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Concurrent validity of the non-exercise based VO_2max prediction equation using percentage body fat as a variable in asian Indian adults

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Abstract

Background: Aerobic capacity (VO_2max) is highly dependent upon body composition of an individual and body composition varies with ethnicity. The purpose of this study was to check the concurrent validity of the non-exercise prediction equation developed by Jackson and colleagues (1990) using percentage body fat as a variable in Asian Indian adults.

Methods: One hundred twenty college-aged participants (60 male, 60 female, mean age 22.02 ± 2.29 yrs) successfully completed a maximal graded exercise test (GXT) on a motorized treadmill to assess VO_2max . VO_2max was then estimated by the non-exercise prediction equation developed by Jackson and colleagues (1990) using percentage body fat. Percentage body fat was calculated by three different models (Sandhu et al's fat mass equation, Durnin-womersley's 4 site percentage body fat and Jackson & Pollock's 4 site percentage body fat) and was used in the above equation. The results of VO_2max obtained using "gold standard" treadmill methods were then compared with the three results of VO_2max obtained by Jackson et al's equation (using three different models to calculate percentage body fat) and it was determined which equation is best suited to determine percentage body fat and in turn VO_2max for Indian population.

Results: Jackson et al's prediction equation overpredicts VO_2max in Asian Indian subjects who have a lower VO_2max (33.41 ± 14.39 ml/kg/min) than those reported in other age matched populations. percentage body fats calculated by the three equations were significantly different and the correlation coefficient (r) between VO_2max calculated by Jackson and colleagues (1990) using Sandhu et al's equation for percentage body fat with VO_2max calculated using treadmill (gold standard) ($r = .817$) was found slightly more significantly correlated than the other two equations and was not statistically different from the measured value.

Conclusions: This study proves that VO_2max equation using Sandhu et al's model for percentage body fat yields more accurate results than other studied equations in healthy college-aged participants in India.

Background

Maximal oxygen uptake or consumption (VO_2max) is the maximum capacity of an individual's body to transport and use oxygen during incremental exercise which reflects the physical fitness of an individual [1]. The measurement of VO_2max as a parameter of cardio-respiratory fitness is useful when educating individuals about their overall fitness status, considering cardiovascular risk such as physical inactivity and overweight

status [2]. Since this method involves the direct measurement of expired gas samples, it is considered highly reliable and accurate and is, thus considered the "gold standard" for determining VO_2max [3]. This approach though is practically difficult, requires fairly expensive equipment and the assistance of trained personnel. Accurately measuring the VO_2max involves a physical effort sufficient in duration and intensity to fully tax the aerobic system, the performance of which is influenced by the individual's motivation. This intense effort makes the procedure difficult to perform because of which, some older or higher-risk individuals should not perform the test without medical supervision [4].

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As a result, researchers have generated various non-exercise based tests for predicting VO_2max that utilize variables of physical parameters (viz. age, gender, height, weight, BMI, body fat percentage) [4]. There are very few valid models available which utilize percentage body fat as a determinant of VO_2max . These models include those of Heil *et al.* (1995) [5] and Jackson *et al.* (1990) [6]. Body composition is known to vary with ethnicity [7]. People of South Asian origin have a higher percentage of body fat for any given BMI while those of Black Caribbean origin have a lower percentage body fat for any given BMI [8-11], (c.f. Higgins, 2008) [12]. Higher amounts of body fat and obesity are associated with increased risk of adverse health events and greater mortality [13]. Obesity has been defined by the American College of Sports Medicine [2] as an excessive amount of adipose tissue, which is defined in young adults as body fat >25percentage in males and >32percentage in females.

Percentage of body fat is usually assessed by using skinfold thickness in clinical & field setting because this method is simple to use and low in cost [14]. Regression equations are used to calculate body composition (body density, percentage body fat) from these skinfold measurements [15]. However, as all these prediction equations are based on mathematical relationships, they predict body composition only if population resembles the reference population that was used in the development of the prediction equation [16]. Most of the existing equations or the estimation of body fat percentage for example Jackson and Pollock [6] and Durnin and Womersley [17] which are widely used in epidemiological studies using skinfolds have been developed and validated in the Caucasian population and tend to under predict body fat percentage in Asian Indians. Considering the ethnic differences in fat percentage in 2010, Sandhu *et al.* [18] developed a body fat mass prediction equation for young Indian adults using skinfold data and body fat percentage using under water weighing.

