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Research Article

STATURE ESTIMATION FROM FOOT DIMENSIONS OF IGBO INDIGENES OF IMO STATE EXTRACTION IN NIGERIA

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ABSTRACT

The use of anthropometric measurements of various anatomical structures for prediction and estimation of the height of an individual has been very useful especially when skeletal remains are often observed to be incomplete, therefore the estimation power of foot length will also be useful. This study was therefore carried out to determine the stature prediction strength of foot dimensions of Igbo indigenes of Imo State, Nigeria. A total of 546 subjects, comprising of 300 males and 246 females were used for the study. Height and weight were measured using weight-bearing stadiometer calibrated in meters and kilogram, while foot dimensions were measured using a ruler and digital venirecaliper. The data was analysed using SPSS (IBM version 23, Amork-USA). The t-test analysis showed that the males were taller than the females with mean heights of 1.73±0.08 and 1.66±0.08 respectively, and were also having larger foot dimensions than the females. The regression analysis showed that all foot parameters correlated significantly with stature, with the best correlation observed for foot length (R.R^2=44.05%, and L.R^2=36.13%; P<0.01). The right foot was seen to be more accurate with a predictability strength of accuracy of 50.26% in males and 44.05% in females. Conclusively, Foot morphometry in relation to stature showed that the foot length gives the highest prediction of stature with the right foot being more accurate than the left and predictability strength of accuracy higher in males than in females.

INTRODUCTION

Over the years, the development of anthropometric measurements of various anatomical structures for prediction and estimation of stature has become very useful especially when skeletal remains are often observed to be incomplete or extensively dismembered (Reddy, 2000). It is important to note that there are no universal formulae applicable for stature estimation from the length of one bone, since the bones are influenced by genes, age, sexand race (Rutihauser 1968; Philip 1989; Kulthanan *et al*., 2003; Ozden *et al*., 2005; Jitender *et al*., 2007; Vijay *et al*., 2013; Nwachukwu *et al*., 2015; Alabi *et al*., 2017).

Statureestimation from various long bones have been well-documented; with their equations providing several degrees of success peculiar to the population studied (Rutihauser 1968; Kulthanan *et al*., 2003; Alabi *et al*., 2016; Alabi *et al*., 2017). Likewise, foot length has also been used for estimating stature, with an above average prediction accuracy reported which are comparable to those of the long bones. The observed sex difference observed in foot dimensions (Vijay *et al*., 2013)informed the study by Jitender *et al*. (2007) and Alabi *et al*. (2017), which they reported that stature prediction are sex-specific, with more accurate and reliable predictions for malewhen compared to females. However, Alabi *et al*. (2016) reported significant relationship between toe length and stature while Ekezie *et al*. (2016) reported no significant relation between foot breadth at heel and stature.

The dimensional relationship between stature and long bones could change in a population after a very long period of time. Thus the need for new equations suggesting current relationship is very necessary (Trotter and Glesser, 1958).Formulae for stature estimation have been investigated to a diverse level which is as a result of it population specificity (Duyar and Pelin, 2003; Alabi *et al*., 2017; Osuchukwu *et al*., 2017). This study was therefore carried out to determine the

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relationship between foot dimensions and stature of Igbo indigenes of Imo State in Nigeria.

MATERIALS AND METHOD

A total of 546 subjects comprising of 300 males and 246 females of Igbo ethnic group from Imo State in Nigeria were used for this study. Height and weight was measured using weight-bearing stadiometer calibrated in meters and kilogram respectively, while foot dimensions [foot length, foot breadth (at the fore, mid and hind aspect of the foot), foot height and navicular height] were measured using a ruler and digital venire caliper calibrated in meters and millimetres. The heights of the subjects were defined as the straight distance from the most inferior part of the heel to the vertex of the head, and was measured using stadiometeron the weight bearing stadiometer while weights of the subjects were measured using the weighing scale. Standard protocol as described by Osuchukwu *et al*. (2017) were followed in taking linear foot dimensions, and McCrory *et al*. (1997) and Watson *et al*. (2014)for the arch index.

Data analysis

The data was analysed using SPSS (IBM version 23, Amork-USA). Student t-test was used to evaluate the difference in the male and female mean values. Sex-specific linear and multiple regression models for stature were derived from the measured foot parameters. Analysis were performed at 95% confidence level with P<.05 considered statistically significant.

