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Estimation of heritability of anthropometry, body composition and blood pressure measures using different methods

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Abstract

Background: The dynamics of gene – environment interaction on occurrence of a disease or trait is complex. Present study is aims to estimate heritability of anthropometry, body composition and blood pressure using parent-offspring and midparent-offspring model.

Materials& Methods: The study was conducted between December 2019 and January 2020. The data was collected on 41nuclear families from six villages about 35 km apart from Kolkata. Apparently healthy sib pair aged 10-18 y and their respective parents were selected in this study.

Results: In parent-offspring and mid parent-offspring model, the ratio of regression sum of square (RSS considered as variation due to genetic component) and total sum of square (TSS considered as variation due to genetic and other additive component) were applied to estimate heritability. In mid parent-offspring model, regression coefficients (β) was also computed as heritability. In general, results showed that parents-offspring model tend to be lower estimate of heritability when compared with mid parent-offspring model.

Conclusions:Using classical methods of heritability to evaluate the relative contribution of genetic components for a given trait/disease must be interpreted with great caution.

Keywords: Asian Indian, Family study, Heritability estimation, Mid parent-offspring model,

Parent-offspring model

Introduction

In quantitative genetics, classical methods of heritability are important that quantify the additive genetic variance to the total phenotypic variance to understandthe relative contribution of all possible genetic effects, but not effect of specific gene (Poveda et al., 2012; Treuth et al., 2001; Hsu et al., 2005; Zilikens et al., 2008).In family studies, four major designs are applied to assess heritability of a quantitative trait such as parent-offspring, midparent-offspring, half sib and full sib but there are some limitations as they are population dependent (Ghosh et al., 2010; Sanchez-Andres et al., 1994).

Some studies are available on Asian Indian families (Ghosh et al., 2010; Arya et al., 2002; Gupta and Kapoor., 2011; Kumar and Badaruddoza et al., 2010; Mathias et al., 2009; Zabaneh et al., 209) where heritability was estimatedfor anthropometry, body composition and blood pressure using a single model, particularly parent-offspring (Gupta and Kapoor., 2011; Kumar and Badaruddoza., 2010). Few studies, where heritability was estimated using different model (Ghosh et al., 2010). In this study it was found that single parent-offspring model tends to lower estimate of heritability compared to midparent-offspring model (Ghosh et al., 2010).This observation wassomewhat different in Spanish population where estimated heritability using mid parent-offspring model was lower than parent-offspring model Sanchez-Andres et al., 1994). Keeping this in mind, present study aims to investigate the heritability of anthropometry, body composition and blood pressure on Asian Indian families using single parent-offspring and mid-parent-offspring model.

Materials and methods

The present study was conducted between December, 2019 and January, 2020. The data was collected from six villages about 35 km apart from Kolkata (Latitude: 22.5726^0 N. and Longitude: 88.3639^0 E.), West Bengal, India. A total of 120 nuclear families were selected with local contact of ASHA (Accredited Social Health Activist) and ICDS (Integrated Child Development Services) workers. Out of which 77 families were agreed to participate and 36 families were excluded due to missing data. Therefore, this study was consisted on 41 families.Apparently healthy sib pair aged 10-18 y and their respective parentswere selected in this study. This work was approved by the Institutional Ethics Committee (IEC) of Heritage Institute of Technology, Kolkata.

Anthropometry, body composition and blood pressure

All anthropometric and body composition measures were taken using standard techniques. Height was measured to the nearest 0.1 cmand weight was measured with a digital weighing scale (Omron, Tokyo, Japan). Circumferences of mid upper arm, waist and hip were measured by an inelastic tape to the nearest 0.1 cm. Body mass index (BMI) and waist hip ratio (WHR) were then computed using standard equation. Skinfolds thicknesses at biceps, triceps, subscapular and suprailiac were measured on the left side of the body to the nearest 0.2 mm using a Holtain skinfold caliper (Holtain Corporation, UK). Sum of four skinfolds (SF4) and trunk extremity ratio (TER) were calculated subsequently.

Left arm blood pressure (BP) was taken from each participant with the help of an aneroid sphygmomanometer. Two BP measurements were taken and averaged for analysis. A five minutes relaxation period between measurements was maintained for all individuals. All BP measurements were taken at room temperature. Systolic (SBP) and diastolic blood pressure (DBP) was defined as the points of appearance (Phase I) and disappearance (Phase V) of the Korotkoff sounds, respectively.

Statistical Analysis

Descriptive statistics (mean, standard deviation) were computed for all anthropometric, body composition and blood pressure measures. Heritability (h^2) was estimated using single parent-offspring and midparent-offspring model. In midparent-offspring model, regression coefficients (β) is equivalent to h^2. On the other hand, in both models, we calculated the ratio of regression sum of square (RSS defined as the variation due to genetic component) and total sum of square (TSS defined as the variation due to genetic and other additive component) to estimate h^2. All statistical analysis was applied using SPSS (version 26).