Several non exercise prediction equations for the estimation of VO_2max use percentage body fat in their formulation. Again these equations were also developed and validated in ethnic populations other than Indians. The ethnic differences in percentage body fat may make them unsuitable for use in Asian Indians. Jackson *et al.* (1990) [6] & Heil *et al.* (1995) [5] proposed prediction models which use body fat percentage of an individual in their formulation. These equations have been shown to be fairly reliable and valid. Researchers [19] have checked the cross-validation of non-exercise models (N-Ex) [6] and have found it accurate for healthy adults and suggested its use in epidemiological studies.

We believe that these N-Ex prediction equations may not be very accurate in the Asian Indian population because of the inherent differences in body compositions that exist in different races, specifically the fact that for a given BMI the percentage body fat in Asian Indians is higher [20] and hence a limited sub maximal aerobic capacity and reduced VO_2max relative to body weight [21]. Jackson [6] equation has been widely used in epidemiological studies. Since it utilizes body fat percentage in its formulation, our study was designed with the objective of trying to examine the correlation between lab measurement of VO_2max and the VO_2max calculated through [6] NEX prediction equation. As it incorporates an individual's body fat percentage we decided to use the body fat percentage calculated through 3 methods and analyse which of these predicted VO_2max values more closely to the lab measured VO_2max . Lastly we wanted to analyze the validity of this non-exercise prediction equation using body fat percentage calculated through the above methods.

Methods

Participants and procedures

One hundred twenty college students (males = 60; females = 60), aged 18 to 27 year, satisfied the requirements of this study. Volunteers, recruited for the study, were primarily the students of Department of Sports Medicine & Physiotherapy, Guru Nanak Dev University, Amritsar, Punjab India. Criteria for inclusion in the study were, participants who were non athletic, but who occasionally participated in recreational activities, who were able to perform exercise, with no prior history of cardiovascular, peripheral vascular, respiratory diseases, malignancy, orthopaedic or musculoskeletal lesion. Subjects should have been non smokers, non alcoholic, not taking any medications and non diabetics. All participants signed an informed consent document in accordance with University ethical Committee guidelines.

Non exercise questionnaires and physical measurements

Prior to testing, all subjects completed

*brief Physical Activity Readiness Questionnaire (PAR-Q) [22] to screen for cardiovascular contraindications.

*Physical Activity Recall (PA-R) questionnaire (0-7 scale) [6].

The physical activity rating (PAR) was determined as follows

The participant was asked to give the appropriate PAR score (0-7) based on the following scale:

- I. Does not participate regularly in programmed recreation, sport, or physical activity.

- 0 points: Avoids walking or exercise (for example, always uses elevators, drives whenever possible instead of walking).
- 1 point: Walks for pleasure, routinely uses stairs, occasionally exercises sufficiently to cause heavy breathing or perspiration.
- II. Participates regularly in recreation or work requiring modest physical activity (such as golf, horseback riding, calisthenics, gymnastics, table tennis, bowling, weight lifting, or yard work).
- 2 points: 10–60 min per week
3 points: Over 1 h per week
- III. Participates regularly in heavy physical exercise (such as running or jogging, swimming, cycling, rowing, skipping rope, running in place) or engages in vigorous aerobic type activity (such as tennis, basketball, or handball).
- 4 points: Runs less than 1 mile per week or spends less than 30 min per week in comparable physical activity.
- 5 points: Runs 1–5 miles per week or spends 30–60 min per week in comparable physical activity.
- 6 points: Runs 5–10 miles per week or spends 1–3 h per week in comparable physical activity.
- 7 points: Runs more than 10 miles per week or spends more than 3 h per week in comparable physical activity.

Four-site skinfold measures were evaluated for females and males (biceps, triceps, subscapularis, and suprailiac) using Harpenden caliper to determine percent body fat (percentage fat).

Participants were instructed to drink plenty of water and abstain from strenuous exercise for 24 h prior to testing, and not to consume food, alcohol, caffeine, or tobacco products three hours before testing [2]. Each participant was fitted with a HR monitor (Polar Inc., NY) to measure exercise HR during the maximal GXT on a calibrated motor driven treadmill (Vacuumed Vista MX, California, USA). Participants' height and body mass were measured and recorded while wearing light-weight clothing and no shoes, using a stadiometer and calibrated digital weight scale (model: EB-EQ90, equinox overseas (P) Ltd., India). Instructions about the maximal GXT (involving the protocol, electronic heart rate monitor, mouth piece, and rating of perceived exertion (RPE) scale [23] were given to all participants prior to testing. Also participants were allowed to practice treadmill walking/jogging as needed to become familiar with the equipment.

