The prevalence of substance abuse among adolescents has increased steadily worldwide [1] and has become an emerging public health problem during the last few decades. In Taiwan, a cross-sectional survey among 9th-grade students in 1994–1995 found that the lifetime weighted prevalence rate of any Diagnostic and Statistical Manual of Mental Disorders, 3rd Edition substance use disorder was 11.0% [2]. A 3-year panel study in 1995–1997 found that the prevalence rate of Diagnostic and Statistical Manual of Mental Disorders, 4th Edition nicotine, betel nut and alcohol use disorders was 2.2%, 0.8% and 0.5%, respectively, in Taiwanese 7th-grade students, and increased to 5.3%, 2.7% and 1.9%, respectively, when the students reached grade 9 [3]. A national survey in 2004–2006 found that ecstasy and ketamine were used by 0.52–1.72% and 0.44–1.13% of Taiwanese adolescents respectively [4]. Substance abuse commonly starts in adolescence and young adulthood, coinciding with the pivotal period

ASSOCIATIONS BETWEEN SUBSTANCE USE AND BODY MASS INDEX: MODERATING EFFECTS OF SOCIODEMOGRAPHIC CHARACTERISTICS AMONG TAIWANESE ADOLESCENTS

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The aim of this study was to analyze the association between substance use and body mass index (BMI) among adolescents in Southern Taiwan. A total of 10,259 adolescent students aged 11–19 years were selected by stratified random sampling for proportional representation of districts, schools and grades in Southern Taiwan, and completed the questionnaires. The body weight, body height, experience of substance use and sociodemographic characteristics including sex, age, residential background and paternal/maternal educational levels were collected. The association between substance use and BMI, and the moderating effects of sociodemographic characteristics were examined. After adjusting for sociodemographic characteristics, BMI was higher for adolescents who smoke cigarettes or drink alcohol than for those who do not regularly smoke or drink. Chewing betel nuts and using illicit drugs were not significantly associated with BMI. Paternal education level had a moderating effect on the association between smoking and BMI. Smoking, alcohol drinking, and low paternal education level were associated with higher BMI among adolescents. Thus, healthcare professionals should pay more attention to the weight-related problems among these adolescents.

Key Words: adolescents, body mass index, substance use

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of physical and psychological development, and is significantly associated with poor psychosocial functioning, comorbid psychiatric conditions and numerous health risky behaviors [5].

In addition to substance use, obesity is another important issue for adolescents. From the 1970s to the end of the 1990s, the prevalence of overweight or obese school-aged children has doubled or tripled worldwide [6]. In Taiwan, obesity-related problems in children and adolescents, as in Western countries, have increased during recent years and have become an important public health problem. Using the International Obesity Task Force standard, the prevalence of overweight and obesity in Taiwanese adolescents was 15.2% and 6.1%, respectively, in 2004 [7]. Obese children and adolescents are more likely to develop health and psychosocial problems than those who are of normal weight [8,9]. In addition, obese adolescents often experience stigmatization and discrimination, as well as pressure to be thin [10]. Therefore, we should pay more attention to the causes of obesity in adolescents.

Researchers have examined the association between obesity and alcohol consumption in adults, showing a positive association between the quantity of alcohol consumed and abdominal obesity [11]. However, few studies have evaluated the association between alcohol consumption and body mass index (BMI) in adolescents. To our knowledge, only two studies have examined this association and both studies showed that obese adolescents were more likely to consume alcohol than their non-obese peers [12,13].

The results of studies on the association between smoking and BMI in adults are still controversial. In some cross-sectional studies, adult smokers were leaner but had larger waist circumferences than non-smokers [14]. In another study, current smokers had a higher risk factor for obesity comparable to non-smokers [15]. To date, very few studies have examined the association between smoking and BMI in adolescents. A recent follow-up study found that smoking in adolescence was a risk factor for abdominal obesity in adults [16].

Researchers have also found that, while marijuana use is associated with high caloric intake but not with increased BMI among young adults [17], cocaine and heroin use were associated with poor nutrition and lower body mass, particularly in adult women [18]. Very few researchers examined the association between BMI and illicit drug abuse in adolescents.

