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journal homepage: www.imr-journal.com

Original Article

Best-fit index for describing physical perspectives in Sasang typology

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ARTICLE INFO

Article history:
Received 14 October 2014
Received in revised form
7 November 2014
Accepted 12 November 2014
Available online 20 November 2014

Keywords:
basal metabolic rate
body mass index
hypothalamus
ponderal index
Sasang typology

ABSTRACT

Introduction: We examined the best-fit index for describing the constitutional or physical characteristics of Sasang typology for its universal application.
Methods: Ponderal index (PI), body mass index (BMI), and basal metabolic rate (BMR) of the nationwide participants ($n = 1663$; age, 31–60 years) were calculated. We described and analyzed the usefulness of each index for maximizing the differences between Sasang types across age and sex using box plots, Pearson's correlation, and analysis of variance.
Results: We found that the So-Eum, So-Yang, and Tae-Eum Sasang types were significantly ($p < 0.001$) different from each other in terms of PI, BMI, and BMR by the World Health Organization with weight (BMR-WHOw). The BMI was significantly correlated with PI ($r = 0.933$) and BMR-WHOw ($r = 0.577$).
Discussion and conclusion: These study results show that PI, BMR, and BMI have their own clinical values, and could contribute to the study of the pathophysiological mechanism underlying the Sasang typology as the *hypothalamus hypothesis*.

1. Introduction

Sasang typology is a clinical classification scheme that divides people into the following four types: Tae-Yang (TY), So-Yang (SY), Tae-Eum (TE), and So-Eum (SE). This classification system has been used as a basis for type-specific prevention and diagnosis of diseases, and treatment and rehabilitation of patients in traditional Korean personalized medicine for hundred years.[1] These four types have their own unique biopsychological traits, and each type can be considered as a clinical guideline or prototype.[2] Previous studies have demonstrated that each Sasang type has distinctive psychological,[3,4] physical,[3,5–7] and genetic[8,9] features; drug response; and pathophysiological symptoms;[10] in addition, they also show variations in biopsychological traits according to age and sex.[2,11]

In psychological or temperament studies, the traits neuroticism and extraversion as defined as *super factors* by Eysenck,[7] and Temperament and Character Inventory devised by Cloninger[4,12,13] are used a biopsychological basis to understand the temperamental traits of Sasang typology.[2,14] The

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http://dx.doi.org/10.1016/j.imr.2014.11.001

Sasang Personality Questionnaire (SPQ) developed based on these previous studies has an acceptable clinical reliability and validity,[2,4,15–18] with the rank order of SPQ scores (lowest to highest) in the following order: SE < TE < SY.[2,15]

With regard to the physical or constitutional characteristics, each Sasang type showed significant differences in weight, circumference length of the neck or chest,[5] bitragus to submandibular arc length,[19] height-to-width ratio of the face,[20] and body mass index (BMI),[2,3,6] and the number increases in the order of SE, SY, and TE. A previous study using SPQ and BMI confirmed that the Sasang type of a person retains the biopsychological profiles that remain stable across the person's life span and the mind–body characteristics are suggested to be useful for clinical diagnosis.[2]

Although the BMI was originally adopted to quantify the physiological *body shape* of each Sasang type,[3] it can be easily mistaken for measuring the pathological factor of *obesity* of each Sasang type, irrespective of its original intention.[1,3] In Jae-Ma Lee's original book, *The Principle of Life Preservation in Eastern Medicine*, the TE type was described as *tall and big* rather than as *fat and obese*, and the SE type is described as *short and small* rather than *thin and skinny*.[1,3]

> "Sometimes the body shape of Tae-Eum and So-Eum types look similar and it is hard to distinguish these Sasang types. When you are not certain with your Sasang type diagnosis, you should focus on the disease symptoms... The body shape of So-Eum type is short and small yet sometimes large up to 225 cm, and the body shape of Tae-Eum is long and large yet occasionally small as 150 cm." (Differential diagnosis of each Sasang type)

In a previous study on Sasang type-specific pathophysiological symptoms with nationwide sample ($n = 1156$), there were no significant differences in the general health status among Sasang types, and rather, this study highlighted the type-specific pathophysiological mechanisms of Sasang typology.[18] Moreover, because the BMI is sensitive to the social and cultural influences, it has innate difficulties in cross-cultural and cross-ethnic application. For example, Western society has higher obese population and a different standard for obesity when compared with the Eastern countries.[21]

Thus, the clinical and pathophysiological importance of Sasang typology should be thoroughly reinvestigated using various indexes suggested in previous studies such as BMI,[3,6] ponderal index (PI),[2] and basal metabolic rate (BMR),[22] which can be calculated with weight, height, age, and sex. Moreover, these equations can also be used as a complementary or alternative corporal index for Sasang typology because they have different theoretical backgrounds and clinical purpose.

