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A Cross Sectional Study to Evaluate Correlation between Vertical Dimension of Occlusion and Various Anthropometric Measurements, among Gujarati Adults

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Running Title Head: *Anthropometric Correlation of Vertical Dimension of Occlusion*

Abstract: ***Aim: The aim is to determine the correlation between various anthropometric measurements with the VDO records; amongst the ethnic group of Gujarat state and also evaluating the consistent correlation of these measurements in males and females. Methodology: The study comprised of a total of 300 dentate subjects in which 150 were female and 150 were male with class 1 molar and canine relation without any malocclusion. A customized instrument was designed to achieve stabilization of head position. Accurate reading of anthropometric landmarks like length of right thumb, length of right index finger, length of external ear auricle, distance between anterior wall of external auditory meatus to exocanthion on right side, interpupillary distance, were recorded and compared with vertical dimension of occlusion in dentate individuals using digital vernier caliper. Statistical analysis was done and regression equation was obtained for each of the anthropometric landmark for determination of VDO. Results: According to the present study a strong positive correlation exists between Length of index finger and VDO among 300 Gujarati adults (Correlation=0.318)) if length of index finger increases by 1 unit, the average VDO increases by 0.343mm.***

Keywords: Occlusion, Anthropometric Measurement

1. Introduction

Vertical dimension of occlusion (VDO) is defined as the distance between two selected anatomic points when in maximal intercuspal position (GPT - 9) (1). Correct VDO has always been a factor of prime importance for successful clinical performance of all prosthetic rehabilitations. If VDO is registered too high or too low, it would end up deteriorating the existing patient's condition instead of improving it (2). Inaccurate VDO leads to multiple adverse effects on aesthetics, functional efficiency of prosthesis; physiological health of temporo - mandibular joints, masticatory muscles and muscles of facial expression of lower half of the face (3). The determination of an acceptable VDO is dependent upon the clinical judgment, skill, and experience of the dentist. (4). Altered state of closure (overclosed/open) and sufficiency (insufficient/ excessive) can cause clinical consequences such as compromised esthetics, diminished masticatory function, angular cheilitis, altered phonetics, and encroachment of the inter- occlusal rest space during speech and pain in the edentulous ridges.

Anthropometric measurements were used to determine proportions of body parts since antiquity. Pythagoras proved that the Golden Section was the basis for the proportions of the human figure and that the human body was built with each part in a definite Golden Proportion to all the other parts. This study was done to identify the predictable correlation between VDO and the anthropometric landmarks that are not dependent on subjective interpretation of individuals and are easily reproducible irrespective of the neuromuscular health of patients. Landmarks such as size of right thumb, size of right index finger, length of right external ear auricle, distance between anterior wall of external auditory meatus to exocanthion on right side and interpupillary distance, will be studied in Gujarati adults (right side is considered for standardization purpose).

2. Material and Methodology

An Exploratory study was done on total of 300 dentate subjects in which 150 were female and 150 were male with class 1 molar and canine relation without any malocclusion were selected for the study according to inclusion and exclusion criteria. A customized head position stabilization instrument was fabricated for maintaining standardized head position such that the participants floor of the mouth stays parallel to the floor and head and back position remains erect while measuring the facial landmarks eliminating the errors

that might occur due to change in position of head (Fig - 1).

Figure 1: Head position stabilization instrument

Participants were asked to place the chin on the horizontal chin rest of the stabilization instrument and the vertical arm of the instrument was adjusted in a manner that it aids participants in maintaining the erect head and back position without any discomfort.

With the head in this position; participant were asked to occlude the teeth in maximal intercuspal position, and the distance between the Subnasale point and Menton point was marked and measured with the help of divider and there by the distance between two arms of divider were calibrated using digital vernier caliper in order to record ***Vertical dimension of occlusion (***Fig - 2)

Figure 2: Measurement of vertical dimension of occlusion

with the digital caliper (Fig - 3).

