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Long Antiquity of Low Resting Metabolism And Recent Shift To Sedentary Lifestyle Leading To Cardiovascular Disease Risk Among South Asians: A Multi-Ethnic Study Of Asian Indian Tribes

Gautam K. Kshatriya[1], Mithun Das[2*] & Kaushik Bose[3]

[1]Department of Anthropology, University of Delhi, Delhi, India

[2]Department of Anthropology & Tribal Studies, Sidho-Kanho-Birsha University, WB, India

[3]Professor, Department of Anthropology, Vidyasagar University, WB, India

*Corresponding Author Email: mithundas01@yahoo.com

ABSTRACT

Migration of modern man out of Africa led to differential environmental exposures. Our ancestors, who settle to hot and humid climate, maintained genes for heat adaptation developing low resting metabolism thereby, leading to susceptibility to obesity. Recent shift to sedentary lifestyle among the Asian Indians have further aggravated the risk of CVD. A multi-ethnic study of nine tribal groups from three states of India was undertaken comprising 2156 participants (including 1055 males and 1090 females) aged >=20 years. Anthropometry, blood pressures, blood glucose, and body composition were all measured using standard techniques. The average resting metabolism is very low among both male (1300 Kcal) and female (1000 Kcal). The prevalence of low physical activity is very high both in males and females (males=26.1 % and females=29.7%). There is a significant correlation (p<0.001) between resting metabolism and CVD risks factors even after controlling of age, sex, ethnicity, and physical activity. The significant predictors for resting metabolism, fat free mass, and percentage body fat were found to be waist circumference, and body mass index. Low resting metabolism due to long antiquity of adaptation to hot climates with recent shift to low physical activity were found to have a significant association with CVD risks among the tribal groups of Indian subcontinent making them genetically disadvantageous. Maintaining higher resting metabolic rate through active lifestyle seems to be of utmost importance for better cardiovascular health among the people of Indian origin.

KEYWORDS

Resting Metabolism, CVD risk, Physical activity, Ethnicity, Asian Indian

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INTRODUCTION

Human migration out of Africa took place around 70,000 years ago. Our early ancestors entered Central Asia by around 60,000 years ago from where one group moved towards Northeast Asia and further to Siberia, thereby, acquired genes for cold adaptation, which in turn resulted in to high resting metabolic (RM) and hence resistance towards obesity. Another group from Central Asia went towards north-west, also acquired genes for cold adaptation, and displaced the Neanderthals. It is the third group that entered in South Asia and further went to Southeast Asia and Australia, and thereby acquired genes for heat adaptation. This in turn resulted into low RM, increased propensity towards obesity, higher risk of cardio-metabolic diseases (Sellayah et al., 2014). The indigenous populations of South Asia (including Asian Indians) are therefore ethnically predisposed to obesity related cardio-metabolic risks due to long antiquity of adaptation to low resting metabolism. On the other hand, the recent shift towards sedentary lifestyle, which is perhaps mediated through low physical activity and change in dietary habit, together exacerbates the risk among the people of Indian origin. It is also known that the Asian Indians are developing cardiovascular disease (CVD) risk at a much lower body mass index (BMI) and lesser waist circumference (WC) as compared to most of the other ethnic group worldwide (WHO, 2000). The specific CVD risk components differ by sex and ethnicity. The aetiology cannot be described by a single known factor. It is a complex interaction between several genetic and environmental factors leading to particular disease phenotype. Furthermore, it shows considerable variation in components among different individuals. The variations among different ethnic groups are even greater across the globe (Grundy et al., 2005).

The present study was therefore undertaken to find out the reasons whether the Asian Indians with rapid changes in lifestyle coupled with long antiquity of low RM result in more susceptible to CVD risks. The study comprises nine tribal populations of three different states of India. It focuses on the association between low RM, sedentary lifestyle and obesity-related CVD risk, keeping into consideration that ethnic variation in susceptibility to obesity related CVD risks even in developing countries is a result of the exposure of our ancestors to diverse environments which initiated since the beginning of human migration out of Africa (Sellayah et al. 2014). In the present study an attempt has been made to test the hypothesis that the *Asian Indians are becoming more susceptible to CVD risks due to recent shift towards sedentary lifestyle, and long antiquity of adaptation to low RM making them genetically disadvantageous.*

MATERIALS AND METHODS

Ethical clearance

The research proposal of the present study was placed before the Institutional Ethics Committee (IEC) of University of Delhi, Department of Anthropology. The study was conducted after getting the approval form IEC which is in accordance with the guidelines of ICMR, New Delhi and Declaration of Helsinki. Consent was obtained from each participant at the beginning of the study.

Area and people

The study consists nine tribes inhabiting three states of India. It includes: the Santal, Kora, and Oraon of West Bengal; the Bathudi, Bhumij, and Santal of Odisha; and the Kukna, Dhodia and Chaudhari of Gujarat as shown in Figure 1. These tribes are some of the major tribes belonging to South Asia. The tribes of the tribes of West Bengal and Odisha are more under privileged and marginalized as compare to the tribes of Gujarat. On the other hand, the tribes of Gujarat were more affluent than Odisha and West Bengal. The impact of modernization has been noticed more among the tribes of Gujarat than in other two states. The socio- economic characteristics of the nine studied tribes with three each from West Bengal (WB), Odisha (OD), and Gujarat (GJ) are important dimensions of the present study and were premeditated during the time of research. Though all the studied groups have the access to basic civic amenities the sedentary lifestyle and leisure time activities were found to be more prevalent among the tribes of Gujarat. The practice of substance consumption (tobacco chewing, and alcohol) were found to be more prevalent among the tribes of Odisha and West Bengal than in Gujarat.

Sample

The study is cross-sectional, observational, and epidemiological. Participants include both male and female with the age ranged from 20 to 60 years. Individuals neither physically nor mentally challenged were included and individuals, who were sick, went under prolong treatment, and pregnant women were excluded. The study comprises 2156 adult individuals including 1066 men and 1090 women based on multi-stage sampling method comprising two states of East India and one state of West India according to their predominant distribution. Data collected with prior

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permission from the village council and under the presence of local inhabitants. Demographic data were collected by means of a structured schedule in five phases during 2011-13. Chronological age in months was recorded from the participants' legal birth certificate/ Govt. ID.