The PI is used to calculate the lean body mass.[23] It is calculated as weight divided by height raised to the power of three in order to measure the density per dimension. The PI is used when the difference in height among study participants is larger. It is also used to adjust the BMI error in the field of pediatrics.

The BMR was developed as a metabolic reference value for nutritional composition of various diets or for diagnosis of hypothyroidism and hyperthyroidism.[24] Various equations using weight, height, age, and sex were suggested for calculating BMR (Table 1). However, because the first developed BMR was Western oriented, the international standard[24] was suggested through more studies of ethnicity,[25] especially on Eastern populations,[26] and women or infants.[27] Considering the fact that BMR uses different equations for different sex and age groups, this study only applied the data of adult participants that share the same equation as that used for those between 31 and 60 years of age.

Table 1 – Equations for the calculating the BMI, PI and BMRs

Measures	Male	Female
Height (H, m)	Height	Height
Weight (W, kg)	Weight	Weight
Age (A, year)		
Body mass index (kg/m^2)[3]	W/H^2	W/H^2
Ponderal index (kg/m^3)[23,28]	W/H^3	W/H^3
Basal metabolic rate (BMR, kcal/day)		
BMR-HB (1919)[30]	13.7516W + 5.0033H – 6.7750A+66.4730	9.5634W + 1.8496H – 4.6756A + 664.0955
BMR-WHOw (1985)[24]	11.6W + 879	8.7W + 829
BMR-WHOwh (1985)[24]	11.3W + 0.16H + 901	8.7W – 0.25H + 865
BMR by Mifflin et al (1990)[25]	9.99W + 6.25H – 4.92A + 5	9.99W + 6.25H – 4.92A – 161
BMR by Liu et al (1995)[26]	13.88W + 0.0416H – 3.43A + 54.34	3.88W + 0.0416H – 3.43A – 58.06

These equations are used for calculating the values in persons between 31 and 60 years of age.
BMI, body mass index; BMR-HB, basal metabolic rate by Harris and Benedict; BMR-WHOw, basal metabolic rate by Word Health Organization/Food and Agricultural Organization/United Nations University with weight; BMR-WHOwh, basal metabolic rate by Word Health Organization/Food and Agricultural Organization/United Nations University with weight and height; PI, ponderal index.

This study tried to find best-fit index for describing physical characters of Sasang typology in combination with SPQ which was used for the previous study of mind-body characteristics of each Sasang types.[2] Based on the clinical data used in previous biopsychological studies of Sasang typology, we identified BMI, PI, BMR of each Sasang type, and compared how well these indexes can distinguish the constitutional or physical characteristics of Sasang typology. Furthermore, a comprehensive comparison of the changes based on sex and age was performed by incorporating various illustration methods. The study provides a better understanding of the pathophysiological mechanisms of each Sasang type and much more useful clinical differentiation tools for the Sasang typology.

2. Methods

2.1. *Participants*

The biopsychological measures of each Sasang type from the study participants ($n = 1663$; age, 31–60 years) were acquired from the Korea Constitutional Multicenter Bank (KCMB).[12,15] The Institutional Review Board of School of Korean Medicine, Pusan National University reviewed and approved this study.

Informed consent was obtained from all participants when they were enrolled in the KCMB.

2.2. Methods

2.2.1. Sasang Personality Questionnaire

The SPQ is a 14-item self-report questionnaire[4,15] that measures the temperament trait of Sasang typology from the Yin-Yang perspective. The SPQ has the following three subscales: SPQ-Behavior (SPQ-B), SPQ-Emotionality (SPQ-E), and SPQ-Cognition (SPQ-C). The SPQ-B measures the behavioral aspect of the participants (passive vs. active); the SPQ-E measures the emotional level of participants (static vs. dynamic); and the SPQ-C measures the cognition or the level of being convinced in terms of decision making (meticulous vs. easy going). The SPQ is the sum of the measurements of these three subscales.

Previous studies have examined the clinical[16] and structural validity[2,4,15] of SPQ and its correlation with physical traits,[2,17] pathophysiological symptoms,[18] and general health status[18] for the concurrent validity. In addition, the temperament of Sasang typology measured with SPQ was consistently shown to have the following order (from lowest to highest): SE < TE < SY.[2,4,15–17] The internal consistency (Cronbach α) values of SPQ-B, SPQ-E, and SPQ-C were 0.789, 0.685, and 0.711, respectively.[15]

2.2.2. Body measures and related index

The body measures and equations used for calculating the related indexes in this study are presented in Table 1. The body measure indexes were calculated using a formula based on height, weight, sex, and age. The BMI[3] is calculated as weight divided by height squared, and the PI[28] is calculated as weight divided by height raised to the power of three.

