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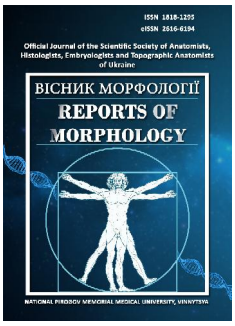

Regression models of the area of the soft palate and tongue in young men and young women with an orthognathic bite without and taking into account the type of face depending on teleroentgenometric indicators of the upper respiratory tract

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The prevalence of pathologies related to the soft palate and its surrounding structures is a serious challenge for medicine. Sleep apnea and other diseases directly related to this anatomical region pose a threat not only due to the actual cause of deaths, but also complications of concomitant diseases. In this regard, the definition of normative indicators of the upper respiratory tract, in particular the soft palate and its surrounding structures, is a relevant topic for study. The purpose of the work is to build and analyze the regression models of the area of the soft palate and tongue in young men and young women with an orthognathic bite without and taking into account the type of face, depending on the features of teleroentgenometric indicators of the upper respiratory tract. With the help of the licensed medical software OnyxCeph³™, version 3DPro and the diagnostic program "UniqCeph", a cephalometric analysis of lateral teleroentgenograms of 49 young men and 76 young women with an orthognathic bite and the absence of upper respiratory tract pathology was performed (primary teleroentgenograms were obtained from the database of the Research Center and Department of Pediatric Dentistry, National Pirogov Memorial Medical University, Vinnytsia). Face types in young men and young women were determined using the Garson index. Regression models of the area of the soft palate and tongue depending on teleroentgenometric indicators of the upper respiratory tract were built using the license package "Statistica 6.0". In Ukrainian young women with an orthognathic bite, regardless of face type, with very wide and wide face types, all possible models of the area of the soft palate and tongue were built depending on teleroentgenometric indicators of the upper respiratory tract with a coefficient of determination (R^2) greater than 0.5 (R^2= from 0.682 to 0.937, p<0.001), which most often include the thickness of the soft palate and the length of the soft palate (42.9 % each), tongue height and tongue length (30.0% each), the value of the position of the hyoid bone relative to the vertical mandibular plane and the angle of inclination of the soft palate (20.0 % each). In Ukrainian young men with an orthognathic bite without taking into account the type of face and with a wide face type, all possible models of the area of the soft palate and tongue were also built depending on teleroentgenometric indicators of the upper respiratory tract with a coefficient of determination greater than 0.5 (R^2= from 0.562 to 0.925, p<0.001), which most often include the thickness of the soft palate and the length of the soft palate (33.3 % each).

Keywords: *teleradiography, cephalometry, soft palate, tongue, regression models, Ukrainian young men and young women, orthognathic bite, facial types.*

Introduction

Respiratory tracts are generally divided into upper and lower parts, which is due to differences in their functions in the respiratory system as a whole. The upper respiratory tract is responsible for performing various functions, such

as filtering, warming the air, moistening it and, of course, conducting it into the lower respiratory tract.

An important and relevant direction in modern medical anthropology is the study of the dimensions of the upper respiratory tract, because as research results have shown, they are directly related to the risk of occurrence and severity of certain diseases.

One of these diseases is bronchial asthma, which is becoming more and more common among young people. Clinical symptoms of asthma, according to the observations of doctors, have increased among this age group in all corners of the world [1]. Indeed, when examining individuals with bronchial asthma, compared to healthy individuals, they have significantly lower indicators of the total volume of the upper respiratory tract (p=0.01) and the area of the narrowest part of the oropharynx (p=0.007) [2].

Another disease that also has a significant prevalence, but is related to the size of the respiratory tract, is obstructive sleep apnea. In addition, it is necessary to take into account the complications of this disease and the possibility of death. The literature describes the observation of one doctor who described 12 fatal cases that occurred as a result of this pathology in post-operative patients [3]. In persons with obstructive sleep apnea, such accompanying pathologies from the cardiovascular system are observed, such as: hypertension (30-83 %), coronary heart disease (30-58 %), myocardial infarction (43-91 %), atrial fibrillation (25-80 %) [7] and the activation of oxidative stress processes affecting such target organs as the brain and heart [15] is noted.