Study variables

The standing height and weight was measured to the nearest of 0.1 cm and 0.1 kg respectively. Stature was measured using a movable anthropometer while the weight was; measured by using Body Composition Monitor (Omron Karada Scan HBF-375, Tokyo, Japan). Waist Circumference (WC) was measured as per the standard technique (Lohman et al., 1988). The pulse rate (per min) was also recorded. Systolic (SBP) and diastolic (DBP) blood pressures were measured twice by means of a sphygmomanometer and stethoscope and the average of it was analysed. A third measurement was taken only if the difference between the two measurements found to be > 5mmHg. A 15-min relaxation period between measurements was maintained for all subjects. Prior medical records like use of anti-hypertensive drugs etc. were also considered. Fasting bold glucose (FBG) was identified through finger prick by strip method with help of glucometer (Accu-Check Active, Mumbai, India). Participants were requested to participate in the morning before taking tea and breakfast. An overnight fasting of ~ 12 hours was maintained throughout all the studied participated. Body composition patterning was identified with the help of Bioelectrical Impedance Analyser (BIA) commonly called body fat monitor (Omron Karada). The percentages of body fat (PBF), subcutaneous fat whole body (SFW), skeletal mass whole body (SMW), subcutaneous fat trunk (SFT), skeletal mass trunk (SMT), and visceral fat (VF) as well as the resting metabolism (RM) in Kcal were identified through Omron body fat monitor. PBF was also computed from biceps (BSF) and triceps (TSF) skinfolds following the equations of Durnin and Womersley (1974). Skinfolds were measured using standard techniques (Lohman et al., 1988). The equations were found to be valid among South Asian populations (Bose 1999) including the Indians (Kuriyan et al. 1998). The following equations were used:- PBF = (4.95 / density* – 4.5) x 100

*for men 1.1356–0.070 x log (BSF+TSF), and for women = 1.1362 – 0.074 x log (BSF + TSF).

Informed written consent from the participants participating in the study was obtained prior to the actual commencement of the study. For non-literate participants, approval of consent was collected by taking thumb impression in the consent form after adequately explaining the nature of the study. Participants who refused to participate were excluded from the study design.

Statistical analysis

Prevalence (%) of low physical activity level and cardio-metabolic risk were calculated. Descriptive statistics, such as mean and standard deviation (SD), were used for the selected body composition variable. Differences in the means of the variables by sex were explained by analysis of variance (ANOVA) between the ethnic groups with *Tukey's-b* Post Hoc. It was followed by Two-way ANOVA test to determine the effect of gender and ethnic groups and the interaction of gender and ethnic groups on RM, FFM, and PBF separately for younger (< 40 years) and older (>=40 years) generation along with post-hoc *Tukey's-b* for ethnic groups. Receiver Operating Characteristic (ROC) curve was plotted for physical activity level as independent variable and RM, FFM, and PBF as dependent variables as illustrated in FIGURE 2. The important thing is AUC (area under the ROC curve). It was treated as statistically significant (the column Asymptotic Sig. in the table just below the figure 2 , if below the reference (diagonal) line, this means that the correlation between a particular independent variable and the dependent one is negative, and if above the reference (diagonal) line, this means that the correlation between a particular independent variable and the dependent one is positive. Partial correlation was applied between RM, FFM, and PBF and cardio-metabolic risk variables (including, waist circumference, SBP, DBP, PR, and FBG) after controlling for age, sex, and ethnic groups, and physical activity. The purpose was to spot spurious correlations (i.e. correlations explained by the effect of other variables) and to reveal hidden correlations (i.e. correlations masked by the effect of other variables). It was followed by stepwise multiple regression to estimate the linear relationship between a dependent variable and one or more independent variables or covariates. It is when a large number of possible explanatory variables are available and there is difficulty interpreting the partial correlation coefficients. It estimated the linear regression (R^2) involving one or more independent variables that best predict the value of the dependent variable. Stepwise linear regression was carried out for cardio-metabolic profiles as independent variables with RM, FFM, and PBF profiles as dependent variables in order to find out the most significant predictor(s) in the studied populations. A statistical significance (two tailed) was set at p<0.05.

RESULTS

The prevalence of low PAL and cardio-metabolic risk variables including higher percentage body fat (PBF), waist circumference (WC), systolic blood pressure (SBP), diastolic blood pressure (DBP) and body mass index (BMI) by gender among the nine tribal groups are shown in TABLE 1. It was found that among males the prevalence of low PAL varied between as 20.7% in Bathudi of OD to 42.5% among the Dhodia of GJ. Prevalence of high PBF was found to be lowest among Santal (4.9%) of WB and highest among Kora (31.6%) of WB. Higher WC was found to be absent among Kora to as high as 13.4% among the Kukna of GJ. Elevated SBP was found to be lowest among the

Kora (27.2%) and highest among the Bhumij (46.6%) of OD. Elevated DBP was lowest among the Bathudi (19.3%) of OD and highest among the Kora (34.2%). Prevalence of high fasting blood glucose (FBG) was very high across all the studied groups with lowest 61.4% among the Kora and highest among the Santal (81%) of OD. Higher BMI varied from as low as 1.85 among the Kora to as high as 25% in Bhumij of OD. Among the females, the prevalence of low PAL varied from 22.6% to 39.2% among the Oraon of WB and Dhodia of GJ, respectively. Higher PBF was noticed to be lowest among Oraon (20.2%) and highest among the Santal (50.4%) of OD. Frequency of higher WC varied from as low as 0.8% among the Oraon to 9.2% among the Dhodia. Prevalence of higher SBP was found to be lowest among the Chaudhuri (27.3%) of GJ to as high as 45.8% in Dhodia of GJ. Diastolic hypertension was found to be lowest among the Chaudhuri (27.3%) and highest among the Oraon (50%). Frequency of elevated FBG was lowest among the Bathudi (53.7%) of OD and highest among the Santal (80.7%) of OD. Higher BMI was found to be lowest among theKora (1.7%) and highest among the Dhodia (23.3%) of GJ.