For the BMR,[29] we used the equation suggested by the World Health Organization/Food and Agricultural Organization/United Nations University,[24] which used the weight (BMR-WHOw) or the weight and the height (BMR-WHOwh), along with Harris and Benedict's equation (BMR-HB),[30] which was reported to have a significant difference across the Sasang types.[22]

2.3. Statistical analysis

The demographic characteristics (sex, age, education, job, marital status, and Sasang type) of the participants were analyzed with descriptive statistics. To examine the significant differences in BMI, PI, and BMR across Sasang types, analysis of variance and Bonferroni *post hoc* analysis were used. Pearson's correlation was used to analyze the correlation among weight, height, SPQ, BMI, PI, and BMR.

To find the best representative mind–body trait profile considering the age of each Sasang type, SPQ was plotted on the *Y* axis and various body measures such as BMI, PI, and BMR on the *X* axis. The distinctive chronological change in their 30s, 40s, and 50s for each Sasang type can be seen in this plot. The box plot was used to show the distribution of BMR, PI, and BMRs for each Sasang type. The median, first, and third quartiles, minimum and maximum, and outliers of each body measure indexes were presented in the box plot.

Table 2 – Demographic features of study participants

	Frequency (%)
Sex	
Male	584 (35.1)
Female	1079 (64.9)
Age	
Mean ± standard error of the mean (46.1 ± 0.2)	
Sasang types	
Tae-Yang	48 (2.9)
So-Yang	568 (34.2)
Tae-Eum	607 (36.5)
So-Eum	439 (26.4)
Education	
None	18 (1.1)
Elementary school	140 (8.4)
Middle school	187 31.5)
High school	524 (35.2)
College	586 (35.2)
Graduate school	208 (12.5)
Job	
Managerial	42 (2.5)
Professional	284 (17.1)
Administrative	255 (15.3)
Service	159 (9.6)
Sales	89 (5.4)
Agricultural	63 (3.8)
skilled trades	53 (3.2)
Plan and machine operators	39 (2.3)
Elementary occupations	31 (1.9)
Others	648 (39)
Marriage	
Single	143 (8.6)
Married	1460 (87.8)
Divorced	35 (2.1)
Widowed	23 (1.4)
Total	1663 (100.0)

Statistical results were presented as frequency (%) or mean ± standard error, and the level of statistical significance was set at $p < 0.05$, $p < 0.01$, and $p < 0.001$. IBM SPSS Statistics 20.0 (IBM, Armonk, NY, USA) was used for all statistical analysis.

3. Results

3.1. Characteristics of participants

Data on the distribution of Sasang type, sex, education, job, marital status, and age of the study participants ($n = 1663$; age, 31–60 years) are presented in Table 2. The ratio of TY: SY:TE:SE was 3:34:37:26 in this study. The TY type was included for the general application of this study despite its small percentage.

3.2. Differences in body measure index between Sasang-type groups

The height, weight, BMI, PI, BMR-HB, BMR-WHOw, and BMR-WHOwh were compared among Sasang types (Table 3). The values of all the parameters increased in the order of SE < SY < TE, except for male height.

With regard to the male participants, there was no difference in height ($F = 1.725$, $p > 0.05$). However, there was a significant difference in other statistics such as weight ($F = 58.082$, $p < 0.001$), BMI ($F = 70.473$, $p < 0.001$), PI

