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A U-shaped Association between Body Mass Index and Psychological Distress on the Multiphasic Personality Inventory: Retrospective Cross-sectional Analysis of 19-year-old Men in Korea

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Objective personality tests, such as the Minnesota Multiphasic Personality Inventory (MMPI), might be more sensitive to reflect subclinical personality and be more state-dependent in an individual's lifetime, so they are good scales to predict the psychological distress regarding certain states. The aim of this study was to identify the specific pattern between body mass index (BMI) and psychological distress using the objective personality test. For this study, we investigated BMI and the Korean Military Multiphasic Personality Inventory (MPI). A retrospective cross-sectional study was conducted with 19-yr-old examinees who were admitted to the Military Manpower Administration in Korea from February 2007 to January 2010. Of 1,088,107 examinees, we enrolled 771,408 subjects who were psychologically apparent healthy possible-military-service groups. Afterwards, we reviewed and analyzed directly measured BMI and MPI results. In terms of the validity scales, the faking-good subscale showed an inverted U-shaped association, and faking-bad and infrequency subscales showed a U-shaped association with BMI groups. In terms of the neurosis scales, all clinical subscales (anxiety, depression, somatization, and personality disorder) also showed a U-shaped association with BMI groups. For the psychopath scales, the schizophrenia subscale showed a U-shaped association, and the paranoia subscale showed a near-positive correlation with BMI. In conclusion, a specific U-shaped pattern was observed between BMI and the MPI in 19-yr-old men in Korea. Underweight and obesity are related to psychological distress, so supportive advice and education are needed to them.

Keywords: Body Mass Index; MMPI; U-shaped Association; Psychological Distress

INTRODUCTION

Obesity significantly increases the risk of chronic diseases such as cardiovascular disease (CVD), type 2 diabetes mellitus, coronary heart disease, osteo-arthritis, and certain cancers (1). Being underweight is also associated with greater mortality from non-cancer and non-CVD causes (2).

Over the past few decades, many studies have been conducted regarding the relationship between body mass index (BMI) and mental health, but the results have been inconsistent. Some studies have reported that increased BMI is associated with poor mental health, such as depression, anxiety disorders, and schizophrenia (3-7). Others have reported that being overweight is associated with a lower risk of depression or a reduction in depressive symptoms, known as the "jolly fat" hypothesis (8-11). However, there are few studies on lower BMI groups; especially those who are underweight. According to one prospective cohort study, BMI is inversely associated with suicide because a low BMI is likely to act as a marker for other factors that may be relevant to understanding the etiology of suicide (12). Currently some studies have reported that the relationship between BMI and mental health has shown a U-shaped association (13-16).

Objective personality tests, such as the Personality Assessment Inventory (PAI), Temperament and Character Inventory (TCI), and California Personality Inventory (CPI), are useful screening tools for the assessment of personality structure and psychopathology. The Minnesota Multiphasic Personality Inventory (MMPI) among them is the most widely used test (17, 18). Objective personality tests, such as the MMPI, might be more sensitive to subclinical personality and more state-dependent in an individual's lifetime (17, 19, 20), so they are good scales to predict the psychological distress regarding certain states. Accordingly, the aim of this study was to identify the specific pattern between BMI and psychological distress using an objective personality test. For this study, we investigated BMI and the Korean Military Multiphasic Personality Inventory (MPI) in 19-yr-old men who were psychologically apparent healthy military-service-candidate groups.

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MATERIALS AND METHODS

Data source

In Korea, a conscription system has been adopted, wherein all men 19 yr old and over have military duty. Before joining the army, all men undergo evaluations of physical and psychological status by clinicians from all departments of the Military Manpower Administration (MMA). These include radiographs (chest X-ray: CT and MRI when necessary), chemical and physical examination of general medical conditions (GMC), and a psychiatric evaluation including completion of the Korean Military MPI. If examinees submit any hospital records, the corresponding clinicians review and certify the medical records. Although they are completed the evaluation on their states, they are not yet soldiers but still general civilian population. They can freely select the time joining the army until their mid-30s. We retrospectively surveyed 19-yr-old examinees who were admitted to all regional MMAs from February 2007 to January 2010. To protect personal information, all personal identification numbers were replaced with numbers that ensured anonymity of data.

Study design and sample

We conducted a retrospective cross-sectional study to investigate the relationship between BMI and the MPI. In the Korean conscription system, all subjects are stratified among seven grades based on physical and psychological health states. Then, they are classified into four categories: a possible-military-service group (grades 1-3), possible-public-service group (grade 4), exemption-from-military-service group (grades 5-6), and reexamine group within a certain period of time (grade 7). Those in grades 1-2 have no health problems, while those in grade 3 have mild social, occupational, or other functional impairments. Thus, grade 1-3 groups are classified as possibly suitable for military service. Respectively, grade 4 and grades 5-6 groups have moderate and severe functional impairments, so they are classified as possibly suitable for public service and exempt from military service. Those in grade 7 group were reserved for further evaluation because there was not enough information about present functioning. The functional evaluations were conducted by clinicians from all departments of the MMA in accordance with the Korean National Defense Law.