Figure 3: Measurement of external ear auricle

Figure 4: Measurement from exocanthus to anterior border of auditory meatus

Then after, the distance between the superior most point of right side external ear auricle to the inferior most point of the right ear auricle (***length of the ear***) will be measured

The distance between the lateral border of the exocanthus of right eye (***Exocanthion)*** to anterior wall of right ***auditory meatus*** were marked with plaster and measured with the digital caliper (Fig - 4).

Figure 5: Measurement of Interpupillary distance

The participant were asked to look straight with head stabilized on the stabilization instrument and the two pupil marking bars were adjusted on the horizontal arm in such a way that they can be seen coinciding with the center of pupil and then the distance between the center of the pupil of right eye to center of pupil of the left eye (***Interpupillary)*** were measured using digital vernier caliper (Fig - 5).

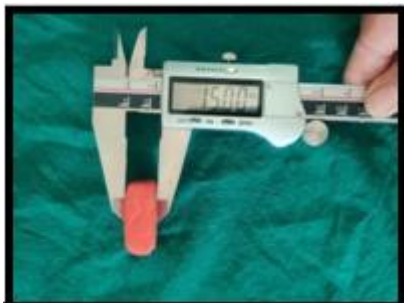


Figure 6: Wax block of 15mm thickness for index finger and thumb rest

Participants were asked to place right hand thumb and finger on a wax block with thickness of 15 mm to orient the straight position (Fig - 6).

Figure 7: Measurement of thumb

Figure 8: Measurement of Index finger

Participants were asked to put the hand straight with thumb stabilized on the wax block and all the fingers supported. The proximal point on the radial side of the proximal crease over the first metacarpo - pharyngeal joint and the distal point of dactylion, the distal most part of the ***thumb***, was marked and measured using digital caliper (Fig - 7).

Participants were asked to put the hand straight with index finger stabilized on the wax block and all the fingers supported. The length of the ***index finger*** of the right hand was measured on the palmar aspect from the tip of finger to the near most point on palmar digital crease with digital caliper (Fig - 8). Statistical analysis was conducted by using appropriate statistical software. Pearson's test was applied to find whether a correlation exist between VDO and various anthropometric landmarks followed by one way ANOVA for regression analysis.

3. Results

Combined statistics of all participants

Table 1: Descriptive statistics of all the parameters

Parameter	n	Mean	SD	Minimum	Maximum
Vertical Dimension of Occlusion	300	58.02	5.84	38.67	76.45
Length of Thumb	300	66.59	5.77	50.99	80.79
Length of Index Finger	300	69.10	5.41	51.00	83.45
Interpupillary Distance	300	58.06	5.32	35.67	84.11
Length of External Ear Auricle	300	60.62	4.93	39.65	86.40
Distance between outer canthus and anterior wall of external auditory meatus	300	71.31	4.47	46.55	83.50

Table 2: Correlation of Vertical Dimension of Occlusion with different parameters

Parameter	Pearson correlation	*P* value
Length of Thumb	0.428	0.000**
Length of Index Finger	0.318	0.000**
Interpupillary Distance	0.354	0.000**
Length of External Ear Auricle	0.400	0.000**
Distance between outer canthus and anterior wall of external auditory meatus	0.415	0.000**

** Correlation is significant at the 0.01 level, $ Correlation is not significant at 0.05 level

Regression Analysis for Vertical Dimension of Occlusion (Dependent variable) and Length of Thumb (Independent variable)

Table 3: ANOVA for Vertical Dimension of Occlusion a

Model	Sum of Squares	DF	Mean Square	F - test	*P* value
Regression	1873.715	1	1873.715	66.993	.000b
Residual	8334.716	298	27.969		
Total	10208.431	299			