Descriptive of RM, fat free mass (FFM), and PBF by one-way ANOVA with post-hoc *Tukey's-b* are shown in TABLE 2A and 2B separately for males and females of the studied population. Among the males (TABLE 2A) there exist highly significant (P<0.001) differences between groups for RM, FFM, and PBF. The mean RM (Kcal) was found to be lowest among the Bathudi (1142.42 ± 383.95) and highest among the Bhumij (1347.86 ± 198.27) both from OD. Mean fat free mass (kg) varied from 39.711 ± 6.55 among the Kora of WB to 44.190 ± 7.09 among the Bhumij of OD. Percentage body fat was found to be lowest among the Bathudi of OD and highest among the Dhodia of GJ. Among the females (TABLE 2B) there exist significant difference in mean FFM (P<0.01), and highly significant difference in mean RM and PBF (P<0.001). Lowest mean RM was noticed among the Oraon (967.40 ± 102.75) of WB and highest in Dhodia (1044.82 ± 150.13) of GJ. Whereas fat free mass was found to be lowest in Bathudi (29.025 ± 4.34) and highest in Santal (33.053 ± 5.03), both from OD. On the other hand, mean PBF was found to be lowest among the Bathudi (24.341 ± 6.09) of OD and highest among the Dhodia (31.362 ± 5.92) of GJ.

Receiver Operator Characteristic (ROC) curve was used to visualize the performance of a binary classier between RM on one side and FFM and PBF on the other. It was estimated separately among individuals with low physical activity and high physical activity by states as illustrated in Figure 2. The area under the curve (AUC) as given below the figure 2 summarizes its performance in a single number. It was found that among the tribes of WB and GJ individuals with LPA had significantly low RM with respect to high FFM and high PBF with GJ being more significant. Similarly individuals with HPA had significantly higher RM with respect to lower FFM and low PBG. In both the occasions GJ being the most significant followed by WB, and the tribes of OD didn't show any significant association with RM.

Interaction between gender and ethnic groups are shown in TABLE3 by means of two-way ANOVA. It was found that gender had highly significant (P<0.001) effect on RM, FFM, and PBF both among the younger and older generations. Ethnic groups also exhibit highly significant (P<0.001) effect on RM, FFM, and PBG among the younger generation. Whereas, among the older generation ethnic groups had highly significant (P<0.001) effect on RM and PBF but not showed no significant effect on FFM (P=0.178). The effect of gender and ethnic groups interactions was found to be highly significant (P<0.001) over RM and FFM but not significant for PBF (P=0.212) among the younger generation. On the other hand, among the older generation the interaction of gender and ethnic groups showed significant effect on RM (P=0.005) and PBF (P=0.004) but no significant effect over FFM (P=0.508).

It was then followed by partial correlation which was applied between body composition (RM, FFM, and PBG) and cardio-metabolic risk variables (WC, SBP, DBP, FBG, BMI) after controlling for age, sex, ethnic groups, and physical activity as shown in TABLE 4. It was done to do away any spurious correlations which could be explained by the effect of other variables as well as to reveal hidden correlations, if any, which actually masked by the effect of other variables. It was found that there exists significant correlation between the body composition patterning and cardio-metabolic risk variables even after controlling for age, sex, ethnic groups, and physical activity.

TABLE 5 shows the result of the stepwise multiple regressions with cardio-metabolic risks as independent variables and RM FFM, and PBF as dependent variables separately. It was carried out to find out the least number of significant predictors. The estimated linear regression involving one or more independent variables that best predict the value of the dependent variable were recorded. It showed significant variation among the tribes of different states. Stepwise multiple regressions of RM as dependent variable showed WC as the most significant predictor (P<0.001) with R^2 change of 0.402 followed by BMI, DBP, and FBG. Similarly, stepwise multiple regressions of FFM as dependent variable also showed WC as the most significant predictor (P<0.001; R^2 change = 0.238) followed by BMI and DBP. Whereas stepwise multiple regressions of PBF as dependent variables showed BMI as the most significant predictor (P<0.001; R^2 change = 0.107) followed by DBP, WC, and FBG.

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DISCUSSION

The averages RM of the nine tribal populations are very low and association between low RM and CVD risk factors showed considerable ethnic heterogeneity among them. There exists significant effect of gender and ethnicity on RM, PBF and FFM among both younger and older generations. Furthermore, there is a significant correlation between RM and CVD risk factors even after controlling for age, sex, ethnicity, and physical activity. Results confirmed that lower levels of RM were strongly associated with CVD risk factors. Low RM has been considered as a risk factor for weight gain for a given body size, which in turn leads to excess adiposity and increases the resistance to weight loss (Sepandar et al., 2019). The area under the curve of the ROC shows that low RM is proportional to LPA and inversely proportional to HPA most significantly among the tribal peoples of WB and GUJ but not among the OD, indicating ethnic heterogeneity in predisposition to CVD risk. The significant predictors for RM, FFM, and PBF were found to be WC and BMI indicating that Asian Indians are developing CVD risks even at a lower BMI and lesser WC (WHO 2000), and low resting metabolism could be a significant indicator. Over the last two decades, occupational change, change in leisure time activities shifted towards sedentary work resulting into less energy expenditure in different parts of world (Popkin, 2001). Similar findings have been noticed in various studies, for instance, in China and Philippines, decrease in physical activity was directly associated with higher preference of modernized transport (Tudor-Locke et al., 2007). In the World Health Survey (2002– 2003) comprising data of 212,021 adults from 51 countries, mostly from developing countries, it was found that around 15% of men and 20% of women were at risk for chronic diseases due to less physical activity (Guthold et al., 2008).

The ethnic groups of South Asian (including the present studied populations) had a long antiquity of low RM due to adaption to hotter climate. On the other hand, a large number of Europeans and most East Asians had higher RM due to adaption to colder climate. The genetic factors that enhance metabolic function are advantageous to people inhabiting cold climates, and thereby making them resistant towards obesity. Whereas, genetic factors that prohibit overheating, dehydration, and heat stroke would have bestowed the predecessors with sufficient survival advantage who had inhabited the subtropical and tropical areas which include Africa, Central America, Southeast Asian, and India. It is therefore ascertained that in the course of evolutionary history, the genes advantageous to effective thermoregulation underwent differential selection pressures for better survival. (Sellayah et al., 2014). It is believed that the susceptibility to obesity varies between ethnicities due to variation in exposures of predecessors of the populations adapted to different climatic pressures in the last 70,000 years.

It now seems clear that the why there exists considerable ethnic variation towards prevalence of overweight and obesity across the globe. The rate of metabolism, adiposity level, and subsequent expenditure of energy are all controlled by the genetic factors associated among the indigenous population depending upon their antiquity to adapt contrasting climatic exposure. Cold adaptation lead to more heat retention and enhanced metabolic rate whereas, heat adaptation lead to more dissipation of heat causing lower metabolic rate. Moreover, higher the metabolism causes better resistance to overweight and obesity like the East Asians and Europeans. On the other hand lower metabolism leads to greater susceptibility to overweight and obesity for instance, the African American, Hispanics, and Native Americans (Hanna, 1983). It is therefore reasonable to argue that the genes adapted for both cold and hot climate had greatly increased the coefficient of selection towards the survival.