Of 1,088,107 19-yr-old examinees tested from February 2007 to January 2010, there were 782,602 placed in grades 1-3, and 305,748 categorized in grades 4-7. Given that our purpose was to examine the relationship between BMI and the MPI in psychologically apparent healthy possible-military-service groups, we enrolled the grade 1-3 groups who were possibly suitable for military service. Of the 782,602 possible-military-service group cases, 1,533 were missing and 9,418 did not have reliable results for the MPI. Furthermore, because it is possible that the relationship between BMI and the MPI could be complicated by the presence of psychiatric problems, we enrolled examinees without any apparent psychological problems (grade 1 psychiatric domain). Therefore, we finally collected and analyzed data for 771,408 examinees.

Body mass index

BMI was calculated as weight (in kilograms) divided by height (in meters) squared, and was directly measured using the same type of equipment used in the MMA. BMI categorization was completed according to the WHO International Classification system that defines the following categories: underweight (< 18.5 kg/m^2), normal weight (18.5-24.9 kg/m^2), overweight (25-29.9 kg/m^2), class I obese (30-34.9 kg/m^2), class II obese (35-39.9 kg/m^2), and class III obese (> 40 kg/m^2) (21). To test our hypothesis, however, the underweight group was divided into the following categories: underweight group 1 (UWG1: < 15.5 kg/m^2), group 2 (UWG2: 15.5-16.4 kg/m^2), group 3 (UWG3: 16.5-17.4 kg/m^2), and group 4 (UWG4: 17.5-18.4 kg/m^2). Then, to identify the distributional tendency of the underweight group, we carried out K-means cluster analysis; Table 1 shows the results. Our underweight group classification is similar to the results of the cluster analysis.

Korean Military Multiphasic Personality Inventory

The MPI has been developed for use in Korean conscription and has the same scoring system as the MMPI. The purpose of the MPI is to distinguish between psychologically healthy and unhealthy subjects, as well as to provide early screening for psychiatric disorders and criminal behavior. The MPI consists of validity scales (faking-good, faking-bad, and infrequency), neurosis scales (anxiety, depression, somatization, and personality disorder), psychopath scales (schizophrenia and paranoia), and specific content scales (criminal and military-related scales) (22, 23). Of these, we collected data for, and analyzed, the validity, neurosis, and psychopath scales.

The MPI consists of 5-steps. First, several questions were created and military related questions were added. Second, a pretest (1,285 questions) was then administered to 1,283 normal soldiers, 352 normal university students, 211 military prisoners, and 388 psychiatric patients in army hospitals. Third, 362 ques-

Table 1. Results of the K-means cluster analysis in the underweight category (BMI < 18.5)

Group	Underweight BMI category	
	UWG (No.)	K-means cluster analysis (No.)
Group 1	< 15.5 (1,838)	12.4-15.6 (2,651)
Group 2	15.5-16.4 (7,172)	15.7-16.6 (8,735)
Group 3	16.5-17.4 (21,275)	16.7-17.5 (21,794)
Group 4	17.5-18.4 (45,096)	17.6-18.4 (42,201)
	(75,381)	(75,381)

UWG, underweight group.

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tions were selected and three scales (validity, clinical, and content scales) were established. Then, the 362 questions were administered to 3,524 normal soldiers, 2,115 new recruits, 489 prisoners, 215 psychiatric patients in army hospitals, 192 civilian prisoners, and 151 psychiatric patients in general hospitals. Finally, score standardization was performed (22-24). Thus, the test is an objective personality test similar to the MMPI. The test-retest reliability and Cronbach's alpha of the MPI range from 0.61-0.83 and 0.58-0.80 for the scales, and the discrimination rate of the MPI is 80% (25).

Statistical analysis

We controlled for age, sex, and race-ethnicity; however, there were still some confounding factors in the multivariate analysis. These factors included education (high school or less, college or more), socioeconomic status (SES: low, low-middle, middle, middle-high, high), and parents relationship (none, father only, mother only, both).

Data were analyzed using STATA 13.0 (Stata Corp., College Station, TX, USA). Differences in the characteristics of examinees by BMI categories were analyzed using the chi-square test for categorical data (education, SES, and parents relationship). To control for confounding factors, we set them as covariates. Then, multivariate analysis of covariance (MANCOVA) with the post-hoc test (Bonferroni test) and locally weighted scatterplot smoothing (LOWESS) were carried out to examine the association between BMI groups and the MPI. Statistical significance was defined as $P < 0.05$.

Ethics statement

This study was approved by the committee of the MMA, and also the protocol was reviewed and approved by the institutional review board of Konkuk University Chungju Hospital (IRB number: 2014-013). Informed consent was exempted by the board.

