



Generation of a predictive equation for required space through linear regression analysis and its comparison with the Moyers and Tanaka Johnston methods in adolescents of 12-14 years of age at the S.U. «Darío Guevara Mayorga» Quito-Ecuador 2014-2015

Generación de una ecuación de predicción de espacio requerido a través del análisis de regresión lineal y su comparación con respecto a los métodos de Moyers y Tanaka-Johnston, en adolescentes de 12-14 años en la U. E. «Darío Guevara Mayorga», Quito-Ecuador 2014-2015

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ABSTRACT

Since the creation of Moyers' tables in 1958 and the method of Tanaka Johnston in 1974, which predict the required space for the canines and premolars to erupt, their effectiveness has been questioned when applied to different ethnic groups than those in which the studies were conducted. In South America, where we find mixed race ethnicity different from the white race, most studies have concluded that during the application of these methods their predictive values are not coincident with actual values. This study made a prediction equation of required space by Pearson correlation coefficients and subsequent creation by linear regression using values of our population, both women and men; then we proceeded to compare its effectiveness with the two methods abovementioned (Moyers and Tanaka Johnston) and concluded that in women and men the generated equation was more effective.

RESUMEN

Desde la creación de las tablas de Moyers en 1958 y el método de Tanaka-Johnston en 1974, los cuales predicen el espacio requerido para que erupcionen los caninos y premolares, se ha venido cuestionando su efectividad al momento de aplicar en otras etnias diferentes en las que se realizaron dichos estudios; a nivel de Sudamérica, en donde encontramos etnia mestiza diferente a la etnia blanca, muestra realizada para la creación de las tablas de Moyers y el método de Tanaka-Johnston, al aplicar dichos métodos la mayoría de los estudios concluyeron que sus valores predictivos no son acordes a los valores reales. El presente trabajo generó una ecuación de predicción de espacio requerido por medio de coeficientes de correlación de Pearson y su posterior creación mediante la regresión lineal con valores de nuestra población, tanto para mujeres como para hombres, luego se procedió a comparar su eficacia con respecto a los dos métodos antes mencionados, obteniendo y concluyendo que en mujeres y hombres la ecuación generada fue más eficaz que dichos métodos.

Key words: Space requirement, Pearson correlation coefficient, linear regression equation.

Palabras clave: Espacio requerido, coeficiente de correlación de Pearson, ecuación de regresión lineal.

INTRODUCTION

The use of predictive teeth to learn the required size for the eruption of canines and premolars in mixed dentition has been used since the year 1958.¹ Dr. R. Moyers conducted a study in white race and his results allowed the creation of tables of probability of required space in mixed dentition.² These tables were divided by gender and consisted in the use of the 4 incisors as predictors. This result would be transported to the tables of probability to know the actual size

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of the canines and premolars in both maxillary and mandible.³⁻⁴

Doctors Marvin Tanaka and Lesly Johnston wanted to corroborate Moyers' tables, so they performed their study in 506 white models; the results derived in two constants: one for the maxilla and another for the mandible, to avoid the use of Moyers' tables.^{5,6} Like Moyers Tanaka and Johnston used as predictors the 4 lower incisors. These methods had a great acceptance in the world since they were simple and inexpensive.^{7,8}

After the application of these predictive methods (Moyers and Tanaka-Johnston) in several populations, it became evident that their results were not in line with reality when applied in different ethnic groups.⁹⁻¹⁰ Several articles published in Latin American countries such as: Peru according to Bernabé E, Flores-Mir C,¹¹ Mercado¹² and Ramos et al.;¹³ Mexico according to Gutiérrez, J. et al.⁷; Colombia according to Botero P. et al.⁸ have concluded that Tanaka-Johnston and Moyers methods show a high margin of error when applied in their populations. In Ecuador, we have a mixed ethnicity, a product of the mixtures and conquests that our country has suffered throughout history.