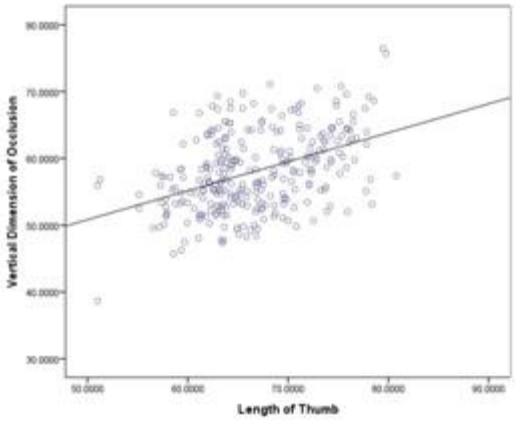
Table 4: Coefficients for Vertical Dimension of Occlusion a

Model	Unstandardized Coefficients		Standardized Coefficients	T - value	*P* Value
	B	Std. Error	Beta		
(Constant)	29.160	3.540		8.238	.000
IPW	0.433	0.053	0.428	8.185	.000

a) Dependent Variable: Vertical Dimension of Occlusion
b) Predictors: (Constant), Length of Thumb

Regression Equation:
Vertical Dimension of Occlusion = 29.160 + 0.433 * Length of Thumb

The regression model statistically significantly predicts the outcome variable. If Length of Thumb increases by 1 unit, the average Vertical Dimension of Occlusion increases by 0.433 unit



Graph 1: Based on correlation analysis (Shown by dots) and regression analysis (Shown by line) graph shows that relation between VDO and length of thumb in Gujarati Adults

Regression Analysis for Vertical Dimension of Occlusion (Dependent variable) and Length of Index Finger (Independent variable)

Table 5: ANOVA for Vertical Dimension of Occlusion a

Model	Sum of Squares	DF	Mean Square	F - test	*p* value
Regression	1034.902	1	1034.902	33.619	.000b
Residual	9173.529	298	30.784		
Total	10208.431	299			

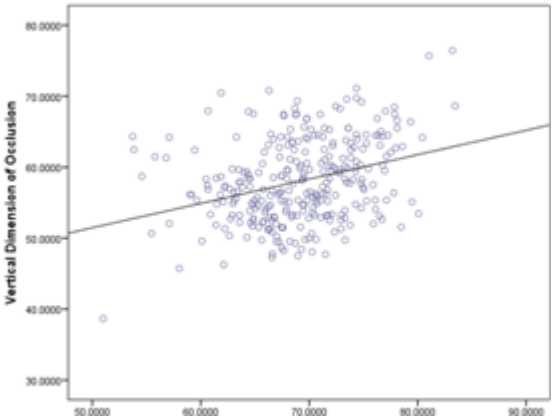
Table 6: Coefficients for Vertical Dimension of Occlusion a

Model	Unstandardized Coefficients		Standardized Coefficients	t - value	*p* value
	B	Std. Error	Beta		
(Constant)	34.289	4.106		8.351	.000
IPW	0.343	0.059	0.318	5.798	.000

a) Dependent Variable: Vertical Dimension of Occlusion
b) Predictors: (Constant), Length of Index Finger Regression Equation:

Vertical Dimension of Occlusion = 34.289 + 0.343 * Length of Index Finger

The regression model statistically significantly predicts the outcome variable. If Length of Index Finger increases by 1 unit, the average Vertical Dimension of Occlusion increases by 0.343 unit



Graph 2: Based on correlation analysis (Shown by dots) and regression analysis (Shown by line) graph shows that relation between VDO and length of Index Figure in Gujarati Adults

Regression Analysis for Vertical Dimension of Occlusion (Dependent variable) and Interpupillary Distance (Independent variable)

Table 7: ANOVA for Vertical Dimension of Occlusion a

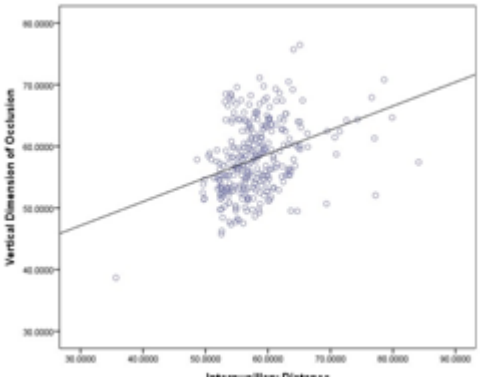
Model	Sum of Squares	DF	Mean Square	F - test	*p* value
Regression	1276.724	1	1276.724	42.597	.000b
Residual	8931.707	298	29.972		
Total	10208.431	299			

