ORIGINAL RESEARCH

How Impulsivity is Associated with Adolescent Depression: The Role of Substance Use, Gender and Social Support

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Background: Some risk/protective factors of adolescent depression have been proposed but have not been comprehensively studied. Recent advances in neuroimaging techniques have provided greater insight into the underlying neuropsychiatric mechanisms of depression-related factors such as impulsivity, substance use, gender difference and social support. However, how these factors are interconnected and how they affect depression in the real world is poorly understood. This study aimed to explore the relationships between adolescent depression with trait impulsivity, substance use and gender. We also tested the hypothesis that social support may play a buffering role in preventing depression. By expanding the diathesis-stress model.

Methods: The adolescents enrolled in this study were grade 1 senior high school students from northern Taiwan (N = 5879), and they were assessed for depression, trait impulsivity, and tobacco/alcohol use. Hierarchical multiple linear regression was performed to control possible confounders, including other depression-related diathesis and sociodemographic variables. Gender differences were also analyzed by separately examining variables significantly associated with depression.

Results: A higher level of depression was associated with female gender, trait impulsivity, low self-esteem, negative attitude towards the future, tobacco use, alcohol use, family discord and difficulty in basic family needs. Good parental health, living with their biological family and social support were protective factors. Trait impulsivity was significantly associated with depression after controlling for the confounding factors. Gender-specific analysis showed that trait impulsivity and tobacco use had a significant synergistic interaction on female depression. Social support from parents/peers was significantly associated with depression, but social support from other family members/teachers was not.

Conclusion: The current study advances the understanding of adolescent depression and highlights that trait impulsivity, addictive substance use, social support and their interaction may play an influential role in the emergence of adolescent depression. Gender-specific research and treatment approach are also crucial, and more investigations are necessary.

Keywords: depression, impulsivity, social support, tobacco, gender, self-esteem

Introduction

Despite advances in screening tools and pharmacological/psychological interventions of adolescent depression,[1–3] depression still causes a great burden on youths during the process of transition. These functional declines may include academic failure, substance use comorbidity, self-harm, suicidality and some sequelae could even persist into adulthood.[4–6] Researchers have reported that even subclinical depression in adolescents may lead to long-term clinical and social complications.[7]

Thus, it is important to understand the risk/protective factors of depression. Nevertheless, the association between impulsivity and depression, and how this association is modulated by other factors such substance use, social support and gender is poorly understood. Advances in neuroimaging techniques and neuropsychiatric research have revealed that seemingly different mental disorders and psychological traits may share unique but interconnected neural substrates and neural biochemistry.[8] For example, depression, impulsivity and substance use may share common functional abnormalities of the prefrontal cortex or reward

systems;[9,10] people with trait impulsivity are more prone to substance use, however, repeated exposure to addictive substances can subsequently lead to dopaminergic hypoactivity and even re-shaping the brain structure.[11–13] However, in the field of managing and treating mental health problems, there is still a gap in our understanding of the interactions between depression, impulsivity, substance use and social support in the real world. Therefore, understanding these potential risk and protective factors of adolescent depression is essential to allow for timely preventions and tailored treatment approaches.[14]

The Stress-Diathesis Model of Depression and Trait Impulsivity

Among theories explaining adolescent depression, the stress-diathesis model is one of the most prominent.[15–17] The cognitive vulnerability perspective is built on the framework of Beck's theory,[18] and current depression-related cognitive vulnerability theory includes a wide range of characteristics, such as dysfunctional attitude, low self-esteem, early maladaptive schema, and attribution bias.[19,20] Current evidence has shown that stressors not only play the roles of current triggers but also act as early factors, which exert their effects by shaping personality traits in one's early life.[15,21] Several socio-contextual factors have been identified as stressors of adolescent depression, including family conflict, not living with parents, poor peer relationships,[22,23] and lower socio-economic status.[24–26]

Although the relationship between trait impulsivity and adolescent suicidality is widely recognized[27,28] and suicidality is known to be related to depression, the connection between trait impulsivity with adolescent depression has been less studied. Among the depression-prone diatheses, the importance of trait impulsivity has only recently been identified,[29–32] and further investigations are needed.