Maximal treadmill graded exercise test

Participants performed a maximal GXT using Bruce graded GXT protocol [24] consists of seven stages. Each stage comprised of 3 mins. During the maximal GXT, metabolic gases were collected using the Vacuumed Vista MX metabolic measurement system (California, USA). The VO_2max and respiratory exchange ratio (RER) were computed, averaged, and printed by an online computer system every 10 seconds. The participants' exercise heart rate (HR) and RPE score was recorded at the end of each stage. VO_2max was considered valid when at least two of the following criteria were met [4]:

- 1 Maximal heart rate within 15 beats of age predicted maximal heart rate [25].
- 2 Respiratory exchange ratio equal to or greater than 1.10 [26].
- 3 RPE equal to or greater than 17.
- 4 The subject did not show any increase in oxygen consumption even after increasing the intensity of exercise.
- 5 Participants who failed to meet at least two of these criteria were dropped from the study.

Body fat percentage was then calculated by using three different formulae i.e.

- 1 Sandhu et al's fat mass equation [18] (S's eqn)
- 2 Durnin-Womersley's 4 site percentage body fat [17] (D-W 's eqn) and
- 3 Jackson & Pollock's 4 site percentage body fat [27]. (J-Ps eqn)

The calculated body fat percentage was utilized in the estimation of VO_2max by using Jackson et al's [6] prediction equation i.e.

N – Ex VO_2max using percentageF

$$= 50.513 + 1.589 (\text{History of physical fitness } 0 - 7) \\ - 0.289 (\text{age}) - 0.552 (\text{percentageF}) \\ + 5.863 (\text{gender } 0 - 1).$$

Statistics

Three different formulae for the calculation of body fat percentage for males and females were applied and thus three different values of the same for both males and females were obtained. ANOVA was applied to test for the statistical significance between these values followed by Scheffe's post hoc test. Then VO_2max was calculated by substituting these body fat percentages in Jackson et al's (1990) [6] equation. Again ANOVA was applied to the VO_2max calculated through different percentage

Table 1 VO₂ max values obtained by the substitution of body fat values obtained by different formulae

	Mean ± SD ml/kg/min
VO ₂ max (Lab)	33.41 ± 14.39
1. VO ₂ max (J-JP)	43.25 ± 7.81
2. VO ₂ max (J-DW)	40.47 ± 8.79
3. VO ₂ max (J-S)	36.05 ± 6.04

body fat followed by post hoc Scheffe's test. Inter- class correlation matrix was also used on the calculated VO₂ max (through substituting percentage body fats) to test the correlation between the measured VO₂max and the calculated VO₂max.

Results

Table 1 shows the mean values and standard deviations of the VO₂ max obtained by a graded exercise treadmill test in the lab indicated as VO₂max (lab); the VO₂max obtained by substituting body fat percentage value obtained by Jackson and Pollock's equation(JP eqn) for estimation of body fat through skinfolds indicated as VO₂ max(J-JP); the VO₂ max obtained by substituting body fat percentage value obtained from Durnin and Womersley's equation(DWs eqn) [17] for estimation of body fat percentage indicated as VO₂ max (J-DW); and theVO₂max obtained by substituting body fat percentage obtained from Sandhu et al's [18] body fat equation(Ss eqn) for the estimation of fat mass indicated as VO₂ max (J-S). This table indicates that VO₂ max (J-S) gives a mean value (36.05 + _6.04 ml/kg/min) which is closest to the measured VO₂max (mean value of 33.41 + _14.39 ml/kg/min) as compared to VO₂max (J-JP) and VO₂max (J-DW) which clearly overestimate the VO₂ max in our subjects. ANOVA values indicated in Table 2 further highlight the fact that the differences between the values for VO₂ max obtained from the 3 equations and measured lab value are statistically significant. Post hoc analysis using Scheffe's test in Table 3 shows that the difference between VO₂max (lab) and VO₂max (J-S) is not statistically significant

(p = 0.226) but the differences between VO₂max (lab) and VO₂ max(J-JP) and VO₂max(J-DW) are statistically significant(p < 0.0001). The application of Inter class correlation matrix (Table 4) further indicates that Vo₂ max (J-S) is slightly more correlated to the measured VO₂ max than the others. Table 2 also indicates the analysis of variance for percentage body fat. The "F" value 191.103 is highly significant. The application of post hoc Scheffe's test indicates that all 3 body fat percentages were significantly different (p < 0.05).