Table 8: Coefficients for Vertical Dimension of Occlusion a

Model	Unstandardized Coefficients		Standardized Coefficients	T - value	*p* value
	B	Std. Error	Beta		
(Constant)	35.500	3.466		10.244	.000
IPW	0.388	0.059	0.354	6.527	.000

a) Dependent Variable: Vertical Dimension of Occlusion
b) Predictors: (Constant), Interpupillary Distance

Regression Equation:
Vertical Dimension of Occlusion = 35.500 + 0.388 * Interpupillary
Distance
The regression model statistically significantly predicts the outcome variable. If Interpupillary Distance increases by 1 unit, the average Vertical Dimension of Occlusion increases by 0.388 unit



Graph 3: Based on correlation analysis (Shown by dots) and regression analysis (Shown by line) graph shows that relation between VDO and Interpupillary distance in Gujarati Adults

Regression Analysis for Vertical Dimension of Occlusion (Dependent variable) and Length of External Ear Auricle (Independent variable)

Table 9: ANOVA for Vertical Dimension of Occlusion a

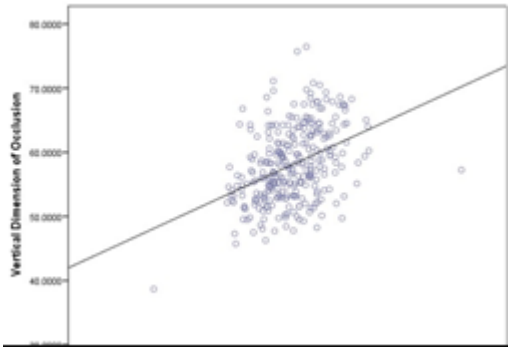
Model	Sum of Squares	DF	Mean Square	F - test	*p* value
Regression	1629.907	1	1629.907	56.620	.000b
Residual	8578.524	298	28.787		
Total	10208.431	299			

Table 10: Coefficients for Vertical Dimension of Occlusion a

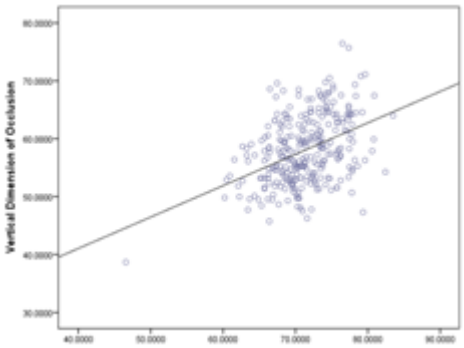
Model	Unstandardized Coefficients		Standardized Coefficients	t - value	*P* value
	B	Std. Error	Beta		
(Constant)	29.366	3.821		7.685	.000
IPW	0.473	0.063	0.400	7.525	.000

a) Dependent Variable: Vertical Dimension of Occlusion
b) Predictors: (Constant), Length of External Ear Auricle

Regression Equation:
Vertical Dimension of Occlusion = 29.366 + 0.473 * Length of External
Ear Auricle
The regression model statistically significantly predicts the outcome variable. If Length of External Ear Auricle increases by 1 unit, the average Vertical Dimension of Occlusion increases by 0.473 unit



Graph 4: Based on correlation analysis (Shown by dots) and regression analysis (Shown by line) graph shows that relation between VDO and length of external ear auricle in Gujarati Adults
.0322222222222.1111111111111 gujarati adults



Graph 5: Based on correlation analysis (Shown by dots) and regression analysis (Shown by line) graph shows that relation between VDO and length distance between outer canthus and anterior wall of external auditory meatus in Gujarati Adults