Results and discussion

Present study was conducted on 41 families. Table 1 represents descriptive statistics such as mean and SD of anthropometry, body composition and blood pressure measures. The mean age of father, mother, sib 1 and sib 2 were 41.93±6.54, 33.85±4.59, 14.63±1.56 and 11.46±1.67 respectively.

The estimated heritability (h^2) of anthropometry, body composition and blood pressure variables using single parent-offspring (father–sib1, father–sib2, mother–sib1, mother–sib2) and midparent– offspring model (midparent-sib1 and midparent–sib2) are presented in table 2. In single parent-offspring model, only the ratios of regression sum of square (RSS) to total sum of square (TSS) has been applied for all the expected combination. In midparent-offspring model, both the regression coefficient (β) and the ratio of RSS and TSS was computed as h^2.

In this study results showed that the estimated h^2 for BMI varied from low to strong(0.00 – 0.70) which was comparable with two study conducted on Asian Indian (Ghosh et al., 2010)and Spanish (Sanchex-Andres et al., 1994)population but not with some other studies (Arya et al., 2002; Gupta and Kapoor et al., 2011; Zabaneh et al., 2009). In these studies,it was observed that BMI was low (Arya et al., 2002; Zabaneh et al., 2009) or moderately (Poveda et al., 2012; Mathias et al., 2009)heritable. For circumferences, estimated h^2 for MUAC was low (0.00 – 0.27) whereas MWC and MHC were varied from 0.07 – 0.54 and 0.02 – 0.80 respectively. In Spanish population (Sanchez-Andres et al., 1994), the reported h^2 for MUAC was varied from moderate to strong. On the other hand, estimated h^2 was similar for MWC and MHC in some other studies (Ghosh et al., 2010; Gupta and Kapoor et al., 2011; Mathias et al., 2011).In our study, h^2 for WHR was within the range (0.00 – 0.43) as found in other studies (Ghosh et al., 2010; Mathias et al., 2009; Zabaneh et al., 2009), except two study where reported h^2 were varied from low to strong (Poveda et al., 2012; Gupta and Kapoor., 2011).[1,8] For skinfold measures, SF_4 and TER was low to moderately (0.02 – 0.56 and 0.00 – 0.34 respectively) heritable. Similar observations were noted in some other study (Poveda et al., 2012; Sanchez-Andres et al., 1994; Arya et al., 2002) except one, where estimated h^2 was varied from low to strong (Ghosh et al., 2010).[5] In our study, h^2 for AMC, AMA and AFA was comparatively lower than two study conducted on Asian Indian (Ghosh et al., 2010) and Spanish Sanchez-Andres et al., 1994) population. For blood pressure, SBP and DBP showed low to moderate heritability (0.03 – 0.35 and 0.01 – 0.38 respectively). Similar findings were also evident in two study pertaining to Asian Indians (Ghosh et al., 2010; Zabaneh et al., 209).

In our study, when we compared h^2 of all anthropometry, body composition and blood pressure variables using two model, we found that parent-offspring model tends to be lower estimate of heritability than mid parent-offspring model. (Table – 2) This finding is almost similar with a study conducted on Asian Indians (Ghosh et al., 2005) but not with Spanish population (Sanchex-Andres., 1994). However, in later study, regression coefficients were considered as heritability using mid-parent-offspring model which was then compared with single parent-offspring correlation as heritability (Sanchex-Andres et al., 1994).

The major limitation of this study was that sample size was relatively small. Furthermore, present study is community specific and may not representative of all Asian Indian as particular this people are ethnically heterogeneous, culturally varied and geographically diversified.

Conclusion

The underlying mechanism of gene – environment interaction on development of a disease/trait is complex, quite unclear.Therefore, using classical methods of heritability to evaluate the relative contribution of genetic components for a given trait/disease must be interpreted with great caution. Table: 1 Descriptive Statistics of anthropometry, body composition, and blood pressure of the study families (n=41)