RESULTS

Univariate linear regression (correlation analysis) From the correlation analysis in Table 1 and 2 for male and female respectively, all variables; FL, FFB, MFB, HFB, FH, NH and MAL (R and L) were significant predictors of stature of both males and females (P<0.01).

A line graph of the percentage accuracy in stature prediction from the studied foot dimensions was presented in Fig. 1 & 2 and it showed that for males, in descending order, FL (R.R^2=50.26%, and L.R^2=37.19%), FH (R.R^2=40.82%, and L.R and R^2=36.54%) and MAL (R.R^2=40.44%, and L.R and R^2=33.23%) provided the highest prediction accuracy for stature while other variables produced accuracies less than 20% while for females, in descending order, FL (R.R^2=44.05%, and L.R^2=36.13%), MAL (R.R^2=25.48%, and L.R and R^2=25.11%) and FH (R.R^2=25.14%, and L.R and R^2=19.77%) had the highest accuracy, while other variables produced accuracies ranging from 6-20%.

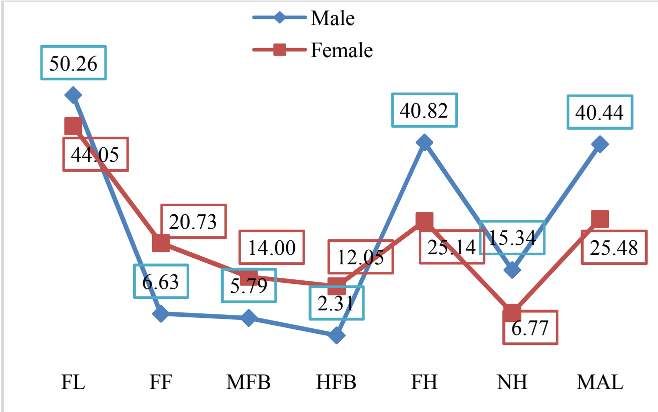

Figure 1 Comparison of the accuracy in prediction (R^2) of male and female right foot dimensions

Multivariate linear regression analysis

The multivariate linear regression model produced a significant prediction model for stature estimation; however, only three (3) variables (RFL [T=6.099; P<0.001], LFL [T=-3.060; P=0.002], and RFH [T=2.618; P=0.009]) significantly contributed to prediction model for male while the remaining eleven (11) variables made contributions that were not significant (P>0.05).

Table 1 Univariate stature prediction for males (with regression equations)

Variables (mm)	*PREDICTION OF STATURE (in m)*				*PREDICTION OF STATURE (in m)*			
	RIGHT FOOT				*LEFT FOOT*			
	r	*R_E*	*P-value*	*Inf.*	*r*	*R_E*	*P-value*	*Inf.*
FL	0.709	0.005 (FL) + 0.501	<0.001	S	0.610	0.004 (FL) + 0.670	<0.001	S
FFB	0.257	0.003 (FFB) + 1.477	<0.001	S	0.292	0.004 (FFB) + 1.342	<0.001	S
MFB	0.241	0.003 (MFB) + 1.485	<0.001	S	0.211	0.003 (MFB) + 1.519	0.002	S
HFB	0.152	0.002 (HFB) + 1.606	0.008	S	0.132	0.002 (HFB) + 1.631	0.021	S
FH	0.639	0.006 (FH) + 1.330	<0.001	S	0.604	0.005 (FH) + 1.353	<0.001	S
NH	0.392	0.004 (NH) + 1.518	<0.001	S	0.355	0.004 (NH) + 1.536	<0.001	S
MAL	0.636	0.0038 (MAL) + 1.087	<0.001	S	0.576	0.0035 (MAL) + 1.138	<0.001	S

Note: *R; Right, L; Left, FL; Foot length, FFB; Fore foot breadth, MFB; Mid foot breadth, HFB; Hind foot breadth, FH; Foot height, NH; Navicular height, MAL; Medial arch length. r, Pearson's correlation coefficient; R_E Regression Equation; Inf., Inference (NS, Not Significant; S, Significant).*

Table 2 Univariate stature prediction for females (with regression equations)