Discussion

In this study we measured the VO₂max by means of a GXT in college aged participants in India. This study was conducted to check the validity of Jackson et al's [6] VO₂max prediction equation using percentage body fat as a variable. An earlier study [21] has indicated that obese individuals have a reduced (VO₂max) relative to body weight thus indicating that percentage body fat has a significant effect on the aerobic capacity (VO₂max) of an individual. Secondary to this is the fact that body composition varies with ethnicity [7]. Recent evidence in the field of body composition has indicated that racial differences may exist in body composition. Specifically researchers [28] have indicated that Asians had more subcutaneous fat than whites and had different fat distributions from whites. Asians had more upper-body subcutaneous fat than whites. Researchers [28] have also indicated that BMI for given weight under predicts the percentage body fat in Asian Indians. A study [29] has indicated that for the same BMI, percentage BF for Pacific Island men was 4percentage points lower and for Asian Indian men was 7–8percentage points higher compared to Europeans. Compared to European men for the same percentage BF, BMI was 2–3 units higher for Pacific Island and 3–6 units lower for Asian Indians. Asian Indians have more abdominal fat deposition than their European and Pacific Island counterparts. Considering this evidence we believed that prediction equations for the estimation of VO₂max would be inaccurate and

Table 2 Analysis of Variances (ANOVA) for VO₂max and percentage Body fat from Jackson Pollock, Durnin Womersley and Sandhu

1. VO ₂ Max	Sum of squares	df	Mean square	F	Sig.
Between Groups	6977.761	3	2325.920	24.343	.000*
Within Groups	45480.583	476	95.547		
Total	52458.345	479			
2. percentage Body Fat	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	8237.445	2	4118.722	191.103	.000*
Within Groups	3814.765	177	21.552		
Total	12052.210	179			

*The mean difference is significant at the 0.05 level.

Table 3 Post Hoc Test Scheffe's for VO₂max(lab),VO₂max (J-JP),VO₂max (J-DW) and VO₂max (J-S)

Variables	Sig.	95percentage confidence interval	
		Lower Bound	Upper Bound
VO ₂ max (lab)			
VO ₂ max (J-JP)	.000*	-13.3742	-6.2935
VO ₂ max (J-DW)	.000*	-10.6037	-3.5230
VO ₂ max (J-S)	.226	-6.1785	.9022
VO ₂ max (J-JP)			
VO ₂ max (J-DW)	.187	-.7698	6.3109
VO ₂ max (J-S)	.000*	3.6554	10.7361
VO ₂ max (J-DW)			
VO ₂ max (J-S)	.007*	.8849	7.9656

*. The mean difference is significant at the 0.05 level.

substituting percentage body fat values obtained from formulae developed specifically for Asian Indians would be better correlated to lab measured values of VO₂max.

Our results indicated that our Asian Indian subjects indeed did have lower VO₂max values as compared to age matched subjects from Caucasian populations indicating a lower level of fitness. Specifically we recorded a mean value of 33.41 ± 14.39 ml/kg/min which is much lower than those recorded by other investigators in age matched subjects (Heil *et al* [5]. : 45.83 ± 6.57 ml/kg/min and Bradshaw *et al.* [22] : $45.17 + -7.59$ ml/kg/min). We believe the lower levels could be because of two reasons. Firstly as reported by previous investigations our subjects did indeed have greater amounts of fat mass for a given weight as compared to other ethnicities which would indeed hamper fitness and not contribute to metabolic activity. Secondly is observation that in general South Asians have lower levels of physical fitness than their European counterparts [30,31]. Reasons for this have been suggested to a more restricted range of sporting and leisure activities than Europeans [30].

