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*Dentition asymmetry in series of skulls
from St. Mary Magdalene church in Wrocław*

**Asymetria uzębienia w serii czaszek z kościoła św. Marii Magdaleny
we Wrocławiu**

Key words: dentition asymmetry, skulls

Słowa kluczowe: asymetria uzębienia, czaszki

Human body is characterized by a model of bilateral symmetry, however, already in the early development deviations in the internal and external structure, as well as other functions of the organism appear- therefore, we are dealing with its asymmetry. One can distinguish: 1. Functional asymmetry - the dominant activity of one of the body sides; 2. Dynamic asymmetry - is a consequence of functional asymmetry; 3. Sensory asymmetry - concerns the differences in the sensitivity of sense organs; 4. Morphological asymmetry - concerns the differences of body shapes structure and internal organs [8]. In case of morphological asymmetry, one can distinguish its varieties: 1. Directional asymmetry - strongly marked on one of the body sides.; 2. Antisymmetry -asymmetry connected with unpredictable body side; 3. Fluctuating asymmetry - characterizes in random deviations from bilateral symmetry without a definite

direction [17]. Fluctuating asymmetry manifests in instability of organism development. The environmental factors disrupt effectiveness of auto-regulating mechanisms in a range of organism development stability among which the so called physiological stress dominates [7]. The bigger environmental stress, the greater effect of fluctuating asymmetry. Therefore, fluctuating asymmetry is a good stability measure for the organism development and an indicator of physiological stress [5].

The purpose of this paper is to determine the kind and direction of teeth asymmetry in series of skulls from 16th to 18th century from St. Mary Magdalene church in Wrocław. The additional purpose of this paper is to establish a social status of the researched population.

MATERIAL AND METHODS

The researched material encompasses 130 pairs of teeth stemming from 22 skulls (10 male and 12 female) in juvenis and adultus age and early maturus period, established for 16th - 18th century. The material comes from crypts which are located in St. Mary Magdalene church in Wrocław.

The height, width, and depth of the crown, as well as the width of dental neck have been measured in accordance with anthropometric measuring technique [9].

The slant and kurtosis have been examined, the results showed that the data has skewed distribution. The analysis of such correlations was enabled by the Shapiro-Wilk test, which was used to establish whether the asymmetry is directional or fluctuating according to the formula: $W = (\sum_{i=1}^n w_i x_i)^2 / \sum_{i=1}^n (x_i - \bar{x})^2$ where w_i - weight for i - of that tooth (number of examined dimensionality of a tooth); x_i - asymmetry i - of that tooth (asymmetric average of the FA indexes of each dimensionality).

To establish the level of fluctuating asymmetry (FA) a formula was used to eliminate the differences in crown size, which was proposed by Palmer and Strobeck [11] according to a formula: $FA = \ln(P/L)$ where: \ln - natural logarithm; P - size of the tooth at the right side of alveolar arch and L - size of the tooth at the left side of alveolar arch.

In order to determine an average level of asymmetry of a given subject, firstly, an average level of asymmetry was calculated for each of its teeth by using the FA indicator which concerns every dimension of a given tooth. Then, the weighted average was calculated from asymmetries of each tooth of a given subject, using the number of measures on a given tooth as "weight", in accordance with the following formula: $\bar{x} = \sum_{i=1}^n w_i x_i / \sum_{i=1}^n w_i$; where w_i - weight for i - of that tooth (the number of examined measures of a tooth), x_i - asymmetry i - of that tooth (asymmetrical average of FA index of each dimension).

With the t-Student test, the dependence between gender and size of asymmetry has been examined, as well as the occurrence of a relation between the FA level and the occurrence of enamel hypoplasia. The statistical analysis was conducted with the Statistica 7 programme, using a relevance level $p=0,05$, and with Microsoft Office Excel 2007.

RESULTS

Characteristics of teeth measurement traits

The differences of arithmetical averages of right and left side of both alveolar arches were analysed. It was alleged that the biggest average differences in bilateral sizes appear in the measurement of the tooth height in first premolars of the jaw and third molars of the lower jaw; for the width measurement among second molars of the jaw and first premolars of the lower jaw; for the depth measurement of the crown of second premolars of the jaw and first premolars of the lower jaw; for the width measurement of dental neck among third molars of both jaw and lower jaw. The negatives of arithmetical average indicate bigger tooth sizes located at the left side of the alveolar arch, and the positives indicate bigger tooth sizes at the right side of the arches.