Variables (mm)	*PREDICTION OF STATURE (in m)*				*PREDICTION OF STATURE (in m)*			
	RIGHT FOOT				*LEFT FOOT*			
	r	*R_E*	*P-value*	*Inf.*	*r*	*R_E*	*P-value*	*Inf.*
FL	0.664	0.004 (FL) + 0.721	*<0.001*	*S*	0.601	0.003 (FL) + 0.799	*<0.001*	*S*
FFB	0.455	0.006 (FFB) + 1.107	*<0.001*	*S*	0.472	0.006 (FFB) + 1.094	*<0.001*	*S*
MFB	0.374	0.004 (MFB) + 1.323	*<0.001*	*S*	0.375	0.004 (MFB) + 1.330	*0.002*	*S*
HFB	0.347	0.005 (HFB) + 1.362	*0.008*	*S*	0.350	0.005 (HFB) + 1.377	*0.021*	*S*
FH	0.501	0.005 (FH) + 1.325	*<0.001*	*S*	0.445	0.005 (FH) + 1.353	*<0.001*	*S*
NH	0.26	0.003 (NH) + 1.513	*<0.001*	*S*	0.296	0.004 (NH) + 1.500	*<0.001*	*S*
MAL	0.505	0.003 (MAL) + 1.122	*<0.001*	*S*	0.501	0.004 (MAL) + 1.101	*<0.001*	*S*

Note: *R; Right, L; Left, FL; Foot length, FFB; Fore foot breadth, MFB; Mid foot breadth, HFB; Hind foot breadth, FH; Foot height, NH; Navicular height, MAL; Medial arch length. r, Pearson's correlation coefficient; R_E Regression Equation; Inf., Inference (NS, Not Significant; S, Significant).*

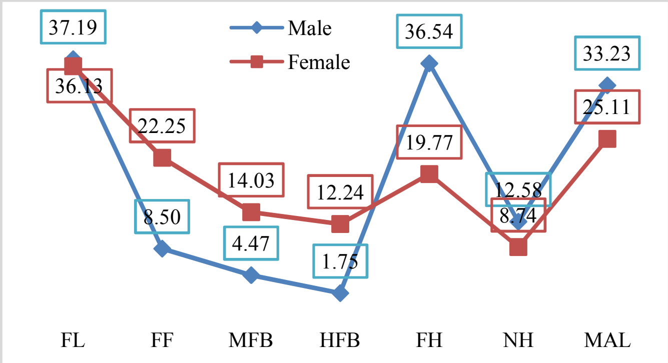

Figure 2 Comparison of the accuracy in prediction (R^2) of male and female left foot dimensions

The accuracy of the predictor variables was 63.28% (Table 3) while highest positive (+ve) contributors to the model (standardised coefficient) were RFL (0.6756), RFH (0.2822), and LHFB (0.019), while highest the negative (-ve) contributors were LFL (-0.3263) and LHFB (-0.0964) (Fig. 3). For females, only RFL [T=2.559; P=0.011], and RFH [T=2.227; P=0.027] were significant contributors to the prediction model for female stature, other variables made contribution that did not significantly influence the accuracy (P>0.05).

Table 3 Regression model characteristics and variables predictability of stature for male population

Term*	Coef	SE Coef	T-Value	P-Value	Inf.
Constant	0.913	0.047	19.400	*<0.001*	S
RFL (mm)	0.004	0.001	6.099	*<0.001*	S
LFL (mm)	-0.002	0.001	-3.060	*0.002*	S
RFFB (mm)	0.000	0.001	-0.337	*0.736*	NS
LFFB (mm)	0.001	0.001	0.731	0.465	NS
RMFB (mm)	0.000	0.001	-0.442	0.658	NS
LMFB (mm)	0.000	0.001	-0.058	0.954	NS
RHFB (mm)	-0.001	0.001	-1.096	0.274	NS
LHFB (mm)	0.001	0.001	1.276	0.203	NS
RFH (mm)	0.003	0.001	2.618	*0.009*	*S*
LFH (mm)	0.000	0.001	0.326	0.744	NS
RNH (mm)	0.001	0.001	0.517	*0.606*	NS
LNH (mm)	0.000	0.001	0.052	*0.959*	NS
RMAL (mm)	0.001	0.001	1.865	0.063	NS
LMAL (mm)	0.000	0.001	0.059	0.953	NS