Table 3 – Differences between Sasang types in body measures

Male	Tae-Yang ($n=11$)	So-Yang ($n=190$)	Tae-Eum ($n=249$)	So-Eum ($n=133$)	F	
Height	169.79 ± 1.09	169.96 ± 0.42	171.14 ± 0.37	170.21 ± 0.5	1.725	
Weight	60.98 ± 1.77	69.39 ± 0.68	76.74 ± 0.65	64.19 ± 0.75	58.082 *	SE < SY < TE, TY < SY
BMI	21.18 ± 0.66	23.98 ± 0.2	26.16 ± 0.18	22.17 ± 0.22	70.473 *	SE < SY < TE, TY < SY
PI	12.48 ± 0.4	14.14 ± 0.13	15.25 ± 0.12	13.02 ± 0.14	51.698 *	SE < SY < TE, TY < SY
BMR-HB	629.02 ± 30.61	711.01 ± 11.04	808.87 ± 10.43	654.54 ± 12.53	33.839 *	SE < SY < TE, TY < TE
BMR-WHOw	1586.39 ± 20.59	1683.94 ± 7.84	1769.14 ± 7.56	1623.59 ± 8.74	58.082 *	SE < SY < TE, TY < SY
BMR-WHOwh	1590.37 ± 20.05	1685.4 ± 7.64	1768.39 ± 7.36	1626.6 ± 8.52	58.077 *	SE < SY < TE, TY < SY
Female	**Tae-Yang ($n=37$)**	**So-Yang ($n=378$)**	**Tae-Eum ($n=358$)**	**So-Eum ($n=306$)**		
Height	159.69 ± 0.78	157.32 ± 0.27	158.34 ± 0.26	159.02 ± 0.29	7.571 **	SE < TE, TY < TE
Weight	53.71 ± 1.14	55.8 ± 0.34	63.72 ± 0.45	53.57 ± 0.36	128.923 *	SE < SY < TE, TY < TE
BMI	21.14 ± 0.44	22.57 ± 0.13	25.41 ± 0.16	21.22 ± 0.14	149.833 *	SE < SY < TE, TY < SY
PI	13.23 ± 0.3	14.36 ± 0.09	16.06 ± 0.11	13.35 ± 0.09	135.934 *	SE < SY < TE, TY < SY
BMR-HB	979.3 ± 12.43	985.82 ± 3.63	1057.49 ± 4.67	969.95 ± 3.73	88.496 *	SE < SY < TE, TY < TE
BMR-WHOw	1299.53 ± 9.96	1317.79 ± 2.95	1387.23 ± 3.95	1298.26 ± 3.18	128.923 *	SE < SY < TE, TY < TE
BMR-WHOwh	1331.91 ± 9.89	1350.05 ± 2.93	1419.01 ± 3.92	1330.64 ± 3.16	128.944 *	SE < SY < TE, TY < TE

* $p<0.001$.
** $p<0.01$.
BMI, body mass index; BMR-HB, basal metabolic rate by Harris and Benedict; BMR-WHOw, basal metabolic rate by Word Health Organization/Food and Agricultural Organization/United Nations University with weight; BMR-WHOwh, basal metabolic rate by Word Health Organization/Food and Agricultural Organization/United Nations University with weight and height; PI, ponderal index.

($F=51.698$, $p<0.001$), BMR-HB ($F=33.839$, $p<0.001$), BMR-WHOw ($F=58.082$, $p<0.001$), and BMR-WHOwh ($F=58.077$, $p<0.001$). The *post hoc* analysis showed that all the body measure indexes increased in the following order: SE < SY < TE.

With regard to the female participants, height ($F=7.571$, $p<0.01$), weight ($F=128.923$, $p<0.001$), BMI ($F=149.833$, $p<0.001$), PI ($F=135.934$, $p<0.001$), BMR-HB ($F=88.496$, $p<0.001$), BMR-WHOw ($F=128.923$, $p<0.001$), and BMR-WHOwh ($F=128.944$, $p<0.001$) showed significant differences among Sasang types. The *post hoc* analysis showed that the body measure indexes increased in the order of SE < SY < TE, except for height, for which the TE type was bigger than the SE type.

3.3. *Correlation between body measure indexes*

Based on the correlation analysis of the body measure indexes across Sasang types, the characteristics of each body measure index were confirmed (Table 4). The body measure indexes showed a correlation coefficient of 0.140–0.054 with the SPQ, which measures the temperament trait of Sasang typology, and this allowed for the presentation of body measure indexes coupled with SPQ to manifest the two perspectives of mind and body.

Height has a positive correlation with weight ($r=0.642$), BMR-WHOw ($r=0.780$), and BMR-WHOwh ($r=0.776$). Weight also has a positive correlation with height ($r=0.828$), BMI ($r=0.828$), PI ($r=0.577$), BMR-WHOw ($r=0.886$), and BMR-WHOwh ($r=0.900$). These positive correlations may come from the fact that these indexes were calculated using weight as the base standard.

The BMI showed a positive correlation with PI ($r=0.933$), BMR-HB ($r=0.339$), BMR-WHOw ($r=0.577$), and BMR-WHOwh ($r=0.597$). The PI has a significant correlation with BMR-HB ($r=0.430$) and BMR-WHOwh ($r=0.306$). However, although the three BMRs showed significant differences among Sasang types, the BMR-HB showed a negative correlation with BMR-WHOw ($r=-0.336$) and BMR-WHOwh ($r=-0.309$), both of which share an identical value. These negative correlations may come from the fact that the BMR-HR has a negative correlation with age ($r=-0.295$) and height ($r=-0.303$), both of which are included in the equation.