Correlation coefficients have been used in Dentistry to predict the size of teeth since 1958 with Hixon and Oldfather, using linear regression equations in the required space. The pioneers were Lee-Chan et al. who conducted a study on Asian Americans and concluded that their linear regression equation was more accurate than the data obtained with the method of Tanaka-Johnston.^{14,15} A linear regression equation is not more than a relationship between the dependent variable (X) with the independent variable (Y); mathematically it is expressed as follows: $Y = f(X)$. In the required space prediction study for canines and premolars Y is equal to the sum of canines and premolars, a and b are the numeric constants, and X is the sum of dental predictors.¹⁶

The present investigation aimed to create a prediction equation of required space by means of a linear regression analysis and compare it with the methods of Moyers and Tanaka-Johnston in adolescents (12-14 years) in the State University «Dario Guevara Mayorga» of the city of Quito during the period of 2014-2015.

MATERIALS AND METHODS

It was an observational, longitudinal, transversal and correlational study. The variables were: The required space that refers to the distance between mesial of the tooth #6 to distal of the #2 (dependent variable) and the coefficient of bivariate correlation of

Pearson which is the linear relationship between two random quantitative variables. It measures the degree of relationship between two measures (independent variable). After approval by the Subcommittee on Ethics in Human Research of the Universidad Central del Ecuador (SEISH-UCE), we gave an informed consent to 220 students of the eighth, ninth and tenth semesters of the S.U. «Dario Guevara Mayorga» Quito-Pichincha during the period from 2014 to 2015. It was pointed out that the consent detailed all the procedure that they were going to be submitted to and that their parents had to sign to approve such consent. A data collection tab was applied to the students who brought the consent signed. It consisted in the inclusion criteria of the study: Ecuadorians of birth and with Ecuadorian ancestors of at least one previous generation, both surnames Hispanic American, without previous orthopedic and orthodontic treatment.¹³ The sample population consisted only of students who met all the inclusion criteria.

The selected students underwent an intraoral examination further selecting only those with complete permanent dentition, without dental caries, trauma, attrition or clinically visible restorations in the mesio-distal faces of all teeth.¹⁷ 70 women and 70 men were chosen since the implementation of the statistical formula for sample validation determined that we had to perform the study in 140 students. We took alginate impressions (Tropicalgin) of the two dental arches of 10 students per day. Subsequently casts were obtained with orthodontic plaster. The sample was divided into two groups: 70% for the creation of the equation and the other 30% for verification. With 70% of the sample of men and women, we analyzed 10 pairs of models per day to prevent eye fatigue as suggested by Ramos et al.¹³ Each tooth was measured with a 150 mm (6") gauge digital caliper with an appreciation of 0.01 mm; the gauge was placed perpendicular to the clinical crown of the tooth making contact with the active tips in the mesial aspect of each tooth. We performed two measurements for each tooth: only the first one was registered, since the difference between the two measurements was less than 0.2 mm in both women and men.¹⁷ Two orthodontists corroborated these data: Dr. Luisana Luzuriaga and Dr. Marcel Ulloa.

Data management and the creation of the equations were performed in Excel 2010. For the possible teeth combinations, we based our study on *table 1* of Ramos et al.^{13(p69)} and the Pearson correlation coefficient was applied to each combination. The combination of teeth that showed the highest correlation according to the Pearson coefficient was selected; these data along with the required space (sum of the canines and

premolars) were submitted to the linear regression analysis. Afterwards, a scatter plot was created where the linear regression equation appeared in both women and men. The program automatically generated a linear regression equation of $y = bx + a$, where the Y = to the sum of canines and premolars, b = slope (numeric constant), a = origin ordinate (numeric constant), X = sum of the combination of teeth with the highest correlation. This procedure was performed on the set of models of women and men. Thus two equations were obtained, one for the maxilla and another for the mandible in both women and men.

The generated equations were applied to the other 30% of the sample as well as the 75% Moyers table and the Tanaka-Johnston method. We compared the three methods in maxilla and mandible in women and men.