An interesting fact is that between both diseases (obstructive sleep apnea and bronchial asthma), strong reliable connections were found regarding the severity of the course, [22] which indicates in favor of the existence of a common mechanism in the pathogenesis, one of which is a violation in the size of the respiratory tract. Thus, when performing the advancement of the upper jaw, an increase in the size of the respiratory tract by an average of 2.5 times was noted. In patients before treatment, the apnea/hypopnea index was 46, after treatment - 4 [21]. In general, a review of literary sources indicates that the performance of orthodontic interventions often changes the size of the respiratory tract - it can be both an increase and, conversely, a decrease [11].

Age is a key factor causing changes in most airway parameters. An analysis of the results of computed tomography of 192 children of various ages revealed that the value of 21 parameters of the respiratory tract changes with age. The biggest changes occur in the first 3 years of life. An equally important factor affecting the parameters of the respiratory tract is body weight [16].

One of the questions that still worries researchers is the determination of the influence of craniofacial indicators on the parameters of the respiratory tract. At present, the results of research carried out in this direction are contradictory and do not provide an opportunity to unequivocally assert the existence of such a connection [12]. Also, the study of the influence and relationship of parameters of the soft palate and tongue with indicators of the respiratory tract is practically unexplored.

The purpose of the work is to build and analyze the regression models of the area of the soft palate and tongue in Ukrainian young men and young women with an orthognathic bite without and taking into account the type of face, depending on the features of teleroentgenometric indicators of the upper respiratory tract.

Materials and methods

Primary lateral radiographs of Ukrainian young men (YM) (n=49, age - from 17 to 21 years) and Ukrainian young women (YW) (n=76, age - from 16 to 20 years) with an orthognathic bite and the absence of upper respiratory pathology ways are taken from the database of the Research Center and Department of Pediatric Dentistry National Pirogov Memorial Medical University, Vinnytsya. After applying for dental care, all young men and young women underwent a teleradiographic examination (effective radiation dose up to 0.001 mSv) at the private dental clinic "Vinintermed" using a Veraviewepocs 3D Morita (Japan) dental cone-beam tomograph.

Committee on Bioethics of National Pirogov Memorial Medical University, Vinnytsya (protocol № 8 from 30.09.2021) found that the studies do not contradict the basic bioethical standards of the Declaration of Helsinki, the Council of Europe Convention on Human Rights and Biomedicine (1977), the relevant WHO regulations and laws of Ukraine.

Face types were determined using Garson's

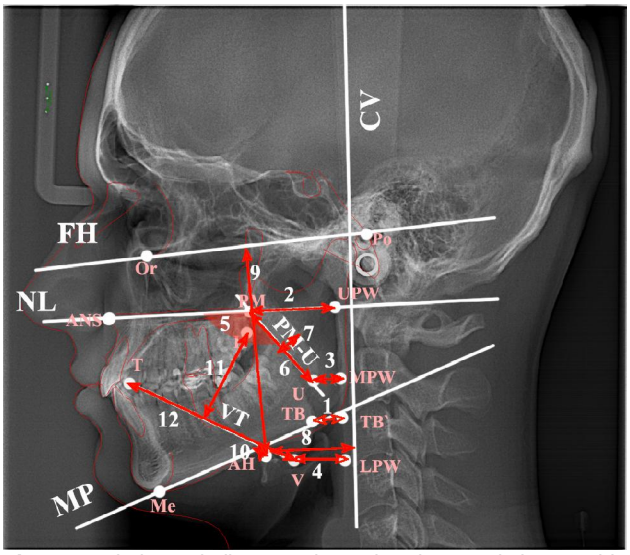

Fig. 1. Cephalometric linear and angular characteristics used in cephalometric examination of the upper respiratory tract. 1 - distance PASmin, 2 - distance PM-UPW, 3 - distance U-MPW, 4 - distance V-LPW, 5 - angle NL/PM-U, 6 - distance PM-U, 7 - distance SPT, 8 - distance AH-CV, 9 - distance AH-FH, 10 - distance AH-MP, 11 - distance H-VT, 12 - distance VT.