Betel nut chewing is prevalent in South and Southeast Asia. Previously, researchers have reported that BMI was greater among people who chewed betel nuts [19] and that betel nut chewing was associated with central obesity in adults [20]. To our knowledge, no study has examined the association between BMI and chewing betel nuts in adolescents. Clearly, further studies are needed to examine the association between substance use and BMI in adolescents.

Meanwhile, studies have shown that sociodemographic factors, including sex, age and parental education level, are associated with the body weight of adolescents [21] and substance use behaviors [22]. Therefore, further studies are needed to examine whether these sociodemographic characteristics moderate the association between BMI and substance use in adolescents.

Thus, the aims of this study were to examine the associations between substance use and BMI, and the moderating effects of sociodemographic characteristics on these associations among adolescents in Taiwan. We hypothesized that the BMI of adolescents is positively associated with the use of various substances, including alcohol, tobacco and betel nuts. We also hypothesized that sociodemographic characteristics moderate the associations between substance use and BMI among adolescents.

**Methods**

**Participants**

The current investigation was based on data from the Project for the Health of Adolescents in Southern Taiwan [23], in which data were collected from three metropolitan cities and four counties. In 2004, there were 257,873 adolescent students across 209 junior high schools and 202,456 adolescent students across 140 senior high/vocational schools in this area. Based on the definitions of urban and rural districts in the Taiwan Demographic Fact Book [24] and school and grade characteristics, a stratified random sampling strategy was used to achieve proportional representation of districts, schools and grades. Twelve junior high schools and 19 senior high/vocational schools were randomly selected from the urban districts. In addition, 11 junior high schools and 10 senior high/vocational schools were randomly selected from the rural districts. The classes of these schools were further
stratified into three levels based on grade. Then, 207 classes containing a total of 12,210 adolescent students aged 11–19 years were randomly selected based on the ratio of students in each grade.

**Body mass index**
BMI was calculated from self-reported weight and height measurements. Those who had inappropriately high (>50 kg/m²) or low (<10 kg/m²) BMI values were excluded from further statistical analyses, as previously described [8].

**Substance use**
The four items on the Questionnaires for Experience in Substance Use (Q-ESU) were used to determine the frequency of smoking, alcohol consumption, betel nut chewing and illicit drug use during the preceding year [25]. In this study, participants were divided into a group who had smoked cigarettes, had consumed alcohol and had chewed betel nuts at least once a month during the preceding year, and a group that had used illicit drugs during the preceding year. In a pilot study, we recruited 76 adolescents (40 junior high school students and 36 senior high school students) and their parents to examine the reliability and validity of the Q-ESU. The 2-week test-retest reliability of the items in this study (κ) was 0.704–0.763 (p < 0.001). The κ coefficients for the agreement between participants’ and their parents’ reports on smoking, alcohol consumption, betel nut chewing, and illicit drug use were 0.602, 0.689, 0.725 and 0.852, respectively (p < 0.01).

We also collected participants’ sociodemographic characteristics, including sex, age (<15 years old vs. ≥15 years old), residential background (urban vs. rural), and paternal and maternal educational levels (≤9 years vs. >9 years of compulsory fundamental education). In this study, we used parental education level to represent the socioeconomic status of the adolescents. Although socioeconomic status could be defined using a broad range of variables, parental education level was reported to be the variable that was most strongly associated with childhood obesity [26,27].

**Procedure and statistical analysis**
The protocol was approved by the Institutional Review Board of Kaohsiung Medical University. Research assistants explained the purpose and procedure of this study to the students in the classes, emphasizing respect for their privacy, and encouraging them to participate. Written informed consent was obtained from each adolescent and the participants were then asked to anonymously complete the questionnaire based on the explanations of the research assistants. Each student received a gift that was worth NT$ 33 (US$ 1) at the end of the assessment.