RESULTS

Table 2 presents the demographic data for each BMI group. All examinees were 19-yr-old men without psychiatric problems who lived in Korea. Education, SES, and parents relationship categorical variables were not independent from BMI category (chi-square = 521.5, $P < 0.001$; chi-square = 1859.14, $P < 0.001$; chi-square = 924.69, $P < 0.001$).

Table 3 summarizes the MPI results for each BMI group. The overall MANCOVA for MPI results by BMI group was significant (Pillai's Trace = 0.013, F = 143.61, $P < 0.001$, partial $\eta^2 = 0.002$). The validity scales were significantly different between most BMI groups. The faking-good and faking-bad subscales were different for all groups except for UWG1 and UWG2. The infrequency subscale was different for all groups except for UWG1 and UWG2, and the normal and overweight groups. The neurosis scales were also significantly different between most BMI groups. The anxiety and personality disorder subscales differed between groups, except for between UWG1 and UWG2, and the normal and overweight groups. The depression subscale differed for all groups except for the normal and overweight

Table 2. Demographic characteristics of body mass index (BMI) groups

Parameters	BMI category									Statistic	*P*
	UWG1 < 15.5	UWG2 15.5-16.4	UWG3 16.5-17.4	UWG4 17.5-18.4	Normal 18.5-24.9	Overweight 25.0-29.9	Class I obese 30.0-34.9	Class II obese 35.0-39.9	Class III obese > 40.0		
No.	1,838	7,172	21,275	45,096	531,140	1,28,176	29,899	5,620	1,192		
Age (yr)	19	19	19	19	19	19	19	19	19		
Sex	Male	Male	Male	Male	Male	Male	Male	Male	Male		
Race-ethnicity	Asian	Asian	Asian	Asian	Asian	Asian	Asian	Asian	Asian		
Education (%)*										$\chi^2 = 521.5$	< 0.001
High school or less	32.1	31.1	28.5	27.6	25.5	26.8	27.9	29.6	35.3		
College or more	67.9	68.9	71.5	72.4	74.5	73.2	72.1	70.4	64.7		
SES (%)*										$\chi^2 = 1,859.14$	< 0.001
Low	9.1	9.5	8.6	8.5	7.4	7.5	8.8	9.7	13.2		
Low-middle	20.1	20.5	20.3	19.5	16.7	16.5	18.5	22.0	20.2		
Middle	48.0	48.5	49.1	48.5	48.0	46.5	45.5	44.1	43.5		
Middle-High	15.1	13.7	14.1	14.8	16.7	17.6	16.6	15.6	13.8		
High	7.7	7.8	8.0	8.7	11.3	11.9	10.6	8.5	9.3		
Parents relationship (%)*										$\chi^2 = 924.69$	< 0.001
None	2.1	2.0	1.8	1.8	1.6	1.6	1.7	1.9	1.4		
Father only	6.9	7.4	6.6	6.1	4.6	4.2	4.8	5.9	7.3		
Mother only	8.5	8.5	8.3	8.1	7.0	7.0	7.9	9.0	9.1		
Both	82.6	82.1	83.3	84.0	86.8	87.3	85.6	83.3	82.2		
Area of residence	Korea	Korea	Korea	Korea	Korea	Korea	Korea	Korea	Korea		
Psychiatric problems	No	No	No	No	No	No	No	No	No		

*SES, socioeconomic status, significant association with BMI category, $P < 0.05$. UWG, underweight group.

Table 3. Results of the Korean military multiphasic personality inventory in relation to body mass index (BMI) groups (Mean ± SD, 95% CI)