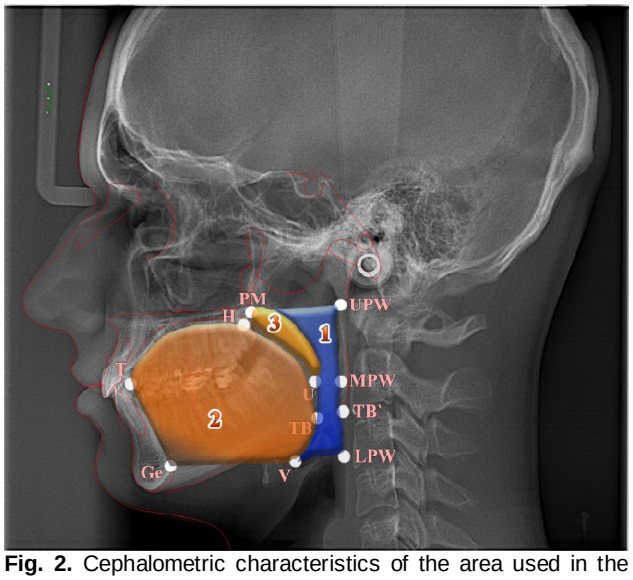

Fig. 2. Cephalometric characteristics of the area used in the cephalometric study of the upper respiratory tract. 1 - area UAA (upper respiratory tract area), 2 - area TA (tongue area), 3 - area SPA (soft palate area).

morphological index [18]. The following distribution was established: in YM - 5 with a very wide face, 22 with a wide face, 11 with an average face and 8 with a narrow face; in YW, 25 with very wide face, 25 with wide face, 10 with average face and 12 with narrow face.

Cephalometric analysis of the soft palate, tongue and upper respiratory tract itself (Fig. 1, 2) was performed using licensed medical software OnyxCeph$^{3™}$, version 3DPro (company Image Instruments GmbH, Germany) and diagnostic program "UniqCeph" (created in National Pirogov Memorial Medical University, Vinnytsya).

Regression models of the area of the soft palate and tongue depending on teleroentgenometric indicators of the upper respiratory tract were built using the license package "Statistica 6.0".

Results

Taking into account the distribution of YM and YW by face types, modeling of soft palate and tongue teleradiographic indicators of the area was carried out in YM without taking into account the face type and with a wide face type, as well as in YW without taking into account the face type and with very wide and wide face types.

Regression models of the area of the soft palate and tongue constructed in Ukrainian young men and young women with an orthognathic bite have the form of the following linear equations:

- *soft palate area (YM regardless of face type)* = -114.6 + 19.95 x SPT + 4.655 x PM-U + 1.648 x V-LPW - 0.019 x TA (R^2=0.888, F(4.44)=87.35, p<0.001),

- *soft palate area (YM with a wide face type)* = -130.5 + 20.47 x SPT + 4.337 x PM-U (R^2=0.925, F(2.19)=116.4, p<0.001),

- *tongue area (YM regardless of face type)* = 278.3 + 18.70 x VT + 44.40 x V-LPW + 16.44 x H-VT - 35.15 x PASmin (R^2=0.562, F(4.44)=14.09, p<0.001),

- *tongue area (YM with a wide face type)* = 8.952 + 23.12 x AH-FH + 19.87 x PM-UPW - 12.55 x AH-CV + 15.91 x PM-U (R^2=0.723, F(4.17)=11.10, p<0.001),