Note: R; Right, L; Left, FL; Foot length, FFB; Fore foot breadth, MFB; Mid foot breadth, HFB; Hind foot breadth, FH; Foot height, NH; Navicular height, MAL; Medial arch length.
Coef., Coeffcient; S.E, Standard error; R^2, Coefficient of determination; R_E, Regression Equation;Inf., Inference (NS, Not Significant; S, Significant). *Model is a good fit with P<0.01

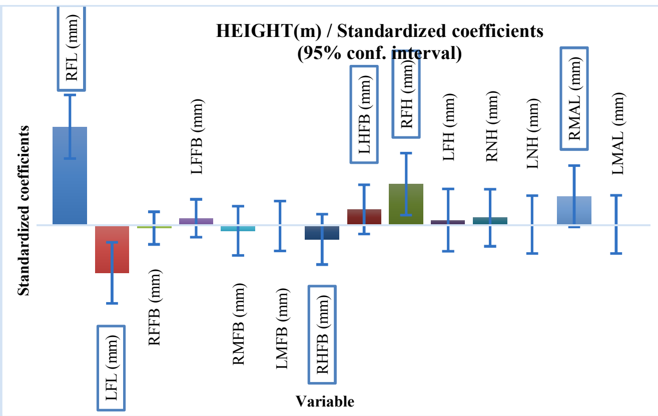

Figure 3 Independent variable contribution to regression model for determining the stature of males

The prediction accuracy (R^2) for the model was 52.10% which can be described as average accuracy (Table 4). The predictor variables with the highest positive (+ve) contributions (standardised coefficient) were RFL (0.3476), RFH (0.2369), LNH (0.1924), and LFFB (0.1738), while highest the negative (-ve) contributor was RNH (-0.1436) (Fig. 4).

Table 4 Regression model characteristics and variables predictability of stature for female population

Term*	Coef	SE Coef	T-Value	P-Value	Inf.
Constant	0.604	0.075	8.100	***<0.001***	S
RFL (mm)	0.002	0.001	2.559	***0.011***	S
LFL (mm)	0.000	0.001	0.398	0.691	NS
RFFB (mm)	0.000	0.002	0.000	1.000	NS
LFFB (mm)	0.002	0.001	1.505	0.134	NS
RMFB (mm)	0.000	0.001	-0.151	0.880	NS
LMFB (mm)	0.001	0.001	0.473	0.636	NS
RHFB (mm)	0.000	0.001	0.342	0.733	NS
LHFB (mm)	-0.001	0.001	-0.740	0.460	NS
RFH (mm)	0.003	0.001	2.227	***0.027***	***S***
LFH (mm)	0.000	0.001	-0.259	0.796	NS
RNH (mm)	-0.002	0.001	-1.298	0.196	NS
LNH (mm)	0.002	0.001	1.708	0.089	NS
RMAL (mm)	0.000	0.001	0.082	0.935	NS
LMAL (mm)	0.001	0.001	0.734	0.464	NS

Note: *R; Right, L; Left, FL; Foot length, FFB; Fore foot breadth, MFB; Mid foot breadth, HFB; Hind foot breadth, FH; Foot height, NH; Navicular height, MAL; Medial arch length.*

*Coef., Coeffcient; S.E, Standard error; R^2, Coefficient of determination; R_E, Regression Equation; Inf., Inference (NS, Not Significant; S, Significant). *Model is a good fit with P<0.01*

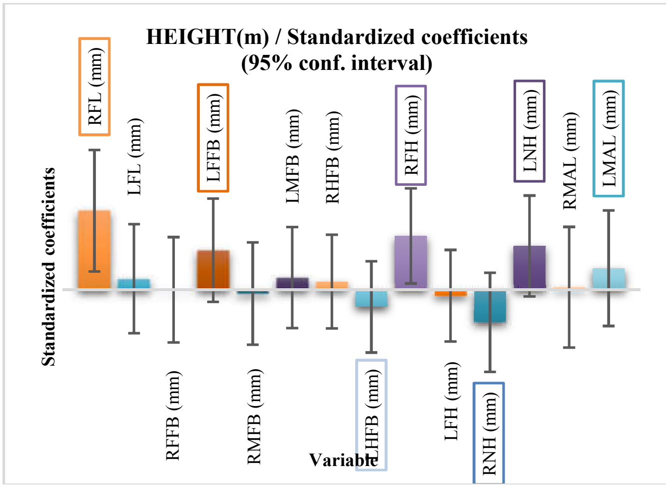

Figure 4 Independent variable contribution to regression model for determining the stature of females