RESULTS

When the Pearson correlation coefficient was applied to 70% of the sample (*Table I*) it was observed that the best predictive combination in women for the maxilla was group 7 (sum of teeth #11, #21, #16, #26); for the mandible, it was group 9 (sum of teeth #42, #32, #16, #26). While in men both for the maxilla and the mandible, it was group 14 (sum of teeth #42, #32, #11, #21, #16, #26). The obtained equations (*Table II*) were applied to the remaining 30% of the sample in both women and men, along with the methods of Moyers at 75 % and Tanaka-Johnston. When comparing the results (*Tables III and IV*) it was noted in all cases that

the generated equations were more effective than the two methods mentioned above.

DISCUSSION

In the analysis of sexual dimorphism regarding the mesiodistal size of the tooth crowns, no significant differences were observed. These results were similar to those obtained by Toshio¹⁷ so we obtained different equations for both women and men like in the study of Ramos.¹³ In the 140 pairs of models of adolescents aged 12-14 years in the SU «Dario Guevara Mayorga» there were no significant differences between hemiarches (less than 0.2 mm) in the mesiodistal size of tooth crowns, as was found in the studies of Bernabé, Flores-Mir¹¹ and Mercado.¹² Thus we obtained a general equation for both maxilla and mandible in women and men. In the 50 models of women and men the best correlation was different to the sum of the incisors used in the Tanaka- Johnston⁵ and Moyers³ methods. This coincided with the results of Bernabé and Flores-Mir,¹¹ Mercado¹² and Ramos (2011).¹³

In the 50 models of women two correlation coefficients for the maxilla and mandible were obtained, different to the results of the abovementioned studies that only obtained a single coefficient for both maxilla and mandible. In each of the above-mentioned studies the correlation coefficient used in women was different, since in the study of Bernabé and Flores-Mir¹¹ the best was group 13 (the sum of teeth #11, #21, #31, #41, #16, #26), in the study by Mercado,¹² the

Table I. Bivariate correlation coefficient of Pearson in the 15 possible predictive sums according to gender.

Group	Teeth	Maxilla women	Mandible women	Maxilla men	Mandible men
1	11, 21	0.52	0.29	0.32	0.40
2	41, 31	0.26	0.19	-0.07	0.14
3	16, 26	0.43	0.43	0.33	0.48
4	42, 32	0.39	0.32	0.24	0.43
5	11, 21, 41, 31	0.46	0.28	0.20	0.39
6	41, 42, 31, 32	0.39	0.31	0.12	0.38
7	11, 21, 16, 26	0.58	0.44	0.39	0.54
8	41, 31, 16, 26	0.44	0.40	0.23	0.44
9	42, 32, 16, 26	0.49	0.46	0.37	0.58
10	42, 32, 11, 21	0.56	0.36	0.33	0.49
11	42, 41, 31, 32, 11, 21	0.51	0.33	0.25	0.47
12	42, 41, 31, 32, 16, 26	0.48	0.43	0.28	0.54
13	41, 31, 11, 21, 16, 26	0.52	0.40	0.32	0.52
14	42, 32, 11, 21, 16, 26	0.59	0.45	0.40	0.59
15	42, 41, 31, 32, 11, 21, 16, 26	0.55	0.42	0.34	0.56

Table II. Linear regression equations according to gender.

Women	
Maxilla	Mandible
$Y = 0,0008X + 21,396$ (mm)	$Y = 0,0045X + 20,310$ (mm)
Where X=sum of teeth #42, #32, #11, #21, #16, #26	Where X = sum of teeth #11, #21, #16, #26
Men	
Maxilla	Mandible
$Y = 0,0043X + 21,984$ (mm)	$Y = 0,0011X + 21,089$ (mm)
Where X = sum of teeth #42, #32, #11, #21, #16, #26	Where X = sum of teeth #42, #32, #11, #21, #16, #26

Table III. Comparison of the effectiveness between the Moyers method with respect to the equation by gender in maxilla and mandible.

Method	Gender	Maxilla (%)	Mandible (%)
Moyers	Women	45	20
Equation	Women	55	80
Moyers	Men	15	10
Equation	Men	85	90

Table IV. Comparison of the effectiveness between the Tanaka-Johnston method and the equation by gender in the maxilla and mandible.