Scales	BMI category									P	Post hoc
	UWG1[a] < 15.5	UWG2[b] 15.5-16.4	UWG3[c] 16.5-17.4	UWG4[d] 17.5-18.4	Normal[e] 18.5-24.9	Overweight[f] 25.0-29.9	Class I obese[g] 30.0-34.9	Class II obese[h] 35.0-39.9	Class III obese[i] > 40.0		
Validity scale											
FG	52.47 ± 0.22	52.42 ± 0.12	52.97 ± 0.07	53.33 ± 0.05	54.12 ± 0.03	54.16 ± 0.04	53.72 ± 0.06	53.10 ± 0.13	52.31 ± 0.28	< 0.001	a = b > c > d > e e = f < g < h < i
FB	53.71 ± 0.21	53.76 ± 0.11	53.00 ± 0.07	52.71 ± 0.05	51.86 ± 0.03	51.85 ± 0.04	52.36 ± 0.06	53.09 ± 0.12	54.16 ± 0.26	< 0.001	a = b > c > d > e e = f < g < h < i
INF	55.30 ± 0.10	55.18 ± 0.05	54.99 ± 0.03	54.85 ± 0.02	54.63 ± 0.02	54.77 ± 0.02	55.07 ± 0.03	55.41 ± 0.06	55.64 ± 0.13	< 0.001	a = b > c > d > e e < f < g < h < i
Neurosis scale											
AX	51.75 ± 0.22	51.25 ± 0.11	50.00 ± 0.07	49.27 ± 0.05	47.76 ± 0.03	47.72 ± 0.04	48.60 ± 0.06	49.71 ± 0.13	50.96 ± 0.27	< 0.001	a = b > c > d > e e = f < g < h < i
DEP	52.69 ± 0.20	52.01 ± 0.10	50.78 ± 0.06	50.10 ± 0.05	48.73 ± 0.03	48.58 ± 0.04	49.17 ± 0.06	50.15 ± 0.12	51.49 ± 0.25	< 0.001	a > b > c > d > e e = f < g < h < i
SOM	51.30 ± 0.21	51.00 ± 0.11	49.93 ± 0.07	49.35 ± 0.05	48.08 ± 0.03	47.71 ± 0.04	48.10 ± 0.06	48.90 ± 0.12	50.01 ± 0.26	< 0.001	a = b > c > d > e e < f < g < h < i
PD	49.33 ± 0.22	49.25 ± 0.11	48.58 ± 0.07	48.25 ± 0.05	47.38 ± 0.03	47.17 ± 0.04	47.63 ± 0.06	48.50 ± 0.13	49.36 ± 0.27	< 0.001	a = b > c > d > e e = f < g < h < i
Psychopath scale											
SCZ	53.00 ± 0.22	52.64 ± 0.11	52.15 ± 0.07	52.00 ± 0.05	51.84 ± 0.03	52.79 ± 0.04	53.52 ± 0.06	53.79 ± 0.13	53.90 ± 0.27	< 0.001	a = b > c = d > e e < f < g = h = i
PA	50.19 ± 0.21	50.38 ± 0.11	50.09 ± 0.07	50.11 ± 0.05	49.94 ± 0.03	50.19 ± 0.04	50.49 ± 0.06	50.96 ± 0.12	51.33 ± 0.26	< 0.001	a = b = c = d > e e < f < g < h = i

SD, Standard Deviation; CI, Confidence Intervals; UWG, underweight group; FG, faking good; FB, faking bad; INF, infrequency; AX, anxiety; DEP, depression; SOM, somatization; PD, personality disorder; SCZ, schizophrenia; PA, paranoia.

groups. The somatization subscale differed for all groups except for UWG1 and UWG2. The psychopath scales show different tendencies compared to the validity and neurosis scales. The schizophrenia subscale differed between groups except for between UWG1 and UWG2, UWG3 and UWG4, and the class I to III obese groups. The paranoia subscale differed between groups except for UWG1 to UWG4, and class II and III obese groups. Fig. 1 shows graphically the relationship between BMI and the MPI.

In LOWESS, specific patterns between BMI and the MPI were identified (Fig. 2-4). For the validity scales, the faking-good subscale tended to show an inverted U-shaped association with BMI categories, while faking-bad and infrequency subscale tended to show a U-shaped association. For the neurosis scales, all subscales tended to show U-shaped associations. For the psychopath scales, the schizophrenia subscale tended to show a U-shaped association, while the paranoia subscale showed a near-positive correlation with BMI.

DISCUSSION

We conducted a retrospective cross-sectional study of 771,408 men to investigate the relationship between BMI and the MPI. A U-shaped association was found between BMI and the MPI. In our study, both underweight and obese groups tended less toward faking good, and more toward faking bad, than each normal and overweight group. The infrequency subscale showed a U-shaped association with BMI categories. It means that both the underweight and obese groups tended to exaggerate their symptoms more than the normal and overweight groups. In terms of the neurosis subscales, the underweight and obese groups tended to be more anxious and depressive. They also had more somatic concerns (or symptoms) and personality disorder traits (social withdrawal or impulsivity, and aggression). In terms of the psychopath scales, higher scores meant that obese groups tended to be more vigilant, sensitive, and suspicious (paranoia subscale). Both underweight and obese groups also tended to be more alienated and isolated from others and they tended to feel more mental and emotional confusion (schizophrenia subscale).