TABLE 6 shows the average resting metabolic rates of some of the ethnic groups of different geographic location across the globe. The present studied population of South Asia have the lowest RM after African aborigines as compare to other parts the world. It clearly indicates that the groups adapted to colder climates have relatively higher RM than those are adapted to hot and humid climates. The indigenous populations of Siberia had consistently higher RM as compared to non-indigenous Siberians (Snodgrass et al. 2005; 2008). Other indigenous populations inhabiting areas closer to the poles also showed similar trend of higher RM indicating long antiquity of adaption towards colder climates (Snodgrass et al., 2007; Leonard et al., 2002; Milan & Evonuk, 1967). For instance, the Inuit peoples of the Canadian Arctic also have greatly elevated metabolic rates and are thus protected from obesity even with today's western lifestyle influence (Rode & Shephard, 1995). Metabolic rates are found to be highest among the arctic people (Snodgrass et al., 2007), followed by the white Europeans (Weyer et al., 1999), and lowest among the African Americans (Wong et al., 1999). The Scandinavian populations genetically adapted to extreme cold for over several hundred generations, although have similar lifestyle and dietary intake, but exhibits much lower rates of obesity when compared with the rest of the European population (Júlíusson et al., 2007; Midthjell et al., 2013). Despite having genetic similarities between indigenous Siberians, East Asians, and Native Americans, the latter one have lower metabolic rates and are susceptible to obesity, whereas, the indigenous Siberians and East Asians had higher metabolic rates and are resistant to obesity (Criado et al., 2013). Prevalence of type 2 diabetes and CVD are found to

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be highest among the Pima Indians living in of both U.S. and Mexico (Fontvieille et al., 1992). These differences could be attributed to long antiquity of the ancestral population that adapted to hotter climates. Interestingly, within the Pima Indians the Mexican group are still maintaining traditional lifestyle as compare to their U.S. counterparts, who adopted modernised lifestyle and therefore more susceptible to obesity than Pima Indians of Mexico (Ravussin et al., 1994). Similarly the indigenous populations living in and around the equator, including Pacific Islander, Samoans, and the Australian aborigines all have lower RM due to adaptation to hotter climate thereby making them susceptible to overweight and obesity (Friedlaender et al., 2008). Even within the U.S., populations inhabiting hotter states had higher prevalence of obesity whereas, the colder states had relatively lower rate of overweight and obesity. For instance, in Colorado, the prevalence of overweight and obesity is lowest despite being one of the coldest state (Levi et al., 2008).

It is said that the descendants of early humans who migrated to subtropical and tropical environments such as Pacific Islanders and black Americans and those who remained in Africa and conserved genes for heat adaption. Whereas, the descendants of early humans those who migrated to temperate and colder regions of Siberia and Europe attained genes for cold adaptation like Chinese and Caucasians. A subgroup of this migrated further in the subtropical regions of Central and North America resulted in to loss of genes favourable to colder climate and reacquired genes favourable for hotter climate. Hence, it is quite clear that adaptation to colder climate enabled the East Asians and Caucasians like Japanese, Koreans, and Chinese with efficient metabolic function resulting into higher resting metabolism and resistant towards obesity. However, for the people of Africa, South Asia (including India), Southeast Asia and Australia that adapted hotter climate enabled low RM and thereby resulted into increased susceptibility to obesity (Sellayah et al., 2014).

It is ascertained that the two major migrations one towards Northeast Asia and northern Europe, and the other towards Australia through Southeast Asia occurred simultaneously. The descendants of the first group adapted to colder climate and developed higher RM. The descendants of the second group adapted to hotter climate and the present indigenous people of this group exhibits low RM, dark skin colour both are indicators of resistant to obesity (Wyndham et al., 1964). It was found that the South Asians had impaired volume of brown adipose tissue and thermogenic capability when compared with Caucasians (Bakker et al., 2013) indicating the differential exposure to contrasting climate and selection pressure. The indigenous people of South Asia and Southeast Asian did not require adapting to colder climate hence they are genetically adaptation to heat. It was found that the Aborigines of Australia had higher prevalence of CVD and diabetes when compared with the non-indigenous Australians (Li et al., 2012; O'Dea 1991). It shows that genetic adaption to hotter climate, low RM and susceptibility of obesity related non-communicable diseases have had long antiquity. Increased susceptibility to obesity when coupled with modernised lifestyle (perhaps mediated through less physical activity and change in dietary habits) increased the risk of cardiovascular diseases in these parts of the world.

The present study among the nine ethnic groups of Asian Indians shows that these ethnic groups had a long antiquity of adaptation to low resting metabolic and hence susceptible to obesity and cardiovascular disease risks. It has been found that among these indigenous groups despite having low resting metabolism those who are still maintaining their traditional lifestyle are at lesser risk of CVD and those who have adopted modern lifestyle which is perhaps mediated through the recent shift in dietary habits and low physical activity. Adopting modern lifestyle making them ethnically predispose to obesity and CVD risk as the genetic make-up is highly disadvantageous to the present obesogenic environment. It is therefore suggested that resting metabolic rate is an important indicator of cardiovascular health and maintaining a higher resting metabolic rate with active lifestyle could be of paramount public health importance among the people of South Asian origin.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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REFERENCES

Bakker LEH, Boon MR, van der Linden RAD, et al. (2013). Brown adipose tissue volume in healthy lean south Asian adults compared with white Caucasians: a prospective, case-controlled observational study. *Lancet Diabetes Endocrinology,* doi:10.1016/S2213- 8587(13)70156-6.

Bose K. (1999). Relationship of age and the body mass index with subcutaneous adiposity in adult European and migrant south Asian males resident in Peterborough, England. *Journal of Human Ecology*, 10(1): 41-45. doi.org/10.1080/09709274.1999.11907443

Criado JR, Gilder DA, Kalafut MA, Ehlers CL. (2013). Obesity in American Indian and Mexican American men and women: associations with blood pressure and cardiovascular autonomic control. *Cardiovascular Psychiatry & Neurology*, 2013: 680687. doi.org/10.1155/2013/680687

Durnin, J.V.J. and J. Womersley. (1974) "Body fat assessed from total body density and its estimation from skinfold thickness: measurements on 481 men and women aged from 16 to 72 years." *British Journal of Nutrition* 32; 1: 77-97.