Regression Analysis for Vertical Dimension of Occlusion (Dependent variable) and Distance between outer canthus and anterior wall of external auditory meatus (Independent variable)

Table 11: ANOVA for Vertical Dimension of Occlusion a

Model	Sum of Squares	DF	Mean Square	F - test	*p* value
Regression	1761.481	1	1761.481	62.143	.000b
Residual	8446.950	298	28.345		
Total	10208.431	299			

Table 12: Coefficients for Vertical Dimension of Occlusion a

Model	Unstandardized Coefficients		Standardized Coefficients	T - value	*P* value
	B	Std. Error	Beta		
(Constant)	19.355	4.915		3.938	.000
IPW	0.542	0.069	0.415	7.883	.000

a) Dependent Variable: Vertical Dimension of Occlusion
b) Predictors: (Constant), Distance between outer canthus and anterior wall of external auditory meatus

Regression Equation:
Vertical Dimension of Occlusion = 19.355 + 0.542 * Distance between outer canthus and anterior wall of external auditory meatu

The regression model statistically significantly predicts the outcome variable. If Distance between outer canthus and anterior wall of external auditory meatus increases by 1 unit, the average Vertical Dimension of Occlusion increases by 0.542 unit

4. Discussion

Anthropometry is a science that deals with the measurement of size, weight, and proportion of the human body (5). It is empirical in nature and has developed quantitative methods to measure various physical dimensions for characterization of phenotypic variations and dysmorphology. Present study was conducted to evaluate correlation between vertical dimension of occlusion and various anthropometric measurements such as length of right thumb, length of right index finger, length of external ear auricle, distance between anterior wall of external auditory meatus to exocanthion on right side, interpupillary distance among Gujarati ethnic group

According to this study mean VDO of 300 Gujarati adults was 58.02± 5.84 mm (Table 1). In male adults mean VDO was found to be 61.07 ± 5.45mm (Table - 13). In female adults mean VDO was found to be 54.97± 4.51 mm (Table - 23). A similar study conducted in Loni, India by **Ladda et al (6),** suggested similar results as obtained in present study, supporting the fact that the VDO is higher in males than in females. This suggests that there is sexual dimorphism in the measurements of VDO. These results were also supported by the similar study done by **Basnet et al (7)** and **A. Bajracharya et al** (8) amongst Aryans and mongoloids and found that Aryans had a mean VDO of 63.89 ± 6.29 mm and Mongolian had 65.86 ± 3.61mm which signified that Mongoloids have longer VDO in comparison to Aryans. This difference may be considered to be due to different facial proportions in these ethnic groups. In a generalized form comparing results of other studies with the present study, it was observed that ethnicity plays an important role in measurement of VDO. Measurements of VDO in Gujarati population differ from Aryans [Kashmiri (9), Deccani (10), Marathi (11), Bengali (12), Rajasthani (13)] and more significantly from Mongoloids [Nepali].

According to the present study a strong positive correlation exists between Length of index finger and VDO among 300 Gujarati adults (Correlation=0.318) (Table - 2) in Gujarati males correlation exists with P value =0.000 (P value<0.01) (Correlation=0.217) (Table - 14). In Gujarati females positive correlation exist (Correlation=0.19) with P value =0.02 (P value<0.05) (Table - 24). For regression analysis

one way ANOVA was applied and regression equation was obtained which suggested that in **300 Gujarati adults (**Table - 5, 6) if length of index finger increases by 1 unit, the average VDO increases by 0.343mm.

VDO = 34.289 + 0.343 * Length of Index Finger.

In Gujarati **males (**Table - 17, 18), if length of index finger increases by 1 unit, the average VDO increases by 0.188 mm

VDO= 47.768 + 0.188 * Length of Index Finger.