Our result is same as previous studies that have shown a U-shaped association between BMI and psychological distress. Zhao et al. conducted a cross-sectional survey of 153,865 adults aged ≥ 18 yr from the 2007 Behavioral Risk Factor Surveillance System (BRFSS). BMI was calculated indirectly and psychological distress was assessed by the Kesler-6 Questionnaire. They found that underweight and obesity were associated with an increased likelihood of having severe psychological distress (SPD) (13). Martínez et al. evaluated the association between BMI and psychological distress in 563 inhabitants aged between 18 and 65 yr of Málaga (South of Spain). They found a symmetric U-shaped relationship between weight status and psycho-

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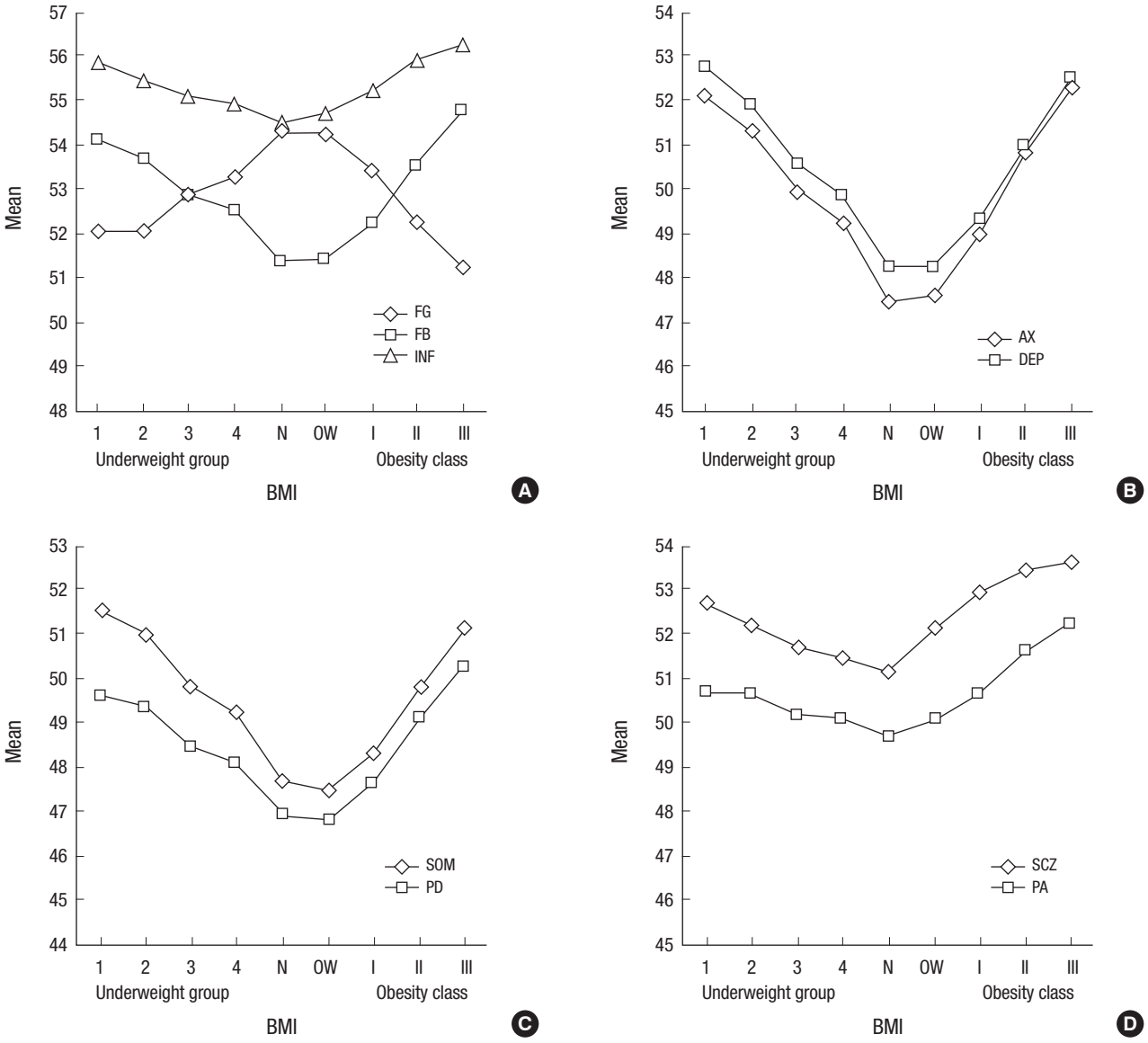

Fig. 1. Means of the Korean military multiphasic personality inventory scales by BMI groups. (**A**) is validity scale. (**B**) and (**C**) are neurosis scale. (**D**) is psychopath scale. Underweight group BMI ranges (1-4) are <15.5, 15.5-16.4, 16.5-17.4, and 17.5-18.4. N, normal; OW, overweight; FG, faking good; FB, faking bad; INF, infrequency; AX, anxiety; DEP, depression; SOM, somatization; PD, personality disorder; SCZ, schizophrenia; PA, paranoia.

logical distress in all the Symptoms Checklist Revised (SCL-90-R) dimensions for both men and women (14).