- *soft palate area (YW regardless of face type)* = -121.2 + 19.48 x SPT + 4.146 x PM-U (R^2=0.775, F(2.73)=125.7, p<0.001),

- *soft palate area (YW with a very wide face type)* = -117.1 + 20.56 x SPT + 3.739 x PM-U (R^2=0.937, F(2,22)=163.2, p<0.001),

- *soft palate area (YW with a wide face type)* = -215.5 + 19.51 x SPT + 3.440 x PM-U + 0.052 x TA (R^2=0.682, F(3.21)=15.04, p<0.001),

- *tongue area (YW regardless of face type)* = -1335 + 60.91 x H-VT + 30.03 x VT - 10.30 x AH-MP - 4.920 x NL/PM-U (R^2=0.824, F(4.71)=83.10, p<0.001),

- *tongue area (YW with a very wide face type)* = -1014 + 28.94 x VT + 55.12 x H-VT - 8.250 x NL/PM-U (R^2=0.907, F(3.21)=68.53, p<0.001),

- *tongue area (YW with a wide face type)* = -1788 + 55.57 x H-VT + 36.19 x VT - 18.54 x AH-MP (R^2=0.729, F(3.21)=18.85, p<0.001),

where, the area of the soft palate and tongue - in mm^2; SPT - known as Maximum soft palate thickness (mm); PM-U - known as Soft palate length (mm); V-LPW - known as Hypopharyngeal airway space (mm); TA - known as Tongue area (mm^2); VT - known as Length of the tongue (mm); H-VT - known as Height of the tongue (mm); PASmin - known as Retroglossal oropharyngeal airway space (mm); AH-FH - known as Vertical position of the hyoid with respect to the Frankfort plane (mm); PM-UPW - known as Nasopharyngeal airway space (mm); AH-CV - known as Horizontal position of the hyoid (mm); AH-MP - known as Vertical position of the hyoid with respect to the mandible (mm); NL/PM-U - known as Soft palate inclination angle (°); R^2 - coefficient of determination; F - Fisher's test; p-level - confidence level.

Discussion

Thus, in Ukrainian YM and YW with an orthognathic bite without pathology of the upper respiratory tract, the analysis of regression models of the area of the soft palate and tongue revealed:

soft palate area - in YW, regardless of face type, all reliable models were built with very wide and wide face types (R^2= from 0.682 to 0.937; p<0.001 in all cases), which most often include the thickness of the soft palate and the length of the soft palate (42.9 % of all independent variables); in YM without taking into account the type of face and with a wide face type, all reliable models were built (R^2=0.888 and 0.925; p<0.001 in both cases), which most often include the thickness of the soft palate and the length of the soft palate (33.3 % of all independent variables);

tongue area - in YW, regardless of face type, with very wide and wide face types, all reliable models were built

(R^2= from 0.729 to 0.907; p<0.001 in all cases), which most often include tongue height and tongue length (30.0 % each of all independent variables), as well as the value of the position of the hyoid bone relative to the vertical mandibular plane and the value of the angle of inclination of the soft palate (20.0 % of all independent variables each); in YM without taking into account the type of face and with a wide type of face, all reliable models were built (R^2=0.562 and 0.723; p<0.001 in both cases), which evenly include various teleroentgenometric indicators of the upper respiratory tract.

Determining the characteristics of various anthropometric indicators depending on nationality, region of residence, age, gender and other indicators is justified within the limits of the Ukrainian population. The results of research by Ukrainian anthropologists testify to the heterogeneity of the distribution of different types of craniotypes and face types in different regions of Ukraine, with a predominance of brachycephals with a narrow or very narrow face type [10].