Data analysis was performed using SPSS version 14.0 (SPSS Inc., Chicago, IL, USA). The association between substance use and BMI were examined by multiple regression analysis to adjust for the effects of sex, age, residential background and parental educational levels. We also used the criteria proposed by Baron and Kenny [28] to examine whether the associations between BMI and substance use were influenced

| Table 1. Body mass index, sociodemographic characteristics, and substance use among 10,259 adolescents* |
|-------------------------------------------------|-------------------------------------------------|
| Variables                                      |                      |
| BM (kg/m²)                                     | 20.809±3.883        |
| Sex                                             |                      |
| Female                                         | 5,180 (50.5)         |
| Male                                           | 5,079 (49.5)         |
| Age (yr)                                       |                      |
| <15                                            | 5,178 (50.5)         |
| ≥15                                            | 5,081 (49.5)         |
| Residential background                         |                      |
| Urban                                          | 6,003 (58.5)         |
| Rural                                          | 4,256 (41.5)         |
| Paternal education level                       |                      |
| High (>9 yr)                                   | 6,777 (66.1)         |
| Low (≤9 yr)                                    | 3,482 (33.9)         |
| Maternal education level                       |                      |
| High (>9 yr)                                   | 6,191 (60.3)         |
| Low (≤9 yr)                                    | 4,068 (39.7)         |
| Smoking                                        |                      |
| No                                             | 9,716 (94.7)         |
| Yes                                            | 543 (5.3)            |
| Alcohol consumption                            |                      |
| No                                             | 9,723 (94.8)         |
| Yes                                            | 536 (5.2)            |
| Betel nuts chewing                             |                      |
| No                                             | 10,139 (98.8)        |
| Yes                                            | 120 (1.2)            |
| Used illicit drugs in the past 1 year           |                      |
| No                                             | 10,135 (98.8)        |
| Yes                                            | 124 (1.2)            |

*Data presented as mean ± standard deviation or n (%).
BMI = Body mass index.
by the sociodemographic characteristics of the participants. According to these criteria, moderation occurred when the interaction term for the predictors (substance use) and the hypothesized moderators (sociodemographic characteristics) was significantly associated with the dependent variable (BMI) after controlling for the main effects of both the predictors and the hypothesized moderator variables. In this study, when sociodemographic characteristics and substance use were significantly associated with BMI in multiple regression analysis, the interactions (sociodemographic characteristics × substance use) were used in multiple regression analyses to examine the moderating effects.

**RESULTS**

A total of 11,111 (91.0%) adolescents provided consent and 10,259 (92.3%) completed all research questionnaires without any missing data. Those who had missing data in the questionnaires were more likely to be male ($\chi^2 = 32.279$, $p < 0.001$) and from a junior high school ($\chi^2 = 52.159$, $p < 0.001$). BMI, substance use and sociodemographic characteristics of the 10,259 participants who completed all the research questionnaires are shown in Table 1. Cigarette smoking, alcohol consumption, betel nut chewing, illicit drug use and sociodemographic characteristics were first entered into the multiple regression analysis, and their associations with BMI are shown in Table 2. The results of Model 1 indicated that, after adjusting for the effects of sociodemographic characteristics, BMI was higher in adolescents who smoked cigarettes or drank at least once a month than in those who did not regularly smoke or drink ($F = 48.237$, degrees of freedom $= 9$, $p < 0.001$). By contrast, chewing betel nuts and using illicit drugs were not significantly associated with BMI.

Because sex, age and paternal education level were significantly associated with BMI, the interactions between smoking cigarettes and drinking alcohol and these variables were included in the multiple regression analysis to examine their moderating effects. The results of Model 2 indicate that the interaction between smoking cigarettes and paternal education level was significantly correlated with BMI. We found that the differences in BMI between adolescents who smoked and those who did not smoke were more significant in those with a low paternal education level (22.217 ± 4.653 vs. 20.915 ± 4.088, $t = -4.073$, $p < 0.001$) than in those with high paternal education level (21.243 ± 4.140 vs. 20.685 ± 3.719, $t = -2.366$, $p = 0.019$) (Figure). Sex and age had no moderating effects on the association between BMI and substance use.