Additionally, some previous studies have shown that underweight and obesity are associated with psychiatric disorders such as depression and anxiety. McCrea et al. conducted a cross-sectional survey of 7,043 adults. All participants were diagnosed with one of six mental disorders (depressive episodes, generalized anxiety disorder, phobias, obsessive compulsive disorder, panic disorder, and mixed anxiety and depressive disorder) using the revised Clinical Interview Schedule (CIS-R). They were categorized into six BMI groups (< 18.5, 18.5 ≤ 25, 25 ≤ 30, 30 ≤ 35, 35 ≤ 40, and > 40). In young men the probability of a U-shaped relationship was higher for both underweight and obese men (15). Scott et al. categorized participants into 11 BMI groups (< 15, 15-16.9, 17-18.49, 18.5-19.9, 20-24.9, 25-29.9, 30-34.9, 35-39.9, 40-44.9, 45-49.9, and ≥ 50) and observed the prevalence of any mood disorder, anxiety disorder, and substance use disorder during a 12-month period. The relationship between BMI and mood and anxiety disorders revealed a roughly U-shaped relationship with the lowest values in the BMI 25-25.9 kg/m^2 group (4). de Wit et al. also categorized 43,534 participants into four BMI groups (underweight, normal, overweight, and obese) and rated depressive symptoms using the mental health inventory (MHI). They found a very significant U-shaped association between BMI and depression ($P < 0.001$) (16). Another study found that increasing BMI was related to higher risk of schizophrenia, although it was not a completely U-shaped association (between BMI and schizophrenia and paranoia) (6). It is nota-

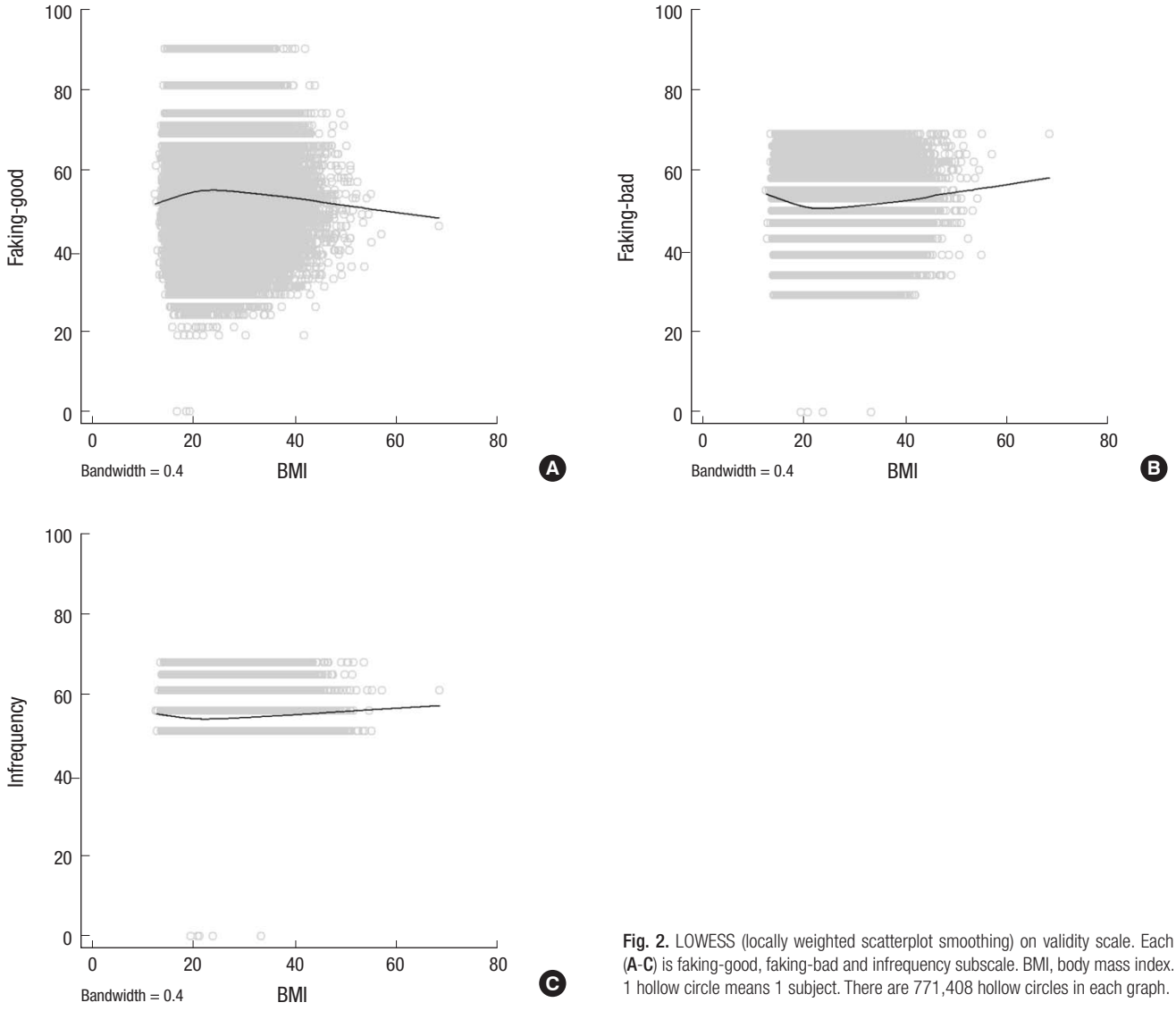

Fig. 2. LOWESS (locally weighted scatterplot smoothing) on validity scale. Each (**A**-**C**) is faking-good, faking-bad and infrequency subscale. BMI, body mass index. 1 hollow circle means 1 subject. There are 771,408 hollow circles in each graph.

ble that the same tendency was observed between previous studies of clinical aspects and the current study of subclinical aspects.