3.4. *Illustrated features of body measure index*

The chronological changes in biopsychological traits for each Sasang type are illustrated in Figs. 1 and 2. We plotted the SPQ on the Y axis because it gives us a good idea for making a comparison among weight, height, BMI, PI, BMR-HB, BMR-WHOw, and BMR-WHOwh. Using this illustration, we could examine which index can show consistent differences among Sasang-type groups regardless of the change in age. BMI, PI, BMR-WHOw, and weight (Figs. 1C, 1D, 1F, 2C, 2D, and 2F) presented distinctive differences across Sasang types, whereas BMR-HR and BMR-WHOwh did not.

We found that the age is an important variable in discriminating each Sasang type based on height, BMR-HB, and BMR-WHOwh; however, these body measure indexes were not more useful than weight. The BMR-WHOw, however, seemed to be more useful for differentiating each Sasang type when compared with the other BMRs. Moreover, the PI, like BMI, which was used for the standardizing the constitutional perspectives in previous studies, was found to be useful for classifying each Sasang type.

Finally, we compared the distribution of each Sasang type using the box plot for BMI, PI, BMR-HB, and BMR-WHOw, which were found to be clinically useful (Fig. 3). We found that the overlapping portion of the TE and SE types was small in BMI and PI, whereas it was relatively big in BMR-HB and BMR-WHOwh.

Table 4 – Correlation coefficients among the measures

	Height	Weight	SPQ	BMI	PI	BMR-HB	BMR-WHOw	BMR-WHOwh
Age	–0.193 *	0.030	0.019	0.180 *	0.250 *	–0.295 *	0.033	0.032
Height		**0.642** *	0.052 **	0.114 *	–0.238 *	**–0.303** *	**0.780** *	**0.776** *
Weight			0.137 *	**0.828** *	**0.577** *	0.102 *	**0.886** *	**0.900** *
SPQ				0.140 *	0.122 *	0.054 **	0.094 *	0.097 *
BMI					**0.933** *	**0.339** *	**0.577** *	**0.597** *
PI						**0.430** *	0.286 *	**0.306** *
BMR-HB							**–0.336** *	**–0.309** *
BMR-WHOw								**1.000** *

Bold entries represent a correlation coefficient of more than 0.3.

* $p < 0.001$.

** $p < 0.01$.

BMI, body mass index; BMR-HB, Basal Metabolic Rate by Harris and Benedict; BMR-WHOw, Basal Metabolic Rate by Word Health Organization/Food and Agricultural Organization/United Nations University with weight; BMR-WHOwh, Basal Metabolic Rate by Word Health Organization/Food and Agricultural Organization/United Nations University with weight and height; PI, Ponderal Index; SPQ, Sasang Personality Questionnaire.

4. Discussion and conclusion

The characteristics of PI, BMI, and BMR as body-measure indexes for describing the body shape of each Sasang type were compared in this study. Although the BMI has been identified as a reliable index for describing the physical characteristics of each Sasang type, because it is used to measure the rate of obesity, which is a pathological factor, it has a significant limitation for describing the physiological characteristics of Sasang typology.

The PI was recognized as a useful index for distinguishing each Sasang type as much as the BMI. The PI, which has a high correlation coefficient with BMI, seems to have clinical usefulness (Figs. 1 and 2). In addition, the BMR-WHOw was also found to be a better index for the Sasang typology than the previously reported BMR-HB.[22]

The correlation analysis revealed the characteristics of anthropometric indexes. The BMI and PI showed a high positive correlation with weight, whereas the BMR-HR had a negative correlation with height, and the BMR-WHOw had a high positive correlation with both weight and height (Table 4).

In this study, data on standardized PI, BMI, BMRs were presented using 1663 nationwide participants that can be used as a body-shape measure for the clinical diagnosis of Sasang typology. Our study also shows that both sex and age should be considered as essential factors.

The study results can be summed up as follows: the significant differences among Sasang types can be used as the pathophysiological basis for Sasang typology, as the lean body mass and thyroid metabolic activity indicate constitutional individual differences, rather than just the level of obesity.[31,32] However, before taking a leap to conclude that the charcteristic feature of TE is obesity, the focus should rather be on the fact that there exists a meaningful difference in the function of the body. An interesting aspect of the present study is that the physical characteristics of the TE type comes from the characteristics of the limbic system being controlled by the hypothalamus that mediates the emotional response and motivated behavior for survival and reproduction, and controls the homeostasis in blood pressure and electrolyte balance, body temperature, food intake and energy metabolism, reproduction, and response to stress.