Variables	Father	Mother	Mid-parent	Sib1	Sib2
Age(years)	41.93±6.54	33.85±4.59	37.89±5.02	14.63±1.56	11.46±1.67
Height(cm)	161.89±5.68	151.72±8.59	155.81±4.27	139.19±11.20	58.34±8.82
Weight(kg)	58.34±8.82	54.50±11.39	56.42±7.97	43.69±10.31	33.91±9.56
BMI	22.22±2.81	24.31±5.02	23.26±3.01	18.86±3.81	17.26±3.43
MUAC(cm)	27.38±2.32	29.43±8.25	28.41±4.64	22.92±3.99	20.50±3.74
WC(cm)	81.09±7.82	78.66±10.55	79.87±7.21	64.56±9.26	60.99±8.98
HC(cm)	86.81±5.91	92.53±10.12	89.67±5.93	79.82±9.34	70.98±9.36
WHR	0.93±0.05	0.85±0.06	0.89±0.05	0.80±0.06	0.86±0.06
BSF(mm)	5.02±2.04	8.98±4.91	6.99±2.90	6.06±3.23	9.23±3.10
TSF(mm)	9.23±3.10	16.37±4.78	12.80±2.98	10.72±5.47	10.50±4.77
SSSF(mm)	13.94±3.78	17.77±6.7	15.86±3.95	10.13±5.05	8.81±4.38
SISF(mm)	10.01±4.76	12.74±5.45	11.34±4.01	7.98±4.24	8.08±5.37
SF4(mm)	38.20±11.34	55.87±19.84	47.03±12.65	34.88±17.06	
34.62±17.52					
TER	1.73±0.42	1.25±0.43	1.49±0.30	1.13±0.25	0.93±0.18
AMC(cm)	24.49±1.96	24.29±7.54	24.39±4.08	19.55±2.81	17.20±3.15
AMA(cm^2)	47.99±7.75	51.34±4.45	49.66±23.22	31.02±8.84	24.30±8.92

AFA(cm^2)	12.09±4.40	22.86±11.71	17.47±6.87	12.00±7.83	10.21±5.88
SBP (mmHg)	130.38±14.87	126.38±18.14	128.38±12.53	114.54±11.56	108.16±11.27
DBP(mmHg)	81.16±8.52	83.71±13.47	82.43±8.03	71.63±9.53	66.20±8.62

BMI – Body mass index, MUAC – Mid upper arm circumference, WC – Waist circumference, HC – Hip circumference, WHR – Waist hip ratio, BSF – Biceps skinfold, TSF – Triceps skinfold, SSSF – Subscapular skinfold, SISF – Suprailiac skinfold, SF4 – sum of four skinfold, TER – Trunk extremity ratio, AMC – Arm muscle circumference, AMA – Arm muscle area, AFA – Arm fat area, SBP – Systolic blood pressure, DBP – Diastolic blood pressure

Table: 2 Heritability estimation of anthropometry, body composition and blood pressure using single
parent – offspring and midparent – offspring model (n = 41)

Variables	Father - Sib-1	Father - Sib 2	Mother - Sib 1	Mother - Sib 2	Mid-parent - Sib 1	Mid-parent - Sib 2	Mid-parent - Sib 1 - Sib 2
	RSS/TSS	RSS/TSS	RSS/TSS	RSS/TSS	RSS/TSS	RSS/TSS	β
BMI	0.26	0.01	0.00	0.10	0.04	0.09	0.70
0.41							
MUAC(cm)	0.24	0.00	0.05	0.11	0.10	0.10	0.27
0.25							
WC(cm)	0.18	0.14	0.07	0.09	0.18	0.18	0.54
0.52							
HC(cm)	0.14	0.02	0.15	0.03	0.26	0.05	0.80
0.36							
WHR	0.06	0.07	0.00	0.06	0.00	0.10	0.22
0.43							
BSF(mm)	0.06	0.02	0.01	0.23	0.01	0.21	0.13
0.59							
TSF(mm)	0.03	0.02	0.01	0.06	0.03	0.06	0.34
0.41							
SSSF(mm)	0.08	0.03	0.03	0.11	0.07	0.13	0.35
0.40							
SISF(mm)	0.27	0.15	0.04	0.07	0.20	0.17	0.47
0.55							
SF4(mm)	0.14	0.09	0.12	0.02	0.08	0.16	0.37
0.56							
TER	0.10	0.03	0.01	0.00	0.07	0.00	0.34
0.03							

AMC(cm)	0.26	0.01	0.00	0.10	0.04	0.09	0.14	0.23
AMA(cm)	0.29	0.00	0.00	0.15	0.02	0.14	0.05	0.14
AFA(cm)	0.06	0.02	0.07	0.13	0.10	0.13	0.35	0.31
SBP(mmHg)	0.09	0.15	0.03	0.05	0.09	0.15	0.27	0.35
DBP(mmHg)	0.01	0.02	0.01	0.11	0.02	0.13	0.16	0.38

BMI – Body mass index, MUAC – Mid upper arm circumference, MWC – Waist circumference, HC – Hip circumference, WHR – Waist hip ratio, BSF – Biceps skinfold, TSF – Triceps skinfold, SSSF – Subscapular skinfold, SISF – Suprailiac skinfold, SF4 – sum of four skinfold, TER – Trunk extremity ratio, AMC – Arm muscle circumference, AMA – Arm muscle area, AFA – Arm fat area, SBP – Systolic blood pressure, DBP – Diastolic blood pressure, RSS – Regression sum of square, TSS – Total sum of square, β – Regression coefficient

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