The present study has some limitations. First, use of the MPI has not been widely documented or analyzed because it was developed only for military conscription. However, the MPI has been officially approved by the Korean government. The validity and reliability of the MPI are also stable. Second, subjects were samples enrolled for military conscription. Therefore, the possibility of a draft-dodging tendency among subjects, and a corresponding tendency to exaggerate responses on the MPI, must be considered. Thus, we excluded high standardized T-scores (> 70) among the faking bad or infrequency subscales. Furthermore, they are not yet soldiers but are still civilians and they can freely select the time joining the army until their mid-30s. Third, although the statistical significance was small (η^2 = 0.002), it was significant. Furthermore, LOWESS showed a U-shaped association between BMI and the MPI, so we could predict the psychological impact of BMI on the MPI. Fourth, subjects were limited to only 19-yr old men, but the large group of over 0.75 million participants is a strength. Fifth, the present study was a retrospective cross-sectional design; therefore, it is somewhat unclear whether the U-shaped association reflected actual clinical psychopathology. Future studies should be performed to address these limitations.

In conclusion, specific patterns were observed between BMI and the MPI in 19-yr-old men in Korea. For the validity scales, the faking-good subscale showed an inverted U-shaped association, and others (faking-bad and infrequency) showed a U-shaped association with BMI groups. For the neurosis scales, all clinical subscales (anxiety, depression, somatization, and personality disorder) also showed a U-shaped association with BMI groups. For the psychopath scales, the schizophrenia subscale showed a U-shaped association, and the paranoia subscale show-

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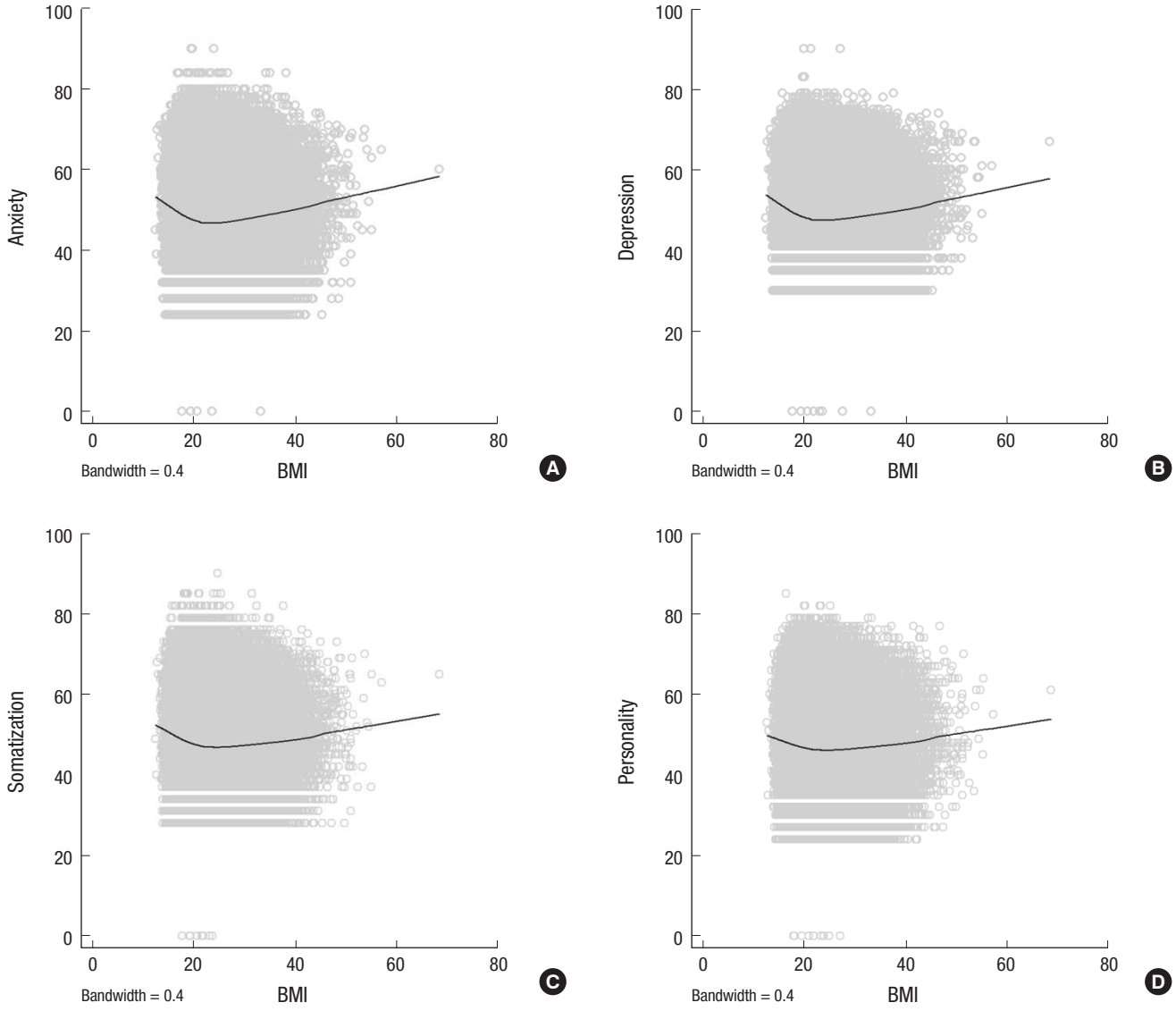