Asymmetry analysis

Based on arithmetical averages of the differences between bilateral teeth and the distribution analysis of these averages, it was possible to establish the direction of the asymmetries. The directional asymmetry was demonstrated by only three teeth of the lower jaw: canine in the dimension of crown width, first premolar and second molar in the dimension of crown depth. The remaining teeth demonstrated fluctuating asymmetry. Additionally, a measurement has been conducted to assess whether there is a link between the gender and the asymmetry direction and it was alleged that the result was statistically essential only in four cases. The percentile result of the teeth size advantage at one of the sides of alveolar arch indicated that there is an advantage of teeth size on the right side of an alveolar arch among women, and on the left side among men (the differences, however, are not statistically essential). The percentile asymmetry distribution made for each of the four dimensions demonstrated that the measurements of height and depth of the crown explicitly dominate on the left side, and it showed a significant instability for the measurements of dental neck width. Among the measurements of each pair of teeth, bigger sizes were exhibited on the left side - in 62,5% of the cases.

Asymmetry indicator

After normalizing the sizes of teeth crowns [11], the evaluation of asymmetry indicator was done. It was alleged that the teeth with the highest level of asymmetry are: in crown height dimension - second upper molar; in crown width dimension - second upper molars, in depth dimension - first lower premolars; in width dental neck dimension - second jaw molars. After calculating the level of asymmetry for each dimension of the analysed teeth, an average level of asymmetry for each tooth was calculated. This average was calculated from each measurement of a given tooth by using the arithmetical average. It was established that second jaw molars (0,081) and lower (0,075) and upper (0,073) third molars and maxillary central incisors (0,033) have the highest level of asymmetry. The research on the relationship of fluctuating asymmetry and gender showed that statistically essential it only concerns upper second premolar. The average level of fluctuating asymmetry based on weighted average for each subject, showed that it is diversified according to gender and age - higher level

of fluctuating asymmetry appears among men (0,056), whereas among women it is 0,043. An average level of fluctuating asymmetry for all subjects is 0,049.

Enamel hypoplasia and the level of fluctuating asymmetry

Within the researched population, the highest frequency of enamel hypoplasia appears among male subjects, and in the whole material it's 27%. The relation between a level of fluctuating asymmetry and the occurrence of enamel hypoplasia appeared to be statistically negligible. Groups of subjects with enamel hypoplasia and without it, were equal. However, the level of fluctuating asymmetry among subjects with enamel hypoplasia was slightly higher (0,049) than among those without hypoplasia (0,041). The obtained result may be a consequence of a low number of teeth and lack of incisors and canines among some of the subjects. Because hypoplasia was being established on incisors and canines, it is the most effective on those teeth, the lack of those teeth among some of the subjects may be essential to the evaluation.

DISCUSSION

The anthropological studies on historical populations, the evaluation of social status is possible thanks to the traits that bear witness to living conditions of specific groups or individuals. Such traits include: indicators of physiological stress being the organism's reaction to negative stimuli of the external environment (malnutrition, inadequate hygienic conditions, sick rate) [13]. The changes caused by the physiological stress occurring on the teeth, concern mainly the early developmental stage (children and youth), but are permanent and may be analysed among adult individuals [15]. The high level of fluctuating asymmetry informs about the intensification of factors interfering the development and competences of mechanisms buffering those factors. Moreover, facial elements, whose development lasts longer, are for most of the time exposed to factors interfering with the development [10].

The advantage of the teeth size at the left side of the alveolar arch (62,5%) is complying with face measurement observations [6].

Statistically insignificant dimorphic differences in terms of asymmetry direction, allowed the analysis of the material for both genders combined.

According to Farkas [4] directional asymmetry is more often manifested within even head structures in relation to a given axis than to measurements. Skvarilova [16] claims that in case of even structures of a face, fluctuating asymmetry occurs. Whereas, directional asymmetry appeared only in a few cases (mainly in molars), similarly to Barret's research [2]. The remaining traits demonstrated fluctuating asymmetry.