We also found that Jackson *et als*' [6] predictive equation overestimated the VO₂max compared to the measured value irrespective of which of the three studied equations was used to estimate the fat percentage of subjects. However of the three studied equations we found that substituting fat percentage values obtained from Sandhu *et al's* [18] fat mass equation yielded a VO₂max value that was closer to the measured value as compared to the other two equations. This better correlation observed could be due to the fact that the indigenously developed body fat mass equation generated by Sandhu

et al., 2010 [18] used actual values of body fat measured using the "gold standard" under water weighing method in its generation and the fact that it was developed on Asian Indian subjects increased its accuracy in this population.

Earlier researchers have proved that Durnin- Womerslay's [17] equation, which was derived using under-water weighing method, over estimate body fat and percentage body fat in populations of developing countries [32]yet it is widely used in many epidemiological studies. Similarly Jackson and Pollock's [6] equation also developed in Caucasian populations is also used worldwide for the estimation of body fat percentage.

Our study has many implications. Despite the fact that we had delimited our study to the investigation of only one predictive equation, our study suggests that prediction equations may not be very accurate when used in populations other than those on whom they were generated. Hence they need to be used with caution in other ethnic populations. Though this study indicates that when fat percentage is determined, Sandhu *et al's* [18] equation is used, the value for VO₂ max is slightly more reliable than the other two. However, further study regarding its validity when it is used in prediction equation is warranted. Therefore, validation of Sandhu *et al's* [18] equation and cross validation of Durnin-Womerslay's [17] body fat equation is warranted.

Conclusions

Our results suggest caution in the use of Jackson *et al's* [6] equation in Indian population given the observation that it tends to over predict the VO₂max in Asian Indian subjects. Similarly the validity of equations for the measurement of percentage body fat is also questionable when used in this population. Thus our study supports the development and validation of population specific prediction equations for the estimation of both body fat and VO₂max.

Table 4 Inter class correlation between VO₂max(lab), VO₂max (J-JP),VO₂max (J-DW) and VO₂max (J-S)

	Vo2max (lab)	VO2(J-JP)	VO2(J-DW)	VO2(J-S)
Vo2max	1.000	.807	.814	.817

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

SS conceived and designed the study, interpreted the data, drafted and revised the manuscript. BT carried out the data collection, statistical analysis and interpretation and drafted the manuscript. JS participated in its design, coordination and revised it critically for important intellectual content. All authors read and approved the final manuscript.