DISCUSSION

This study focused on foot morphometry and its relation to stature among the Igbos of Imo state extraction in Nigeria. In this study, males had greater anthropometric values than females, which was unsurprising, as this trend is established and widely accepted (McCrory *et al.*, 1997; Hironmoy *et al.*, 2012; Reena *et al.*, 2012; Saharan *et al.*, 2015; Alabi *et al.*, 2016; Alabi *et al.*, 2017). From the correlation analysis, it was observed that statureof male and females significantly correlated with all the measured foot parameters except the arch indices in both the left and right foot. Studies have shown that indices and ratios were often poor predictors of stature (Ekezie *et al.*, 2016; Alabi *et al.*, 2017). Among all foot parameters used for stature estimation in this study, foot length (FL) provided more accurate predictions for stature (Ozden *et al*., 2005; Jitender *et al*., 2007; Saharan *et al*., 2015; Ekezie *et al*., 2016; Alabi *et al*., 2017), with betterpredications in right, and in males when compared to females (Ozden *et al*., 2005; Jitender *et al*., 2007; Ekezie *et al*., 2016; Alabi *et al*., 2017). Although, left foot parameters could also correlate better than the right foot (Saharan *et al*., 2015). However, when foot parameters with high prediction accuracies where entered into a multiple regression model, better accuracy was observed (*R-sq*=63.28% for males and *R-sq*=52.10% for females).

Therefore, in the event of an incident, where an individual of Imo State extraction is involved and body parts are dismembered, partially or completely, estimation of the stature of that individual is very possible using the underlisted equation for the available foot part.

Males; using foot lengthS_{Male} = 0.005 (FL) + 0.501, Fore foot breadthS_{Male}= 0.003(FFB)+1.477, Mid foot breadthS_{Male}= 0.003 (MFB) + 1.485, Hind foot breadth S_{Male}= 0.002(HFB)+1.606, using Foot height S_{Male}= 0.006(FH) + 1.330, Navicular height S_{Male}= 0.004(NH)+1.518, Medial arch length S_{Male}= 0.0038 (MAL) + 1.087.

Females; using foot length is S_{Female} = 0.004(FL) + 0.721, Fore foot breadth S_{Female} = 0.006 (FFB) + 1.107, Mid foot breadth S_{Female} = 0.004 (MFB) + 1.323, Hind foot breadth S_{Female} = 0.005(HFB) + 1.362, the Foot height S_{Female} = 0.005(FH) + 1.325, Navicular height S_{Female} = 0.003 (NH) + 1.513, Medial arch length S_{Female} = 0.003 (MAL) + 1.122.*Note; in the equations above, S represents Stature*.

Regression equation $_{(male)}$: All foot dimensionsentered into the model

HEIGHT(m) = 0.68566 + 0.00435*RFL(mm) - 0.00211*LFL(mm) - 0.00019*RFFB (mm) + 0.00064*LFFB(mm) - 0.00046*RMFB(mm) - 0.00006*LMFB(mm) - 0.00117*RHFB (mm) + 0.00121*LHFB(mm) + 0.00253*RFH(mm) + 0.00032*LFH(mm) + 0.00057*RNH (mm) + 0.00006*LNH (mm) + 0.00119*RMAL(mm) + 0.00004*LMAL(mm) (*R-sq=63.28%*).

Regression equation $_{(female)}$: All foot dimensionsentered into the model

HEIGHT(m) = 0.60449 + 0.00191*RFL(mm) + 0.00027*LFL(mm) - 7.51489E-7*RFFB(mm) + 0.00220*LFFB(mm) - 0.00020*RMFB(mm) + 0.00061*LMFB (mm) + 0.00049*RHFB (mm) - 0.00099*LHFB(mm) + 0.00252*RFH(mm) - 0.00028*LFH(mm) -0.00185*RNH(mm) + 0.00238*LNH(mm) + 0.00007*RMAL(mm) + 0.00065*LMAL(mm) (*R-sq=52.10%*).