Considering the differences in teeth crown sizes among particular subjects, a formula has been used to establish the level of fluctuating asymmetry which eliminates these differences. Additionally, thanks to this, the difference in the size of male and female skulls does not affect the results of asymmetry multiplicity analysis. Apart from one example, no statistically essential dimorphic differences were proven in the level of fluctuating asymmetry. However, with male subjects, in relation to their higher ecosensitivity, a higher level of fluctuating asymmetry may be observed [1].

Traits, which differ in spite of the consequences of the environmental “murmur” during ontogenesis, begin to form at a certain level of symmetry and structural stability. Each structure goes through a critical period during embryogenesis, when a possibility of interference and the appearance of a pathology of that process is higher. Additionally the level of asymmetry may be affected by the length of a process of forming these traits. The longer this period is, the longer given structures are exposed to factors disrupting the development [10]. In the examined series from St. Mary Magdalene church, the highest level of fluctuating asymmetry was demonstrated in second upper molars and third lower molars. Over-average level of fluctuating asymmetry was also shown in upper lateral incisors. Second and third molars are the teeth whose relations take the longest time to form. The period of their formation (6th month - 4th year of life) falls on the phase of weaning, and on the phase when many childhood diseases appear. Therefore, a possible cause of the biggest asymmetry of these teeth to form is the so called “weaning stress” and childhood diseases. It does not explain why lateral incisors are more vulnerable to developmental disruptions than central incisors. In case of canines, it may be caused by the long process of crown development. It turned out that the most asymmetric teeth are first upper and lower molars and maxillary central incisors. The stability of crown formation has the biggest effect on fluctuating asymmetry expression. This mechanism is probably well protected thanks to the buffer from the mother's side [14].

Hypoplasia is a lessening in a regular thickness of enamel, which arises from eating disorder or diseases [12]. In the material from St. Mary Magdalene church, enamel hypoplasia appeared slightly more often with men. Similar observations were noted by Barrett [2]. It may result from the fact that boys, being the ecosensitive gender, rarely had to grow up facing excessive stress. No essential relation between enamel hypoplasia and a level of fluctuating asymmetry has been noted, in spite of a slightly higher level of this asymmetry in case of enamel hypoplasia occurrence. It is essential that hypoplasia was being observed on teeth which are most vulnerable to hypoplasia. The analysis of correlation between enamel hypoplasia caused by stress and fluctuating asymmetry gave a negative dependence for the third molar in case of Barrett's studies [2] and for canines in case of Coorucini's studies [3]. These researchers agreed that there is no relation between these two traits.

In the analysed material, symptoms of physiological stress were more visible among men. It is rather atypical within average medieval populations, because women were more prone to the loss of such elements as iron or calcium. On such basis, one may assume that the symptoms of physiological stress were not resulting from food shortage or bad living conditions. Moreover, the lack of correlation between the level of fluctuating asymmetry and the occurrence of hypoplasia may be evident to rather good conditions within the analysed population. Therefore, more visible symptoms of physiological stress with men may have been a result of them being more ecosensitive. The place of burial indicates a rather high social status of the analysed population (city centre in goldsmiths' district), paradoxically a high percentage of persons with dental caries (83%) is close to Wrocław patricians buried by the St Elizabeth's church (92%)

and a small percentage of people with cribra orbitalia (14%). Whereas average, relative to other Wroclaw series, percentage of people with enamel hypoplasia (27%) does not contradict the following conclusions.

CONCLUSIONS

1. No relation between gender and level of fluctuating asymmetry has been stated.
2. Directional asymmetry has been observed in dimensions of three lower jaw teeth: canine width, first premolar and second molar depth.
3. With women, bigger teeth sizes appeared at the right side of alveolar arch.
4. Bigger tooth sizes have been proven at the left side of alveolar arch - with the crown height (81%) and with the depth dimension in 75% of the cases. The crown and dental neck width dimension has proven a high variability in relation to the direction of the asymmetry.
5. Among all of the measured teeth pairs, bigger sizes at the left side of alveolar arch have been observed in 62,5% of the cases.
6. The highest average level of fluctuating asymmetry for a given tooth has been observed in second upper molar and in third molars. The lowest level of that asymmetry occurred in first molars and maxillary central incisor.
7. With men, a higher average level of fluctuating asymmetry (0,056) has been observed than with women (0,046). An average level of fluctuating asymmetry is 0,049.
8. An average level of fluctuating asymmetry with people with enamel hypoplasia (0,049) is negligibly higher than with people without hypoplasia (0,041).