In the study of Marchenko A. V. et al. [17] in Ukrainian young men and young women with an orthognathic bite and different types of faces, regression models of teleroentgenographic parameters according to Schwarz A. M. were built and analyzed, which can be corrected during surgery depending on teleroentgenographic parameters that usually do not change. Built reliable highly informative models provide an individualized approach to the necessary dental intervention.

In foreign publications, there are few studies on the relationship between respiratory tract parameters and craniofacial morphology. Individuals with a brachyfacial face type had greater nasopharyngeal width values than individuals with a mesofacial (p=0.030) or dolichofacial (p=0.034) face type. Together with an increase in the value of Vert, the width of the nasopharynx increased (R^2=26.2 %, p<0.001) [8]. However, in the study of Di Carlo G. et al. [6], any relationship between the parameters of the respiratory tract and the types of skeletal malocclusion was not found.

Indriksone I. and Jakobsone G. [13], analyzing the data of 276 healthy individuals aged 17-27 years, found a small number of weak relationships between craniofacial parameters and parameters of the upper respiratory tract, namely: the volume of the nasopharyngeal respiratory tract is affected by the angle of SNA, gender and the presence of adenoids. Weak correlations were found between SNB angle and OPV (r=0.144, p<0.05) and CSAmin (r=0.182, p<0.01).

Zheng Z. H. and others [25] found a relationship between anterior-posterior craniofacial parameters and the volume and Min-CSA of the pharyngeal airways (p<0.05). In addition, significant (p<0.05) differences in the volume of nasopharyngeal airways were found between representatives with different facial skeletal types.

In general, it is proven that excess weight is associated with an increased risk of respiratory tract collapse, which affects changes in the position of the hyoid bone, which in turn causes changes in the indicators of pharynx length, tongue length, tongue volume and volume upper respiratory tract [9].

Studies of the parameters of the tongue and its influence on the volume of the respiratory tract are more common in the world scientific literature [4, 24]. In particular, it has been proven that patients with apnea have a larger tongue (p=0.001) and an increased amount of fat (p=0.002) compared to healthy individuals, even when adjusting for body mass index, sex, age, and race [14]. The loss of body weight is associated with a decrease in the amount of fat in the tongue. The decrease in fat on the tongue was closely correlated with the decrease in the apnea-hypopnea index (Pearson's rho=0.62, p<0.0001) [23].

Rana S. S. and others [19] found a significant and positive correlation with tongue volume, oral cavity volume, and tongue volume (r=0.65; p=0.009). In addition, the authors found a significant negative correlation between the volume of the tongue, the volume of the oral cavity and the oropharynx (r=-0.51; p=0.04), the volume of the tongue, the volume of the oral cavity and the volume of the respiratory oral cavity pathways (r=-0.74; p=0.002).

After the correction of mandibular prognathism, a significant decrease in the area of the pharynx (p=0.046), a slight decrease in the area of the tongue (p=0.305) and an increase in the speed of air flow in the pharynx (p=0.133) were noted [5]. In another study, after a similar procedure, a significant increase in tongue length (p<0.001), a significant increase in airway parameters (p<0.001) was also found [20].

Conclusion

1. With the help of stepwise regression analysis, highly informative models of the area of the soft palate and tongue were built depending on teleroentgenometric indicators of the upper respiratory tract in Ukrainian YW with an orthognathic bite without taking into account the type of face, with very wide and wide face types (R^2= from 0.682 to 0.937, p<0.001 in all cases) and in Ukrainian YM with an orthognathic bite regardless of face type and with a wide face type (R^2= from 0.562 to 0.925, p<0.001 in both cases).

2. In YW, the models of the area of the soft palate and tongue most often include the thickness of the soft palate and the length of the soft palate (42.9 % each), the height of the tongue and the length of the tongue (30.0 % each), the value of the position of the hyoid bone relative to vertical mandibular plane and the value of the angle of inclination of the soft palate (20.0 % each); in YM - the thickness of the soft palate and the length of the soft palate (33.3 % each).