**DISCUSSION**

**Prevalence of substance use**

In the present study, the self-reported rates of cigarette smoking, alcohol consumption and betel nut chewing

<table>
<thead>
<tr>
<th>Table 2. Associations between body mass index and sociodemographic characteristics and substance use</th>
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<td>Model 1</td>
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<tr>
<td>Smoking</td>
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<tr>
<td>Alcohol consumption</td>
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<tr>
<td>Betel nuts chewing</td>
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<tr>
<td>Used illicit drugs in the past 1 year</td>
</tr>
<tr>
<td>Sex, male</td>
</tr>
<tr>
<td>Age ≥ 15 yr</td>
</tr>
<tr>
<td>Living in rural areas</td>
</tr>
<tr>
<td>Low paternal education level</td>
</tr>
<tr>
<td>Low maternal education level</td>
</tr>
<tr>
<td>Male × smoking</td>
</tr>
<tr>
<td>Male × alcohol consumption</td>
</tr>
<tr>
<td>Older age × smoking</td>
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<tr>
<td>Older age × alcohol consumption</td>
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<tr>
<td>Low paternal education × smoking</td>
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<td>Low paternal education × alcohol consumption</td>
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*p < 0.05; †p < 0.01; ‡p < 0.001.
Figure. Differences in body mass index between adolescents who smoked and those who did not smoke according to paternal education level.

<table>
<thead>
<tr>
<th>Paternal Education Level</th>
<th>Body Mass Index (kg/m²)</th>
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<tr>
<td>High</td>
<td>22.217 ± 4.653</td>
</tr>
<tr>
<td>Low</td>
<td>20.915 ± 4.088</td>
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except for the separate explanations for the association between alcohol consumption and smoking cigarettes with increased BMI, there are some common causes. For example, alcohol consumption and smoking cigarettes were reported to be associated with irregular food intake, unhealthy weight control and sedentary behaviors [13,34], which further increase BMI. Individuals with high BMI may be discriminated and ridiculed by others [10], and alcohol consumption and smoking cigarettes may be used to relieve their distress. Furthermore, based on the cluster of risky behaviors proposed by Jessor [35], alcohol consumption, smoking cigarettes and unhealthy patterns of food intake may be risky behaviors that are noted at the same time during adolescence, and may compromise the adolescent’s development.

BMI and illicit drug use
We found no significant association between illicit drug use and BMI. The associations between illicit drug use and BMI were difficult to identify. This was partly due to the low rates of illicit drug use in this adolescent population, and the different pharmacological effects of illicit drugs on appetite and body weight [36]. In our study, ecstasy was the most frequent illicit drug used by these Taiwanese adolescents (0.9%), followed by ketamine (0.7%), marijuana (0.4%), amphetamine (0.3%) and heroin (0.3%). This order of prevalence of illicit drug use was similar to the results of a recent national survey [4]. Although ecstasy and amphetamines may inhibit appetite, no significant association was found between BMI and illicit drug use.

One of the possible reasons for these findings is that, although the adolescents in this study might have attempted illicit drug use, the duration of use was too short to affect BMI.

BMI and chewing betel nuts
Previous studies on middle-aged adults have shown positive associations between chewing betel nuts with increased BMI among individuals living in Sarawak [19], and with central obesity among Asians living in London [20]. These associations may be due to the fact that the alkaloid contained in betel nuts can stimulate appetite by inhibiting γ-aminobutyric acid receptors [37]. In this study, we did not find a significant association between chewing betel nuts and BMI. The possible explanation for this finding is that, compared with adults, adolescents chew fewer betel nuts, limiting...
the impact of betel nut chewing on BMI in adolescents. In fact, a previous study found that the prevalence of chewing betel nuts was much lower in adolescents (1.2%) than in adult (35%) [38]. Another interesting issue is that there are marked differences in the ingredients of betel nuts differ between races and provinces. For chewing, a few slices of the nut are commonly wrapped in a betel leaf with lime, and may also include clove, cardamom and catechu (kattha). Generally, Taiwanese people prepare a “sandwich” of more raw areca nut within a single inflorescence of Piper Linn rather than the stem of Piper Linn, as compared with other people [38]. Further studies are needed to examine whether the ingredients of betel nuts influence its association with BMI.

Paternal education as a moderating variable

Another important finding of this study was that low paternal education had a moderating effect on the association between smoking cigarettes and increased BMI. Several Western studies have shown that the maternal education level is significantly associated with pediatric obesity [39,40]. One of the possible explanations for the discrepancy between the results of our study and those of Western studies is that, in Taiwan, fathers may have an important role on the household preferences for food and daily activities. In addition, in many traditional Taiwanese families, the father is the sole wage earner. Thus, the father’s education level is likely to play a significant role in determining the family’s income and may have strong implications on meal budgets and options.