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ABSTRACT

The evaluation of fluctuating asymmetry of denture is essential in examining the influence of physiological stress on the state of historical populations. The aim of this paper is to establish the kind and direction of teeth asymmetry in the series of skulls from archaeological excavations. The research was conducted on 130 pairs of teeth stemming from 22 skulls (10 male and 12 female) in juvenis and adultus age and early maturus period, estimated for 16th - 18th century. The material comes from crypts located in St. Mary Magdalene church in Wrocław. It has been stated that 1. There is no relation between gender and the level of fluctuating asymmetry. 2. Directional asymmetry has been observed in dimensions of three teeth of the lower jaw: canine

width, first premolar and second molar depth. 3. With women, bigger teeth sizes appeared at the right side of alveolar arch. 4. Bigger tooth sizes have been proven at the left side of alveolar arch – at the crown height (81%) and at the depth dimension in 75% of the cases. The crown and dental neck width dimension have proven a high variability in relation to the direction of the asymmetry. 5. Among all of the measured teeth pairs, bigger sizes at the left side of alveolar arch have been observed in 62,5% of the cases. 6. The highest average level of fluctuating asymmetry for a given tooth has been observed in second upper molar and in third molars. The lowest level of that asymmetry occurred in first molars and maxillary central incisor. 7. With men, a higher average level of asymmetry (0,056) has been observed than with women (0,046). An average level of fluctuating asymmetry is 0,049. 8. An average level of fluctuating asymmetry with people with enamel hypoplasia (0,049) is negligibly higher than with people without hypoplasia (0,041).

STRESZCZENIE

Ocena asymetrii fluktuacyjnej uzębienia ma istotne znaczenie w badaniu wpływu stresu fizjologicznego na stan historycznych populacji. Celem pracy jest określenie rodzaju i kierunku asymetrii zębów w serii czaszek z wykopalisk archeologicznych. Badania przeprowadzono na stanowi 130 par zębów pochodzących z 22 czaszek (10 męskich i 12 żeńskich) w wieku juvenis, adultus i wczesnego okresu maturus, oszacowanych na XVI-XVIII wiek. Materiał pochodzi z krypt znajdujących się w kościele św. Marii Magdaleny we Wrocławiu. Stwierdzono że, 1. Brak związku pomiędzy płcią a poziomem asymetrii fluktuacyjnej. 2. Asymetria kierunkowa została zaobserwowana w wymiarach trzech zębów żuchwy: szerokości kła, głębokości pierwszego przedtrzonowca i drugiego trzonowca. 3. U kobiet większe wymiary zębów występowały po prawej stronie łuku zębodołowego. 4. Wykazano większe rozmiary zębów po lewej stronie łuku zębodołowego - w wysokości korony (81%) a w wymiarze głębokości w 75% przypadków. Wymiar szerokości korony i szerokości szyjki zęba wykazał dużą zmienność w stosunku do kierunku asymetrii. 5. Spośród wszystkich mierzonych par zębów większe rozmiary po lewej stronie łuku zębodołowego wykazano w 62,5% przypadków. 6. Najwyższy średni poziom asymetrii fluktuacyjnej dla danego zęba zaobserwowano w drugim górnym trzonowcu oraz w trzecich trzonowcach. Najmniejszy poziom tej asymetrii wystąpił w pierwszych trzonowcach i górnym przyśrodkowym siekaczu. 7. U mężczyzn zaobserwowano wyższy średni poziom asymetrii (0,056) niż u kobiet (0,046). Średni poziom asymetrii fluktuacyjnej wynosi 0,049. 8. Średni poziom asymetrii fluktuacyjnej u osób z hipoplazją szkliwa (0,049) jest istotnie wyższy niż u osobników bez tej hipoplazji (0,041).

Artykuł zawiera 22336 znaków ze spacjami