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РЕГРЕСІЙНІ МОДЕЛІ ПЛОЩІ М'ЯКОГО ПІДНЕБІННЯ ТА ЯЗИКА В ЮНАКІВ І ДІВЧАТ ІЗ ОРТОГНАТИЧНИМ ПРИКУСОМ БЕЗ І З УРАХУВАННЯМ ТИПУ ОБЛИЧЧЯ В ЗАЛЕЖНОСТІ ВІД ТЕЛЕРЕНТГЕНОМЕТРИЧНИХ ПОКАЗНИКІВ ВЕРХНІХ ДИХАЛЬНИХ ШЛЯХІВ

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Поширеність патологій, пов'язаних з м'яким піднебінням та оточуючими його структурами є серйозним викликом для медицини. Апное сну та інші захворювання напряму пов'язані з даним анатомічним регіоном несуть загрозу не тільки за рахунок власне можливості летальних випадків, але і ускладнення супутніх захворювань. У зв'язку з цим визначення нормативних показників верхніх дихальних шляхів, зокрема м'якого піднебіння і оточуючих його структур є актуальною темою для вивчення. Мета роботи - побудувати та провести аналіз регресійних моделей площі м'якого піднебіння та язика

в українських юнаків і дівчат із ортогнатичним прикусом без і з урахуванням типу обличчя у залежності від особливостей телерентгенометричних показників верхніх дихальних шляхів. За допомогою ліцензованого медичного програмного забезпечення OnyxCeph³™, версії 3DPro та діагностичної програми "UniqCeph" проведено цефалометричний аналіз бокових телерентгенограм 49 українських юнаків і 76 українських дівчат із ортогнатичним прикусом і відсутністю патології верхніх дихальних шляхів (первинні телерентгенограми отримані з бази даних науково-дослідного центру та кафедри стоматології дитячого віку Вінницького національного медичного університету ім. М. І. Пирогова). Типи обличчя в юнаків і дівчат визначали за допомогою індексу Гарсона. Регресійні моделі площі м'якого піднебіння та язика у залежності від телерентгенометричних показників верхніх дихальних шляхів побудовані за допомогою ліцензійного пакету "Statistica 6.0". В українських дівчат із ортогнатичним прикусом без урахування типу обличчя, з дуже широким і широким типами обличчя побудовані усі можливі моделі площі м'якого піднебіння та язика в залежності від телерентгенометричних показників верхніх дихальних шляхів з коефіцієнтом детермінації (R^2) більшим 0,5 (R^2= від 0,682 до 0,937, p<0,001), до яких найчастіше входять товщина м'якого піднебіння та довжина м'якого піднебіння (по 42,9 %), висота язика та довжина язика (по 30,0 %), величина положення під'язикової кістки відносно нижньощелепної площини за вертикаллю та величина кута нахилу м'якого піднебіння (по 20,0 %). В українських юнаків із ортогнатичним прикусом без урахування типу обличчя та з широким типом обличчя також побудовані усі можливі моделі площі м'якого піднебіння та язика в залежності від телерентгенометричних показників верхніх дихальних шляхів з коефіцієнтом детермінації більшим 0,5 (R^2= від 0,562 до 0,925, p<0,001), до яких найчастіше входять товщина м'якого піднебіння та довжина м'якого піднебіння (по 33,3 %).

Ключові слова: *телерентгенографія, цефалометрія, м'яке піднебіння, язик, регресійні моделі, українські юнаки та дівчата, ортогнатичний прикус, типи обличчя.*

Author's contribution

Kostiuchenko-Faifor O. S.: conceptualization, research, review writing and editing, methodology and writing of the original draft, formal analysis and validation.
Piliponova V. V.: project administration.
Beliaiev E. V.: data visualization.
Ocheretna O. L.: resources.
Ivanitsa A. O.: software.
Vakar T. V.: supervision.
Koliadenko S. V.: resources.