA B., WESSEL J., SCHORK N.J., HART T.C., BRETZ W.A.: Inheritance of occlusal topography: a twin study. *Eur. Arch. Paediatr. Dent.* 2008, 9, 19–24.
- [26] LIU M.T., IGLESIAS R.A., SEKHON S.S., LI Y., LARSON K., TOTONCHI A., GUYURON B.: Factors contributing to facial asymmetry in identical twins. *Plast. Reconstr. Surg.* 2014, 134, 638–646.
- [27] SPIELMAN A.I., BRAND J.G., BUISCHI Y., BRETZ W.A.: Resemblance of tongue anatomy in twins. *Twin Res. Hum. Genet.* 2011, 14, 277–282.
- [28] ŚMIECH-SŁOMKOWSKA G., KRZYWAŃSKA-KAROLEWSKA M.: Type of malocclusion and dynamics of tooth eruption in twins and children from unifoetal pregnancies. *Czas. Stomatol.* 2006, 59, 876–881 [in Polish].
- [29] CONDO R., PERUGIA C., BARTOLINO M., DOCIMO R.: Analysis of clinical efficacy of interceptive treatment of class II division 2 malocclusion in a pair of twins through the use of two modified removable appliances. *Oral Implantol.* 2010, 3, 11–25.
- [30] KOT M., KRUK-JEROMIN J.: The occurrence of the cleft lip and/or palate in cleft-twins. *Pol. Merk. Lek.* 2005, 19, 614–616 [in Polish].
- [31] TESSLER A.Y., FRANCHI L., MCNAMARA J.A., BACCETTI T.: Morphometric analysis of craniofacial features in mono- and dizygotic twins discordant for unilateral cleft lip and palate. *Angle Orthod.* 2011, 81, 878–883.
- [32] LINNETT V., SEOW W.K.: Dental erosion in children: A literature review. *Pediatr. Dent.* 2001, 23, 37–43.
- [33] TAJI S.S., SEOW W.K., TOWNSEND G.C., HOLCOMBE T.: A controlled study of dental erosion in 2- to 4-year-old twins. *Int. J. Paediatr. Dent.* 2010, 20, 400–409.
- [34] DOOLAND K.V., TOWNSEND G.C., KAIDONIS J.A.: Prevalence and side preference for tooth grinding in twins. *Aust. Dent. J.* 2006, 51, 219–224.
- [35] TAJI S.S., HUGHES T., ROGERS J., TOWNSEND G.: Localised enamel hypoplasia of human deciduous canines: Genotype or environment? *Aust. Dent. J.* 2000, 45, 83–90.
- [36] TAJI S.S., SEOW W.K., TOWNSEND G.C., HOLCOMBE T.: Enamel hypoplasia in the primary dentition of monozygotic and dizygotic twins compared with singleton controls. *Int. J. Paediatr. Dent.* 2011, 21, 175–184.
- [37] BIESBROCK A., CORBY P.M., BARTIZEK R., CORBY A.L., COELHO M., COSTA S., BRETZ W.A.: Assessment of treatment response to dental flossing in twins. *J. Periodontol.* 2006, 77, 1386–1391.
- [38] CORBY P.M., BIESBROCK A., BARTIZEK R., CORBY A.L., MONTEVERDE R., CESCHIN R., BRETZ W.A.: Treatment outcomes of dental flossing in twins: Molecular analysis of the interproximal flora. *J. Periodontol.* 2008, 79, 1426–1433.
- [39] WASMER C., POHL Y., FILIPPI A.: Traumatic dental injuries in twins: is there a genetic risk for dental injuries. *Dent. Traumatol.* 2008, 24, 619–624.
- [40] CORBY P.M., BIESBROCK A., GERLACH R., CORBY A.L., MOREIRA A., SCHORK N.J., BRETZ W.A.: Treatment responses to tooth whitening in twins. *Twin Res. Hum. Genet.* 2014, 17, 23–26.

Address for correspondence:

Anna Turska-Szybka
Department of Paediatric Dentistry
Medical University of Warsaw
Miodowa 18
00-246 Warsaw
Poland
E-mail: pedodoncja@wum.edu.pl
Tel: 22 502 20 31

Conflict of Interest: None declared

Received: 14.02.2016

Revised: 19.06.2016

Accepted: 5.07.2016