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References

1. Lars H, Lange A: **Aerobic work capacity in young Norwegian men and women.** *J. of Applied Physiology* 1965, **20**(3):425-431.
2. American College of Sports Medicine: *ACSM's Guidelines for Exercise Testing and Prescription*. 7th edition. Philadelphia, PA: Lippincott Williams & Wilkins Publishers; 2006.
3. American College of Sports Medicine: *ACSM's guidelines for exercise testing and prescription*. 8th edition. Baltimore, MD: Lippincott Williams & Wilkins; 2010.
4. American College of Sports Medicine: *ACSM's guidelines for exercise testing and prescription*. 6th edition. Philadelphia: Lippincott Williams & Wilkins; 2000.
5. Heil DP, Freedson PS, Ahlquist LE, Price J, Rippe J: **Nonexercise regression models to estimate peak oxygen consumption.** *Med Sci Sports Exerc* 1995, **27**:599-606.
6. Jackson AS, Blair SN, Mahar MT, Wier LT, Ross RM, Stuteville JE: **Prediction of functional aerobic capacity exercise testing.** *Med Sci Sports Exerc* 1990, **22**:863-870.
7. Harsha DW, Bray GA: **Body composition and childhood obesity.** *Endocrinol Metab Clin North Am* 1996, **25**:871-878.
8. Snehaltha C, Viswanathan V, Ramachandran A: **Cutoff values for normal anthropometric variables in Asian Indian adults.** *Diabetes Care* 2003, **26**:1380-1384.
9. McKeigue PM, Shah B, Marmot MG: **Relation of central obesity and insulin resistance with high diabetes prevalence and cardiovascular risk in South Asians.** *Lancet* 1991, **337**:382-386.
10. Prentice A, Jebb S: **Beyond body mass index.** *Obes Rev* 2001, **2**:141-147.
11. Rush EC, Goedecke JH, Jennings C, Miclesfield L, Dugas L, Lambert EV, Plank LD: **BMI, fat and muscle differences in urban women of five ethnicities from two countries.** *Int J Obesity* 2007, **31**:1232-1239.
12. Higgins V: **Ethnic Differences in Obesity, Diet and Physical Activity - A Literature review.** *CCSR Working Paper* 2008, **17**:1-20.
13. Deurenberg P, Deurenberg YM, Wang J, Lin FP, Schmidt G: **The impact of body build on the relationship between body mass index and percent body fat.** *Int J Obesity* 1999, **23**:537-542.
14. Heymsfield S, Smith R, Aulet M, Benson B, Litchman S, Wang J, Pierson NR Jr: **Appendicular skeletal muscle mass: measurement by dual-photon absorptiometry.** *Am J Clin Nutr* 1990, **52**:214-218.
15. Jackson AS, Pollock ML: **Generalized equations for predicting body density for men.** *Br J Nutr* 1978, **40**:497-504.
16. Wickramasinghi VP, Laabadusuriya SP, Clegghorn GJ, Davis PS: **Development of height weight based equation for assessment of body composition in Sri Lankan Children.** *Indian J. of Paediatrics* 2010, **77**:155-160.
17. Durnin JV, Womersley GA: **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.** *Brit J of Nutr* 1974, **32**:77-97.
18. Sandhu JS, Gupta G, Shenoy S: **Prediction equation for calculating fat mass in young Indian adults.** *Asian J of Sports Med* 2010, **1**(2):101-107.
19. Williford HN, Scharff-Olson M, Wang N, Blessing DL, Smith FH, Duey WJ: **Cross-validation of non-exercise predictions of VO2peak in women.** *Med Sci Sports Exerc* 1996, **28**:926-930.
20. Liew CF, Seah ES, Yeo KP L: **Nondiabetic asian Indians have decreased insulin sensitivity and insulin clearance, and raised leptin compared to Caucasians and Chinese subjects.** *Int J Obes* 2003, **27**:784-789.
21. Goran M, Fields DA, Hunter GR, Herd SL, Weinsier RL: **Total body fat does not influence maximal aerobic capacity.** *Int J Obes* 2000, **24**:841-848.
22. Bradshaw DJ, George JD, Hyde A, LaMonte MJ, Vehrs PR, Hager RL, Yanowitz FG: **An accurate VO2max non-exercise regression model for 18-65-year-old adults.** *Res Q Exerc Sport* 2005, **76**(4):426-432.
23. Borg GAV: **Psychophysical Bases of Perceived Exertion.** *Med Sci Sports Exerc* 1982, **14**:377-381.
24. Bruce RA, Kusumi F, Hosmer D: **Maximal oxygen intake and nomographic assessment of functional aerobic impairment in cardiovascular disease.** *Am Heart J* 1973, **85**:546-562.
25. Howley ET, Bassett DR Jr, Welch HG: **Criteria for maximal oxygen uptake: a review and commentary.** *Med Sci Sports Exerc* 1995, **9**:1292-1301.
26. Issekutz B, Birkhead NC, Rodahl K: **The use of respiratory quotients in assessment of aerobic power and capacity.** *J of App Physiol* 1962, **1**:47-50.
27. **Body fat calculator 6 formula to calculate body fat percentage Database.** <http://www.linear-software.com/online.html>.
28. Wang J, Thornton JC, Russell M, Burastero S, Heymsfield S, Pierson NR Jr: **Asians have lower body mass index (BMI) but higher percent body fat than do whites: comparisons of anthropometric measurements.** *Am J Clin Nutr* 1994, **60**:23-28.
29. Elaine R, Lindsay P, Vishnu C, Manaia L, David S, Boyd S, Chittaranjan Y: **Body size, body composition, and fat distribution: a comparison of young New Zealand men of European, Pacific Island, and Asian Indian ethnicities.** *NZMJ* 2004, **117**:1207.
30. Hayes L, White M, Unwin N, Bhopal R, Fichsbacher C, Harland J, Alberti KGM: **Patterns of Physical activity and relationship with risk markers for cardiovascular disease and diabetes in Indian, Pakistani Bangladeshi and European adults in a UK population.** *Journal of Public Health Medicine* 2002, **24**(3):170-178.
31. Erens B, Primatesta P, Prior G: **Health Survey for England 1999.** In *The Health of Minority Ethnic Groups*, Volume 1. London: TSO; 2001.
32. Immik MD, Flores R, Diaz EO: **Body mass index, body composition and chronic energy deficiency classification of rural adult population in Guatemala.** *Eur J Clin Nutr* 2003, **77**:71-75.

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