Except for the possible reasons for the association between substance use and BMI, other confounding factors, such as psychiatric comorbidities should be mentioned. The most common comorbid psychiatric disorders associated with substance use disorders were conduct disorder, attention-deficit hyperactivity disorder and mood disorders [2]. Moreover, depressive symptoms were related to high BMI by affecting the ability of youth to engage in healthy lifestyle behaviors [41]. Further studies are needed to clarify the influence of mood disorders on substance use and BMI.

Limitations

Some limitations of this study should be addressed. First, the cross-sectional research design of this study limited our ability to draw conclusions regarding the causal relationships between substance use and increased BMI. Nevertheless, appropriate analysis of cross-sectional data is a valuable initial step to identify associations between substance use and BMI, and to guide the development of further follow-up studies. Second, the authenticity of some data, such as self-reported substance use, cannot be easily verified. Although we found good agreement between the substance use reported by the participants and by their parents’ using the Q-ESU, there were still some discrepancies between the participants’ and their parents’ reports. Because adolescent substance use is considered a forbidden behavior, it is likely that adolescents will under report their substance use, as compared with that reported by their parents. However, we also found that some parents under reported their child’s substance use. One possible explanation for this discrepancy is that the parents may not be aware of substance use by their child away from home. Nevertheless, the questionnaires used in this study were anonymous, which may have encouraged adolescents to accurately report their substance use. In fact, the prevalence of illicit substance use in this study was similar to that reported in a national survey [4], which may support the validity of the Q-ESU used in this study. Third, we used self-reported weight and height to determine BMI. In addition to being subject to recall bias, some adolescents may under report their weight to comply with social norms [42]. Ideally, a validation study should be conducted with objective measures such as blood pressure, total cholesterol and other blood parameters to verify body weight status in a subgroup of this study population, although the results from validation studies cannot be extrapolated to a population with different cultural and socio-demographic characteristics. However, the study of Goodman et al reported that BMI based on self-reported height and weight correctly classified 96% in terms of obesity status and they concluded that studies can use self-reported height and weight to understand adolescent obesity and its correlates or sequelae [43]. Further studies are needed to examine the association between adolescent substance use and body weight status evaluated by objective measures.

In conclusion, the study provides a basis for understanding the association between increased substance use and BMI in adolescents. Since obesity and substance use are important parameters in adolescent health, clinicians and other professionals must monitor...
these two parameters. More studies are needed to better understand the mechanisms involved in the significant associations between smoking and alcohol consumption with increased BMI. If there is a causal relationship between substance use and increased BMI, interventions for one parameter may improve the other. Meanwhile, adolescents who reported low paternal education should be monitored for smoking and increased BMI.

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青少年的物質使用和身體質量指數相關性研究

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本研究的目的在於以大規模、具代表性的南台灣青少年樣本，檢驗青少年物質使用和
身體質量指數之間的相關性。本研究按照城鄉、學校、各年級的人口比例，以分層抽
樣的方式隨機選出受試者，共有 10,259 位 11–19 歲的南台灣青少年學生參與本研究
並完成研究問卷的填寫。研究中收集青少年的身高、體重、物質使用經驗、社會人口
學資料（包括性別、年齡、居住城鄉背景、父母職業教育程度），並以迴歸分析方式檢
驗物質使用和身體質量指數之間的相關性，並探討社會人口學資料的調節效果。本研
究結果發現：在控制社會人口學資料後，每個月固定抽菸或喝酒的青少年相較於未每
個月固定抽菸或喝酒者有較高的身體質量指數值，至於有嚼檳榔和使用非法物質則和
身體質量指數則未有統計顯著相關。此外，父親教育程度為抽菸和身體質量指數值相
關性的調節因子。本研究結果顯示：每月固定抽菸、喝酒、父親為低教育程度，與較
高的身體質量指數值有顯著相關，健康促進相關工作者需對於有上述因子的青少年注
意其體重相關的健康問題。

關鍵詞：青少年、身體質量指數、物質使用
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