Fig. 3. LOWESS (locally weighted scatterplot smoothing) on neurosis scale. Each (**A**-**D**) is anxiety, depression, somatization and personality disorder subscale. BMI, body mass index. 1 hollow circle means 1 subject. There are 771,408 hollow circles in each graph.

ed a near-positive correlation with BMI. Underweight and obesity are related to psychological distress, so supportive advice and education are needed to them.

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DISCLOSURE

There is no potential conflict of interest among the authors.

AUTHOR CONTRIBUTION

Conception & design of the study: Seo JS, Kim T, Kim JJ. Data collection: Kim T, Kim JJ, Kim MY. Analyzed the data: Data analysis: Kim T, Kim SK, Roh S. Writing the first draft: Kim T. ICMJE criteria for authorship read and met: Seo JS, Kim T, Kim JJ, Kim MY, Kim SK, Roh S. Agree with Approval of manuscript: Seo JS, Kim T, Kim JJ, Kim MY, Kim SK, Roh S.

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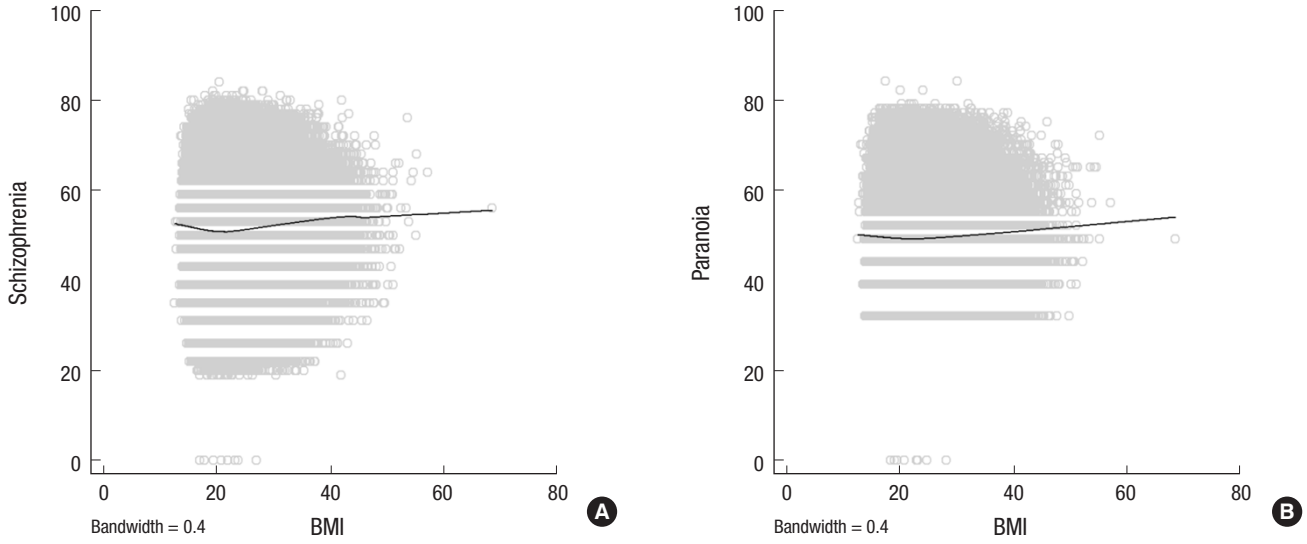

Fig. 4. LOWESS (locally weighted scatterplot smoothing) on psychopath scale. Each (**A**) and (**B**) is schizophrenia and paranoia subscale. BMI, body mass index. 1 hollow circle means 1 subject. There are 771,408 hollow circles in each graph.

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