The BMI is related to the function of growth hormone and PI is related to the activity of thyroid hormone.[23,28] BMR is related to the stress response and energy expenditure[33] in the sympathetic system where responding to stress requires higher resting metabolic rate that consumes precious bodily energy.[33]

Besides these, it is known that the oxytocin[34] plays an important role in sociability, which is recognized as one of characteristics of the TE type.[14] Sweating and thermal regulation, which are major common pathophysiological symptoms of the TE type, are influenced by sympathetic nervous activity[35] and these physiological functions are under the influence of the hypothalamus.

The pathophysiological characteristics of the TE type in lipid accumulation,[3,36,37] insulin metabolism,[38] hunger or food intake,[6,35] immunological characteristics,[8] and low sensitivity to stress response[39] are under the influence of the hypothalamic–pituitary–adrenal axis,[40,41] where the hypothalamus is located at the peak of its cascade.[42,43] In addition, water intake and excretion, which are controlled by vasopressin/antidiuretic hormone, play an important role in the high blood pressure of the TE type,[36] and at the peak of this cascade is the hypothalamus.

Hypothalamus controls the homeostasis and adaptation to the external environment by modifying the automatic responses, and it decides the sensitivity of autonomic response to environmental stimulus, in another words, it decides the balance of whether or not to respond to the outer stress and focus on one's own growth. In the perspective of Sasang typology, it might be said that this kind of individual differences in balance are the biological basis of what distinguishes the TE from the non-TE types. Therefore, the perception of the TE type should change from *weight or not to weight* to *respond or not to respond*. The hypothalamus hypothesis from a constitutional or physical standpoint might be a useful foundation for the study of pathophysiological mechanism of Sasang typology along with Temperament