While in Gujarati **females** if length of index finger increases by 1 unit, the average Vertical Dimension of Occlusion increases by 0.222 unit (Table - 25, 26)

VDO = 39.964 + 0.222 * Length of Index Finger

Similar study was done by **M. Alhajj (14), R. Balla (15), Majeed et al (3), H. Yazdanie et al (16),** who also found correlation between index finger and VDO.

In this study statistical analysis was performed and mean length of right thumb was found to be 66.59 mm (Table - 1) Mean length of Thumb in males was found to be 69.62 mm (Table - 13) and in females mean was 63.55mm (Table - 23). Pearson"s test of correlation found that positive correlation exists between length of thumb and VDO among 300 Gujarati adults (Correlation=0.428) (Table - 2) in Gujarati male with P value=0.000 (P value<0.01) (Correlation= 0.298) (Table - 14). While no correlation was found in gujarati females with P value=0.603 (P value>0.05). Regression analysis suggested that in **300 Gujarati adults (**Table - 3, 4) if length of thumb increases by 1 unit, the average VDO increases by 0.433 mm (Table - 15, 16)

VDO = 29.160 + 0.433 * Length of thumb

In **males** regression analysis suggested that if Length of Thumb increases by 1 unit, the average Vertical Dimension of Occlusion increases by 0.271 unit

VDO= 42.182 + 0.271 * Length of Thumb

The results of this study were in accordance with the study done by **Shiuay et al (17)** where they found no correlation between VDO and length of thumb. . Similar study was done by **T. Haroon (18), R. Balla (9), R. Ladda (2)** who also found correlation between legth of thumb and VDO.

Inter - pupillary distance was found to be 58.06 mm with maximum value being 84.11mm and minimum being 35.67 mm (Table - 1) Mean inter - pupillary distance in males was found to be60.05 mm where maximum value was 84.11mm and minimum was 35.67 mm (Table - 13) and in females mean was 56.06 mm and maximum was 65.10 mm with minimum being 48.64 mm (Table - 23). Pearson's test of correlation found that a positive correlation exists between inter - pupillary distance and VDO among 300 Gujarati adults (Correlation=0.35) (Table - 2) where in 150 male no significant correlation was found. While in females positive correlation was found (Correlation=0.313) (p value=0.000) (Table - 24).

Regression analysis of findings **300 Gujarati adults (**Table - 3, 4) if interpupillary distance increases by 1 unit, the average VDO increases by 0.388 mm (Table - 15, 16)

VDO = 35.500 + 0.388 * Inter - pupillary distance.

In **female** regression analysis (Table - 27, 28) suggested that if Inter - pupillary distance increases by 1 unit, the average Vertical Dimension of Occlusion increases by 0.412 unit. Thus in Gujarati females

VDO=31.874 + 0.412 * Inter - pupillary distance

Mean length of ear was found to be 60.62 mm with maximum value being 86.40 mm and minimum being 39.65 mm (Table - 1) Mean length of ear in males was found to be 62.25 mm where maximum value was 72.34mm ad minimum was 39.65 mm (Table - 13) and in females mean was 58.99 mm and maximum was 86.40mm with minimum being 50.82 mm (Table - 23). Pearson's test of correlation found that a positive correlation exists between length of ear and VDO among 300 Gujarati adults (Correlation=0.35) (Table - 2) where in 150 male significant correlation was found (Correlation=0.308) (P value=0.000) (Table - 14). Regression analysis in **300 Gujarati adults (**Table - 9, 10) if length of ear increases by 1 unit, the average VDO increases by 0.473 mm

VDO = 29.366 + 0.473 * Length of ear

While in **males (**Table - 19, 20), if length of External Ear Auricle increases by 1 unit the average Vertical Dimension of Occlusion increases by 0.344 unit

VDO=39.670 + 0.344 * Length of Ear

While in 150 **females** correlartion was found (Correlation= 0.248) (P value=0.000) (Table - 24) and regression analysis suggested that if Length of External Ear Auricle increases by 1 unit I **females** (Table - 29, 30), the average Vertical Dimension of Occlusion increases by unit

VDO= 40.189 + 0.251 * Length of Ear

Similar study was done by **P. Krishnamurthy (21) and A. Bhandari (6)** who also found correlation between legth of ear and VDO.