Esparza J., Fox C., Harper I.T., Bennett P.H., Schulz L.O., Valencia M.E., Ravussin E. (2000). Daily energy expenditure in Mexican and USA Pima Indians: low physical activity as a possible cause of obesity. *International Journal of Obesity,* 24: 55-59.

Fontvieille AM, Lillioja S, Ferraro RT, Schulz LO, Rising R, Ravussin E. (1992). Twenty-four-hour energy expenditure in Pima Indians with type 2 (non-insulin-dependent) diabetes mellitus. *Diabetologia*, 35: 753–759.

Foster G.D., Wadden T.A., Vogt R.A. (1997). Resting energy expenditure in obese African American and Caucasian Women. *Obesity Research,* 5(1): 1-8.

Friedlaender J.S., Friedlaender F.R., Reed F.A., et al. (2008). The genetic structure of Pacific Islanders. *PLoS Genetics*. 2008;4:e19. doi.org/10.1371/journal.pgen.0040019

Grundy, S.M., J.I. Cleema, S.R. Daniels, et al. 2005. "American Heart Association; National Heart, Lung, and Blood Institute. Diagnosis and management of the metabolic syndrome: An American Heart Association/National Heart, Lung, and Blood Institute Scientific Statement." *Circulation* 112: 2735–2752.

Guthold R, Ono T, Strong K.L., Chatterji S, Morabia A. (2008). Worldwide variability in physical inactivity a 51-country survey. *American Journal of Preventive Medicine*, 34(6): 486-494. 10.1016/j.amepre.2008.02.013.

Gurven M.D., Trumble B.C., Stieglitz J., Yetish G., Cummings D., Blackwell A.D., Beheim B., Kaplan H.S., Pontzer H (2016). High resting metabolic rate among Amazonian forager-horticulturalists experiencing high pathogen burden. *American Journal of Physiological Anthropology*, 161(3): 414-425.

Hanna J.M. (1983). Human heat tolerance: an anthropological perspective. *Annual Review of Anthropology,* 12:259 – 284.

Júlíusson PB, Roelants M, Eide GE, Hauspie R, Waaler PE, Bjerknes R. (2007). Overweight and obesity in Norwegian children: secular trends in weight-for-height and skinfolds. *Acta Paediatrica*, 96: 1333– 1337.

Katzmarzyk P.T., Leonard W.R., Crawford M.H., Sukernik R.I. (1994). Resting metabolic rate and daily energy expenditure among two indigenous Siberian populations. *American Journal of Human Biology*, 6(6): 719-730.

Kuriyan, R., C. Petracchi, A. Ferro-Luzzi, P. S. Shetty, A. V. Kurpad. 1998. "Validation of expedient methods for measuring body composition in Indian adults." *Indian Journal of Medical Research* 107; 37-45.

Leonard W.R., Snodgrass J.J., Sorensen M.V. (2005). Metabolic adaptation in indigenous Siberian populations. *Annual Review of Anthropology*, 34: 451-471.

Li M, McCulloch B, McDermott R. (2012) Metabolic syndrome and incident coronary heart disease in Australian indigenous populations. *Obesity (Silver Spring*). 20: 1308 –1312.

ISSN: 0975-3583, 0976-2833 VOL 12, ISSUE 03, 2021

Lohman, T.G., A.F. Roche, and R. Martorell. 1988. *Anthropometric standardization reference Manual.* Champaign, Illinois, Human Kinetics Books.

Leonard WR, Sorensen MV, Galloway VA, et al. (2002). Climatic influences on basal metabolic rates among circumpolar populations. *American Journal of Human Biology*, 14: 609 – 620.

Levi J.V., Vintner S., Richardson L., St Laurent R., Segal L.M. (2008). *F As in Fat: How Obesity Policies Are Failing in America.* Washington, DC: Trust for America's Health; 2008. 152.

Midthjell K, Lee CM, Langhammer A, et al. (2013). Trends in overweight and obesity over 22 years in a large adult population: the HUNT Study, Norway, *Clinical Obesity*. 3:12–20.

Milan FA, Evonuk E. (1967). Oxygen consumption and body temperatures of Eskimos during sleep.

Journal of Applied Physiology, 22:565–567.

Nsatimba P.A.A., Pathak K., Soares M.J. (2016). Ethnic differences in resting metabolic rate, respiratory quotient and body temperature: a comparison of Africans and European Australians. *European Journal of Nutrition*, 55(5): 1831-1838.

O'Dea K. (1991) Westernisation, insulin resistance and diabetes in Australian aborigines. *Medical Journal of Australia*, 155: 258 –264.

Piers L.S., Diffey B., Soares M.J., Frandsen S.L., McCormack, Lutschini M.J., O'Dea K. (1997). The validity of predicting the basal metabolic rate of young Australian men and women. *European Journal of Clinical Nutrition*, 51: 333-337.

Piers L.S., Rowley K.G., Soares M.J., O'Dea K. (2003). Relation of adiposity and body composition to body mass index in Australians of Aboriginal and European ancestry. *European Journal of Clinical Nutrition*, 57: 956-963.

Pontzer H., Raichen D.A., Wood B.M., Mabulla A.Z.P., Racette S.B., Marlowe F.W. (2012). Hunter-Gatherer energetics and human obesity. *PLoS One*, 7(7): e40503. doi:10.1371/journal.pone.0040503.

Popkin B.M. (2001). The nutrition transition and obesity in the developing world. *The Journal of Nutrition*, 131(3): 871S-873S. doi.org/10.1093/jn/131.3.871S

Ravussin E., Valencia M.E., Esparza J., Bennett P.H., Schulz L.O. (1994). Effects of a traditional lifestyle on obesity in Pima Indians. *Diabetes Care*. 17: 1067–1074.

Rode A, Shephard RJ. (1995). Basal metabolic rate of Inuit. *American Journal of Human Biology,* 7: 723–729.

Rush E.C., Plank L.D., Robinson S.M. (1997). Resting metabolic rate in young Polynesian and Caucasian women. *International Journal of Obesity*, 21: 1071-1075.

Sellayah D., Cagampang F.R., Cox R.D. (2014). On the evolutionary origins of obesity: a new hypothesis. *Endocrinology*, 155(5): 1573-1588.