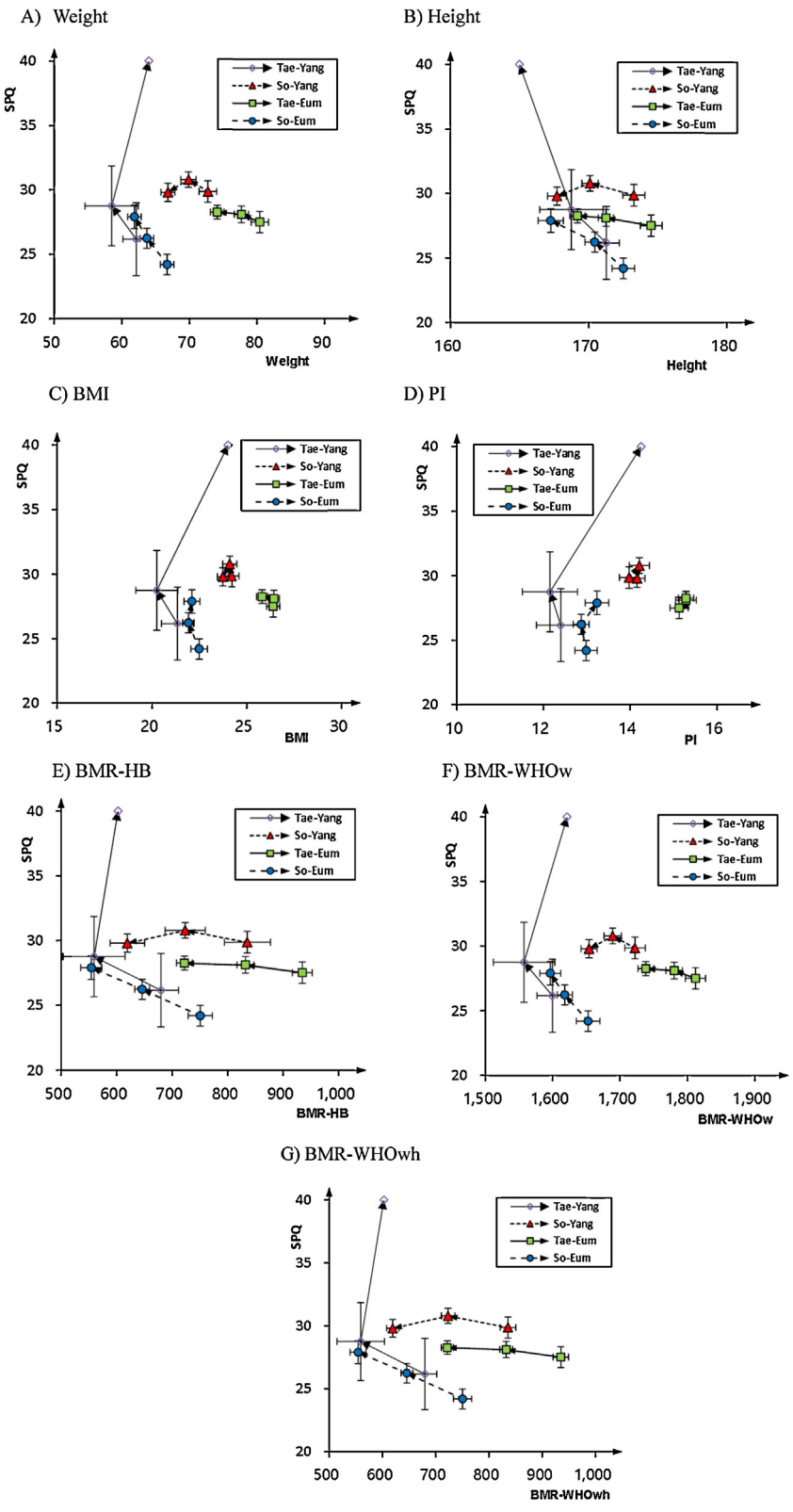

Figure 1 – Body measures of each Sasang type with Sasang Personality Questionnaire in males.

and Character Inventory Hypothesis from a temperament standpoint.[14] However, the hypothalamus hypothesis in this study was derived from the previous Sasang typology studies, and therefore, more studies with Sasang type-specific drug–response are required for confirming the results presented in this study.

This study presented the usefulness of BMI, PI and BMRs as anthropometric measures in describing the physical traits

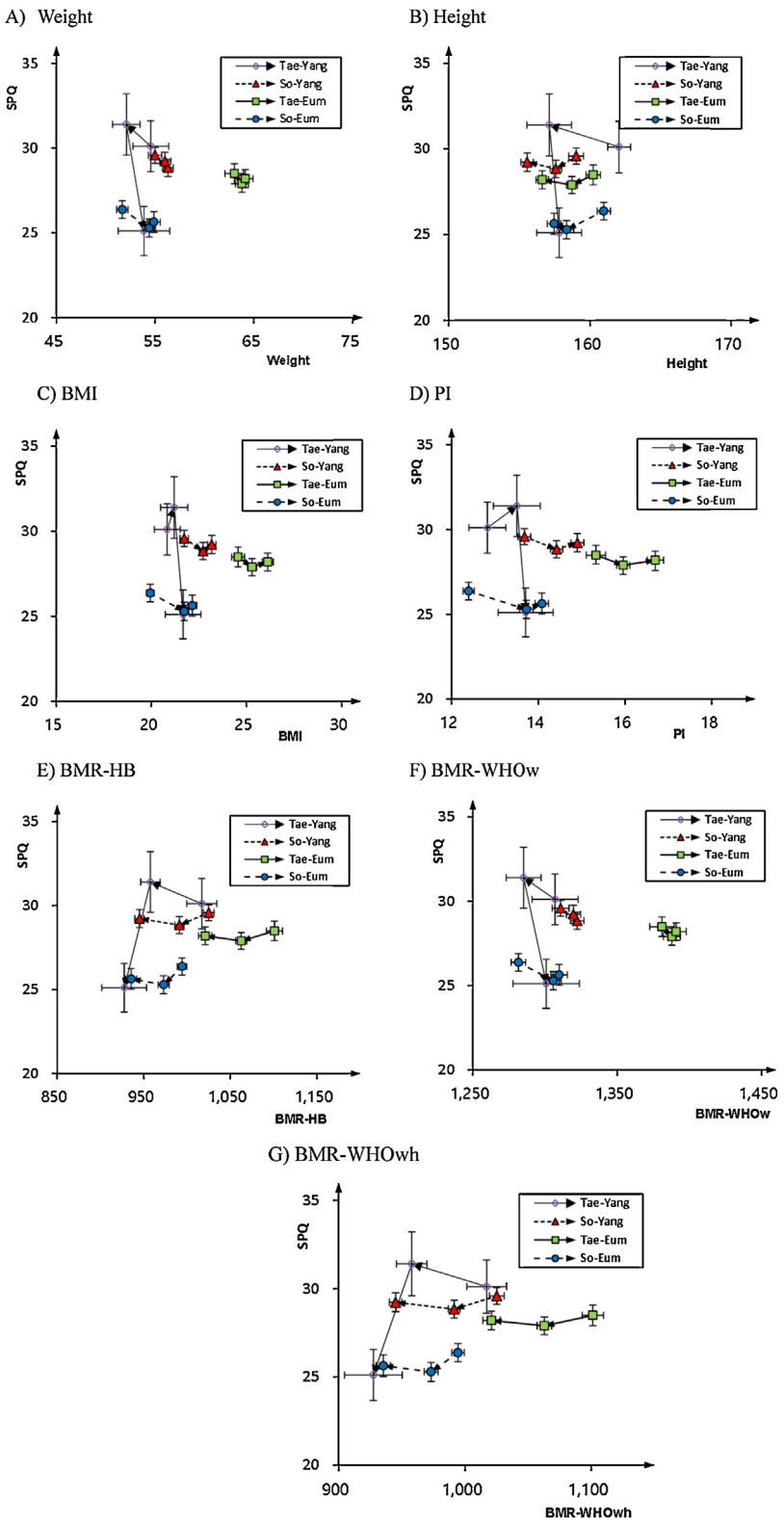

Figure 2 – Body measures of each Sasang type with Sasang Personality Questionnaire in females.