Method	Gender	Maxilla (%)	Mandible (%)
Tanaka-Johnston	Women	20	5
Ecuation	Women	80	95
Tanaka-Johnston	Men	35	15
Ecuation	Men	65	85

best was group 8 (sum of teeth #31, #41, #16, #26); in the study of Ramos.¹³ the best was group 9 (the sum of teeth #42, #32, #16, #26) while in our study it was observed that the best group for the maxilla was 14 (the sum of teeth #42, #32, #11, #21, #16, #26) and for the mandible, it was group 9 (the sum of teeth #11, #21, #16, #26).

In none of the above-mentioned studies the best coefficient in men was the same since in the studies by Bernabé and Flores-Mir¹¹ the best was group 13 (the sum of teeth #11, #21, #31, #41, #16, #26); in the study by Mercado,¹² the best was group 8 (the sum of teeth #31, #41, #16, #26); in the study by Ramos,¹³ it was group 12 (the sum of teeth #42, #41, #31, #32, #16, #26), while in our study it was group 14 (the sum of teeth #42, #32, #11, #21, #16, #26).

In the 40 sets of models obtained from adolescents aged 12-14 years of the SU «Dario Guevara Mayorga»

when comparing the equation with the methods of Tanaka-Johnston and Moyers at 75% a better prediction of the size of the canines and premolars was obtained as in the studies by Bernabé, Flores-Mir,¹¹ Mercado¹² and Ramos.¹³

With regard to the average value (maxilla) in the 20 models of women, there was a deviation from the real value of canines and premolars of 0.26 mm with the generated equation; 0.29 mm, with Moyers at 75% and 0.64 mm with Tanaka-Johnston, thus the generated equation showed the least deviation. The average value (mandible) in 20 models of women showed a deviation from the real value of canines and premolars of 0.20 mm with the generated equation; of 0.28 mm with Moyers at 75% and 1.06 mm with Tanaka-Johnston, therefore the generated equation showed the least deviation similar to the results obtained in the studies of Bernabé, Flores-Mir,¹¹ Mercado¹² and Ramos.¹³

With regard to the mean value (maxilla) in the 20 models of men, there was a deviation from the real value of canines and premolars of 0.43 mm with the generated Equation; 1.20 mm, with Moyers at 75 % and of 0.65 mm with Tanaka-Johnston. The generated equation showed the least deviation just as the data presented in the studies of Bernabé, Flores-Mir,¹¹ Mercado¹² and Ramos.¹³ In the mean value (mandible) of the 20 models of men, there was a deviation from the real value of canines and premolars of 0.10 mm with the generated Equation; 0.28 mm with Moyers at 75% and of 0.44 mm with Tanaka-Johnston, being the generated equation the one that presented the least deviation.

CONCLUSIONS

- In the 140 pairs of models of adolescents aged 12-14 years of the SU «Dario Guevara Mayorga», there were no discrepancies in the mesiodistal sum of the teeth between hemiarches in the maxilla or mandible.
- In the 50 models of female adolescents 12-14 years of the SU «Dario Guevara Mayorga», the best Pearson's correlation coefficient for maxilla was the sum 14 ($r = 0.59$), the sum of teeth #42, #32, #11, #21, #16, #26; while for the mandible, it was sum 9 ($r = 0.46$), the sum of teeth #42, #32, #16, #26.
- In the 50 models of adolescent males 12-14 years of the SU «Dario Guevara Mayorga», the best Pearson's correlation coefficient for maxilla was sum 14 ($r = 0.40$), the sum of teeth #42, #32, #11, #21, #16, #26, as well as for the mandible ($r = 0.59$), the sum of teeth #42, #32, #11, #21, #16, #26.
- In the 20 pairs of models of adolescent women and men of 12-14 years of the S.U. «Dario Guevara Mayorga», the generated equation was more effective than the Tanaka-Johnston and the Moyers table of 75% methods.
- The equations product of this research could be used in the Ecuadorian population as a tool for the prediction of required space in the mixed dentition.

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