Sepandar F, Rashidbeygi E, Maghbooli Z, Khorrami-Nezhad L, Hajizadehoghaz M, Mirzaei K. (2019). The association between resting metabolic rate and metabolic syndrome may be mediated by adipokines in overweight and obese women. *Diabetes & Metabolic Syndrome: Clinical Research & Reviews*, 13(1): 530-534. doi.org/10.1016/j.dsx.2018.10.012

Snodgrass J.J., Leonard W.R., Tarskaia L.A., Alekseev V.P., Krivoshapkin V.G. (2005). Basal metabolic rate in the Yakut (Sakha) of Siberia. *American Journal of Human Biology*, 17(2): 155-172.

Snodgrass JJ, Sorensen MV, Tarskaia LA, Leonard WR. (2007). Adaptive dimensions of health research among indigenous Siberians. *American Journal of Human Biology*, 19: 165–180.

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Snodgrass J.J., Leonard W.R., Sorensen M.V., Tarskaia L.A., Mosher M.J. (2008) The influence of basal metabolic rate on blood pressure among indigenous Siberians. *American Journal of Physiological Anthropology*, 137:145–155.

Tudor-Locke C, Ainsworth B.E., Adair L.S., Du S, Nee N, Popkin B.M. (2007). Cross-sectional comparison of physical activity and inactivity patterns in Chinese and Filipino youth. *Child Care Health Development*, 33(1): 59-66. 10.1111/j.1365-2214.2006.00612.x

Weyer C, Snitker S, Bogardus C, Ravussin E. (1999). Energy metabolism in African Americans: potential risk factors for obesity. American Journal of Clinical Nutrition, 70:13–20.

Wong WW, Butte NF, Ellis KJ, et al. (1999). Pubertal African-American girls expend less energy at rest and during physical activity than Caucasian girls. *Journal of Clinical Endocrinology & Metabolism*, 84: 906 –911.

World Health Organization. 2000. *WHO/IASO/IOTF – the Asia-Pacific Perspective: Redefining Obesity and its treatment*. Health Communications Australia Pty Ltd.

Wyndham CH, McPherson RK, Munro A. (1964). Reactions to heat of Aborigines and Caucasians. *Journal of Applied Physiology*, 19: 1055–1058.

TABLE 1 Prevalence (%) of low physical activity and cardio-metabolic risk variables

Ethnic Groups	Gender	n	LPA	Higher PBF	Higher WC	Higher SBP	Higher DBP	Higher FBG	Higher BMI
						Prevalence (%)			
Santal WB	Male	123	22.8	4.9	2.4	39.0	30.1	74.8	12.2
	Female	122	36.1	26.2	3.3	29.5	30.3	63.1	12.3
Oraon WB	Male	114	30.7	21.1	0.9	34.2	29.8	62.3	9.6
	Female	124	22.6	20.2	0.8	43.5	50.0	62.1	5.6
Kora WB	Male	114	22.8	31.6	0.0	27.2	34.2	61.4	1.8
	Female	121	25.6	32.2	0.0	33.9	28.1	62.8	1.7
Bhumij OD	Male	116	20.7	9.5	8.6	46.6	26.7	80.2	25.0
	Female	122	30.3	34.4	5.7	41.8	44.3	69.7	10.7
Santal OD	Male	121	26.4	14.0	5.0	40.5	22.3	81.0	14.9
	Female	119	31.1	50.4	10.9	37.0	41.2	80.7	15.1
Bathudi OD	Male	119	31.9	19.3	5.0	35.3	19.3	79.0	10.9
	Female	121	27.3	23.1	0.0	44.6	47.1	53.7	4.1
Dhodia GJ	Male	120	42.5	7.5	11.7	35.0	20.8	65.0	16.7
	Female	120	39.2	30.8	9.2	45.8	34.2	72.5	23.3
Kukna GJ	Male	119	30.3	26.9	13.4	40.3	29.4	64.7	16.8
	Female	120	26.7	21.7	4.2	35.8	28.3	62.5	16.7
Chaudhari GJ	Male	120	27.5	28.3	11.7	35.0	20.8	65.0	16.7
	Female	121	28.9	41.3	0.8	27.3	27.3	62.8	10.7
Total	Male	1066	26.1	18.0	6.6	37.1	25.9	70.5	13.9
	Female	1090	29.7	31.1	3.9	37.7	36.8	65.5	11.1

LPA = low physical activity, PBF = percentage body fat, WC = waist circumference, SBP = systolic blood pressure, DBP = diastolic blood pressure, FBG = fasting blood glucose, BMI = body mass index

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TABLE 2A Descriptive of the studied male populations

Ethnic Groups	n	RM (Kcal)		FFM (Kg)		PBF (%)	
		Mean	+ SD	Mean	+ SD	Mean	+ SD
Santal WB	123	1323.89	146.48	42.550	6.87	18.433	5.71
Oraon WB	114	1312.02	130.59	42.732	7.18	17.246	6.57
Kora WB	114	1247.46	116.88	39.711	6.55	17.289	6.48
Bhumij OD	116	1347.86	198.27	44.190	7.09	18.834	6.42
Santal OD	121	1327.58	160.83	43.119	7.83	18.731	6.24
Bathudi OD	119	1142.42	383.95	40.301	6.13	15.460	7.17
Dhodia GJ	120	1328.22	145.41	41.041	6.49	22.096	5.70
Kukna GJ	119	1339.68	151.53	41.727	7.15	21.635	6.85
Chaudhari GJ	120	1318.22	142.42	40.031	6.41	22.046	5.30
ANOVA#		13.897***		5.128***		16.650***	

*#Post-Hoc Tukey's-b; *** P < 0.001; degree of freedom between groups = 8*

TABLE 2B Descriptive of the studied female populations

Ethnic Groups	n	RM (Kcal)		FFM (Kg)		PBF (%)	
		Mean	+ SD	Mean	+ SD	Mean	+ SD
Santal WB	122	1005.37	139.42	31.319	4.53	27.283	4.44
Oraon WB	124	967.40	102.72	32.001	4.97	25.381	6.07
Kora WB	121	926.47	175.42	29.621	4.19	25.095	2.64
Bhumij OD	122	1034.11	114.39	32.023	4.74	27.251	5.81
Santal OD	119	1040.27	145.94	33.053	5.03	27.721	7.02
Bathudi OD	121	951.48	128.96	29.025	4.34	24.341	6.09
Dhodia GJ	120	1044.82	150.13	31.633	4.74	31.362	5.92
Kukna GJ	120	1013.57	165.69	31.138	4.34	30.141	5.69
Chaudhari GJ	121	1013.05	101.25	30.988	4.44	28.180	6.07
ANOVA#		11.095***		1.469; ns		16.999***	

*#Post-Hoc Tukey's-b; *** P < 0.001; degree of freedom between groups = 8; ns = not significant*
RM = resting metabolism, FFM = fat free mass, PBF – percentage body fat

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TABLE 3 Results of two-way analysis of variance (ANOVA) – interaction between gender and ethnic-groups on RM, FF, and PBF among younger and older generations.