CONCLUSION

Indexes and ratios are poor predictors of stature. More accurate and significant prediction can be obtained from linear foot dimensions. However, dimensions of the same anatomical structure produces varying accuracy in stature prediction, which are sex specific. But better predictions can be obtained when all foot dimensions are considered together.

References

1. Reddy, K.S.N. (2000). The Essentials of Forensic Medicine and Toxicology, 30th Edn. Hyderabad: Devi KS. Pp 51.
2. Nwachukwu, M.I., Elijah, S.O., Abidoye, T.E., Soyeye, T.P., Bello, A.O., Raheem, S.A. (2015). Estimation ofulna length from its morphometry ina South West Nigerian population. *JAS*. 6 (2): 100-107.
3. Kulthanan, T., Techakampuch, S., Bed, N.D. (2004). A study of foot prints in athletes and non-athletic people. *J Med Assoc Thai*.87:788-793.
4. Rutihauser, I.H. (1968). Prediction of height from foot length: Use of measurement in field surveys. *Arch Dis Child*. 43:310-312.
5. Ozden, H., Balci, Y., Demirustu, C., Turgut, A., Ertugrul, M. (2005). Stature and sex estimate using foot and shoe dimensions. *Forensic Sci Internat*. 147:181-184.
6. Philip, T.A. (1989). Reconstruction of stature from foot outline and footprint size. *J Indian Acad Forensic Med*. 11:15-20.
7. Vijay, K.D., Pravir, B., Prashanth, P. (2013). Determination of stature and sex from anthropometry of the foot among South Indians; *IntJ Rev Life Sci*.3 (2): 22-26.
8. Jitender, K.J., Vijay, P., Paliwal,P.K. (2007).Estimation of height from measurements of foot length in Haryana Region. *J Indian Acad Forensic Med*. 32(3): 231-233.
9. Alabi, A.S., Oladipo, G.S., Didia, B.C., Aigbogun,(Jr) E.O. (2017). Regression equations for stature prediction in Nigerian Hausas, Igbos and Yorubas from toe length and toe-length ratios. *Anthropol*. 5 (1): 176-181.
10. Alabi, S.A., Didia, B.C., Oladipo, G.S., Aigbogun, (Jr) E.O. (2016). Evaluation of sexual dimorphism by discriminant function analysis of toe length (1T-5T) of adult Igbo populace in Nigeria. *Nigerian Med J*. 57: 226-232.
11. Ekezie. J., Ndubuka, G.I., Okeke, S.N., Osuchukwu, I.W. (2016). A study of correlations and estimation of stature from foot trace and shoe trace dimensions. *Int J Forens Sci*. 1(3): 1-13.
12. Trotter, M., Glesser, G.C. (1958). A re-evaluation of estimation of stature based on measurements taken during life and long bones after death. *Am J PhyAnthropol*. 16:79-124.
13. Duyar, I. Pelin, C. (2003). Body height estimation based on tibia length in different stature groups. *Am J PhyAnthropol*. 122: 23-27.
14. Osuchukwu, I.W., Paul, W.C., Aigbogun, (Jr) O.E. (2017). Foot morphometry in the differentiation and determination of sex among Igbo indigene of Imo State extraction in Nigeria. *EJBPS*. 4(8): 895-900.
15. Watson, A., Ganesh, P., Joseph, O.R. Impact of anthropometric measures on medial arch height in half marathon runners. *Eur J Sports Exerc Sci*, 2014; 3 (3): 37-41.
16. McCrory, J.L., Young, M.J., Boulton, A.J.M., Cavanagah, P.R. (1997). Arch index as a predictor of arch height. *Foot*. 7:79-81.
17. Hironmoy, R., Kalyan, B., Samar, D., Kuntala, R. (2012). Arch Index: An easier approach for arch height

(A Regression Analysis).*Al Ameen J Med Sci*.5 (2): 137-146.

18. Reena S, Minu B, Mrinal B. Sex estimation from foot anthropometry in HaryanviJats and north Indian mixed population; *J Punjab Acad Forensic Med Toxicol*. 2012;12(1):13
19. Saharan R.A., and Arun M. Stature estimation from foot anthropometry in individuals above 18 years belonging to Indian demography. *J Med Sci Health*; 2015; 1(2):25-29.

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