of each Sasang type using a sample size of 1663 nationwide participants. The PI and BMR-WHOw along with BMI were found to be clinically useful, and through this study result, we could suggest the pathophysiological hypothesis for Sasang typology from the physical standpoint. These anthropometric measures for describing Sasang typology would provide multifaceted window for analyzing the physical traits for clinical diagnosis of each Sasang type.

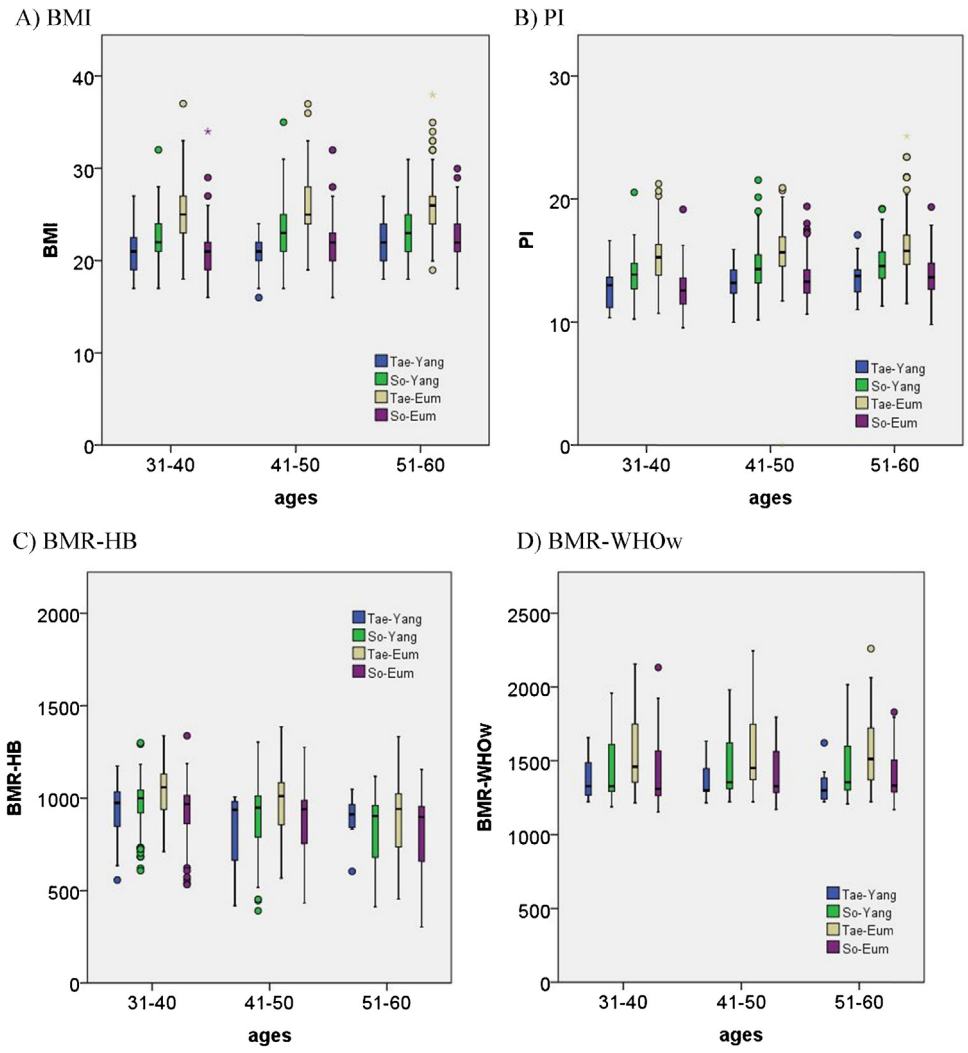

Figure 3 – Box plot presentation of body measures according to the Sasang types.

Conflicts of interest

All contributing authors declare no conflicts of interest.

Acknowledgments

This work was supported by the National Research Foundation of Korea grant funded by the Korea government (MEST No.20110027739).

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