		Younger Generation (< 40 yrs)			Older Generation (≥ 40 yrs)		
		RM	PBF	FFM	RM	PBF	FFM
Gender	SS	26802511.1	17946.6	35604.9	21648566.2	17015.6	22185.3
	F	1036.279	645.437	1358.015	767.717	495.544	181.304
	P	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Ethnic Groups	SS	2915634.8	4412.6	1894.8	2414066.8	5644.7	1403.5
	F	14.091	19.837	9.034	10.701	20.549	1.434
	P	<0.001	<0.001	<0.001	<0.001	<0.001	0.178
Interaction	SS	826607.1	301.4	810.2	619634.4	778.8	889.9
	F	3.995	1.355	3.863	2.747	2.835	0.909
	P	<0.001	0.212	<0.001	0.005	0.004	0.508

SS – sum of squares, F – value of the F-statistics, p – probability value, Post-Hoc Tukey's b.
RM = resting metabolism, FFM = fat free mass, PBF – percentage body fat

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TABLE 4 Partial Correlation between body composition and cardio-metabolic risk variables (controlling for age, sex, ethnic groups, and physical activity).

Variables	RM	FFM	PBF
WC	0.543***	0.413***	0.425***
SBP	0.145***	0.144***	0.081***
DBP	0.151***	0.123***	0.109***
FBG	0.049*	0.092***	0.068**
BMI	0.629***	0.466***	0.516***

* P<0.05; ** P< 0.01; *** P<0.001

RM = resting metabolism, FFM = fat free mass, PBF – percentage body fat

TABLE 5 Stepwise multiple regression with cardio-metabolic risks as independent variables

Dependent Variables	β	R^2	R^2 change	Significant Predictor(s)
RM	0.513***	0.402	0.402	WC
	0.198***	0.418	0.016	BMI
	-0.101***	0.429	0.010	DBP
	-0.075***	0.434	0.005	FBG
FFM	0.346***	0.238	0.238	WC
	0.206***	0.255	0.017	BMI
	-0.086***	0.263	0.007	DBP
PBF	0.454***	0.107	0.107	BMI
	0.193***	0.145	0.038	DBP
	-0.223***	0.165	0.021	WC
	0.059**	0.168	0.003	FBG

* P<0.05; ** P< 0.01; *** P<0.001, WC = waist circumference, BMI = body mass index, DBP = diastolic blood pressure, FBG = fasting blood glucose, RM = resting metabolism, FFM = fat free mass, PBF – percentage body fat

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TABLE 6 Resting Metabolic Rate (RMR) of different ethnic groups worldwide

Sl. No.	Ethnic Groups	Geographical Location	Mean RMR		Author(s)
			Males	Females	
1.	Inuits	Igloolik, Canada	1828 ∧	1656 ∧	Rode & Shephard, 1995
2.	Evenki & Keto	Siberia, Russia	2290 ∧	1786 ∧	Katzmarzyk et al., 1994
3.	Buryat	Siberia, Russia	2021 ∧	1586 ∧	Leonard et al. 2005
4.	Yakut (Sakha)	Siberia, Russia	1820 ∧	1709 ∧	Snodgrass et al. 2005
5.	Mexican Pima Indians vs.	Maycoba, Mexico &	1529 ∨		Esparza et al., 2000
	US Pima Indians	Arizona, USA	1881 ∧		
6.	African American vs. Whites	USA	-	1637 ∨	Foster et al. 1997
			-	1731 ∧	
7.	Tsimane	Amazonia	1991	1632	Gurven et al., 2016
8.	European Australian vs.	Australia	2018 ∧	1566 ∧	Piers et al., 2003
	Aboriginal Australian		1845	1519	
9.	Sub-Saharan African vs.	Australia	1070 ∨		Nsatimba et al., 2015
	European Australian		1429 ∧		
10.	Caucasians vs.	New Zealand	-	1663	Rush et al., 1997
	Polynesians		-	1703	
11.	Hazda (hunter-gatherer)	Tanzania	1466∨	1270 ∨	Pontzer et al., 2012
	Western (Markets)	Europe, USA	1948∧	1626 ∧	
	Bolivian Farmers	Bolivia	1418∨	1310 ∨	
12.	Asian Indian Tribes	India	1300∨	1000 ∨	Present Study, 2021

∧ higher RMR; ∨ lower RMR

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FIGURE 1 Geographic location of the selected areas