Mean Distance between outer canthus and anterior wall of external auditory meatus was found to be 71.31 mm with (Table - 1) Mean Distance between outer canthus and anterior wall of external auditory meatus in males was found to be 72.90 mm (Table - 13) and in females mean was 69.71 mm (Table - 23). Pearson's test of correlation found that a positive correlation exists between distance between outer canthus and anterior wall of externalauditory meatus and VDO among 300 Gujarati adults (Correlation=0.415) (Table - 2) while in 150 males it was significantly correlated. (correlation= 0.309) (Table - 14) Regression analysis in **300 Gujarati adults (**Table - 11, 12) if length of ear increases by 1 unit, the average VDO increases by 0.542 mm

VDO= 19.355 + 0.542 * Distance between outer canthus and anterior wall of external auditory meatus.

While in 150 **males** (Table - 21, 22), if Distance between outer canthus and anterior wall of external auditory meatus increases by 1 unit the average Vertical Dimension of Occlusion increases by 0.361 unit

VDO== 34.735 + 0.361 * Distance between outer canthus and anterior wall of external auditory meatus.

It was correlated in 150 **females (**correlation=0.256) (Table - 24) Regression analysis suggested that if Length of External Ear Auricle increases by 1 unit in females (Table - 31, 32), the average Vertical Dimension of Occlusion increases by 0.473 unit.

VDO== 33.187 + 0.312 * Distance between outer canthus and anterior wall of external auditory meatus.

Similar study was done by **D K singh et al (19), Basnet B et al (10)** who also found correlation between distance from exocanthion to anterior wall of external auditory meatus and VDO**.**

5. Conclusion

1) Mildly significant correlation between right **length of thumb** with Vertical dimension of occlusion was found in males and no correlation was found between right **length of thumb** with Vertical dimension of occlusion in females.
2) Moderately significant correlation between right **length of index finger** with vertical dimension of occlusion was found in males as well as females.
3) Mildly significant correlation was found between right **length of external ear auricle** with VDO in male and females.
4) Moderately significant correlation was found between **interpupillary distance** and VDO in females no correlation was found between right **interpupillary distance** and Vertical dimension of occlusion in females.
5) Moderately significant correlation was found for **distance between exocanthion to anterior wall of external auditory meatus on right side** with VDO in both males and females.
6) Amongst above mentioned anthropometric measurements **distance between exocanthion to anterior wall of external auditory meatus on right side** was found to have maximum correlation while length of thumb have least correlation with VDO in **Gujarati adults**.
7) Various formulas were derived from the present study for detmination of vertical dimension of occlusion.

6. Limitations of the Study

1) The limitation of the study was that it was restricted to the subjects with class I occlusion and other skeletal or dental malocclusions were not considered.
2) Further the subjects were not categorized based on facial forms as all facial forms were included in this study and specific differences between various facial forms need to be studied.
3) Limited sample size was considered in the present study, thus further study with larger sample size should be done.

7. Clinical Implications of the study

1) According to this study there exists correlation between measurements of various anthropometric landmarks and vertical dimension of occlusion in dentate Gujarati adult population which can help us in determining vertical dimension of occlusion.
2) In edentulous patient while fabrication of complete dentures to determine vertical dimension of occlusion.
3) It also guides us in patients in which harmony of musculoskeletal system is disturbed due to unhealthy occlusion and helps us in reestablishment and equilibration of lost vertical dimension of occlusion.
4) This study aids us in determining vertical dimension of occlusion in patients with neuromuscular disorders.
5) This study will help us in patients with mutilated dentition for reproduction of vertical dimension in future prosthetic reconstruction

Source of Support in Form of Grants, Equipments, Drugs: NIL

Conflict of Interest: None

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