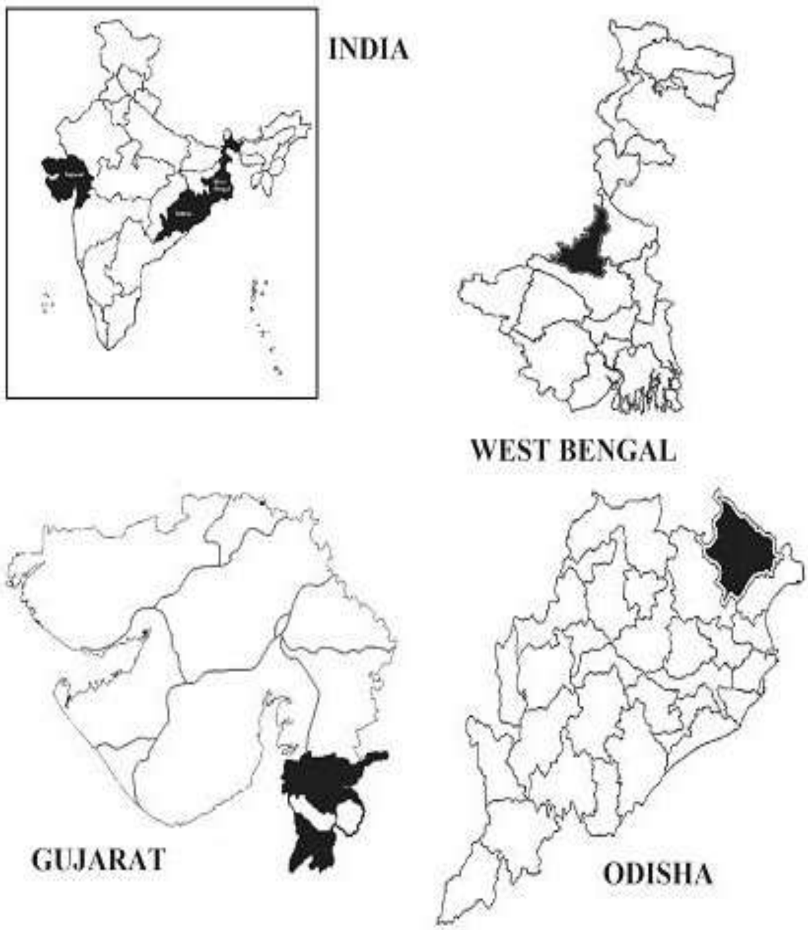

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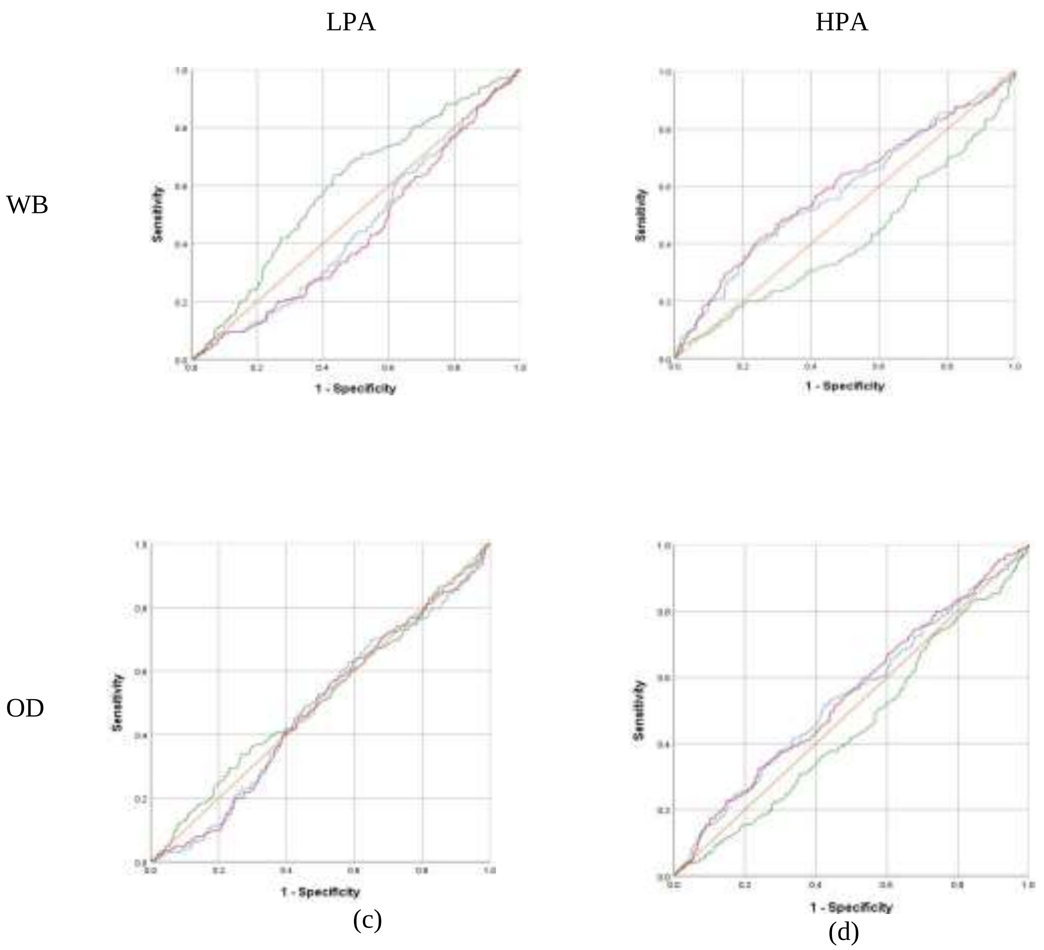
FIGURE 2 Receiver Operating Characteristic (ROC) Curve of Resting Metabolism, Fat Free Mass, and Percentage Body Fat by Physical Activity Level in three states



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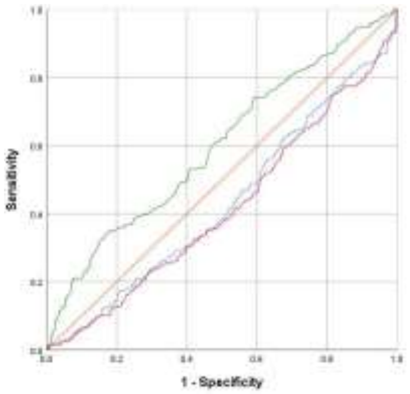
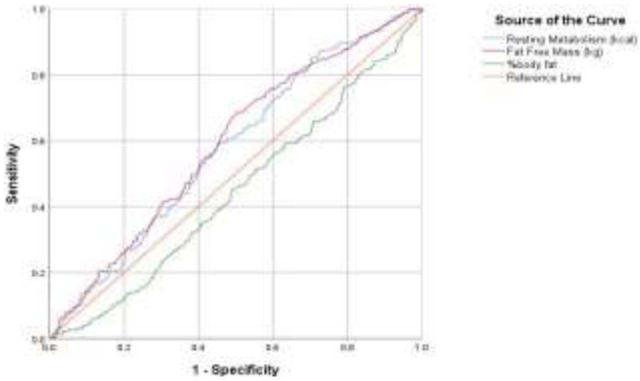
GJ



(e)



(f)

Area Under the Curve (AUC)			RM		FFM		PBF	
			AUC	Asymptotic Sig.	AUC	Asymptotic Sig.	AUC	Asymptotic Sig.
WB	a.	LPA	0.453	0.065	0.435	0.025	0.596	0.024
	b.	HPA	0.580	<0.001	0.591	0.023	0.416	0.023
OD	c.	LPA	0.479	0.375	0.480	0.399	0.515	0.025
	d.	HPA	0.540	0.084	0.545	0.050	0.452	0.035
GJ	e.	LPA	0.431	0.004	0.415	<0.001	0.598	<0.001
	f.	HPA	0.577	0.001	0.589	<0.001	0.444	0.015