Social Support and Substance Use

Beyond the traditional stress-diathesis model, accumulating evidence has shown that social support[23,33,34] and addictive substance use[35] are influential trajectory-altering factors for depression.

Some researchers have speculated that social support may act as a buffer between environmental adversity and cognitive vulnerability during the disorder emerging process of depression.[36–38] For adults and the elderly, the importance of social support in preventing depression has been well-identified, and the effects from different supporting sources have been shown to be different among different age groups.[39,40] However, there is still a lack of understanding of how various social relationships differently support adolescents from mental health problems.[41]

In contrast to merely viewing substance use as a risk factor for adolescent depression,[39] it is currently believed that substance use has a more complex role in the etiology of adolescent depression. Substance use may simultaneously act as predisposing, comorbid or perpetuating factors for adolescent depression. Moreover, a bidirectional association may also exist between depression and substance use behavior.[42,43]

The Present Study

In the current study, we explored the risk and protective factors of adolescent depression using the stress-diathesis model including social support and substance use variables. Based on previous literature, we hypothesized that: (1) trait impulsivity may be positively associated with depression in adolescents after controlling for other predictive variables; (2) substance use, ie, tobacco use and hazardous alcohol use, may be an additional risk factor for depression; (3) there may be synergistic interplay between impulsivity and substance use; (4) social support from different relationships may have differing effects on depression; and (5) these effects may differ among girls and boys, since some researchers have reported that male and female responses to environmental stressors seem to differ.[44–46]

Method

Study Population and Recruitment

This study was part of the Taiwan Adolescent Self-harm Project (TASP). A total of 5879 adolescents from 14 senior high schools were recruited in northern Taiwan from October 2008 to March 2010. These schools account for 11.7% of all high schools in Taipei (9 urban, 3 suburban, and 2 rural schools according to the Taiwan-Fukien Demographic Fact Book). All of the selected high schools had well-equipped computer classrooms, and the participants independently filled

out the self-administered questionnaires on computers to ensure anonymity. To avoid the risk of coercion, recruitment was performed by a master's level research assistant, and the school staff were not involved. The study procedure and confidentiality issues were explained in detail to the participants by the research assistant, and written informed consent was obtained from all participants and their parents. This study was approved by the Institutional Review Board of our hospital and complied with the Declaration of Helsinki.

Measurements

The online questionnaire was interactive with a skip pattern design and took about 30 minutes to complete. The questionnaires included the Chinese version of the Patient Health Questionnaire (PHQ-9),[47] the Chinese version of the Multidimensional Scale of Social Support (MDSS), the Chinese version of the Barratt Impulsiveness Scale Version 11 (BIS-11),[48] the Rosenberg Self-Esteem Scale (RSES),[49] the Alcohol Use Disorder Identification Test-Consumption (AUDIT-C),[50] tobacco use habit and the participant's attitude with regards to the future. Sociodemographic variables, which may reflect the participant's socioeconomic level or be possible stressors, were also collected.

Depression

The outcome variable was the score of the PHQ-9, which is a 9-item self-report inventory based on the Diagnostic and Statistical Manual of Mental Disorders-Fourth Edition (DSM-IV).[50] The Chinese version of the PHQ-9 has been shown to have good internal consistency (alpha = 0.84) and acceptable test-retest reliability (ICC = 0.80) in adolescent populations.[47]

Sociodemographic Variables

The participant's age, gender, school region, school ranking and family situation were collected. The family situation included living with their biological family, difficulty in basic family needs, parental education level, current parental health status, and the existence of family discord.

Social Support

The MDSS is a self-report questionnaire which measures social support from various sources. It can be tailored according to the needs of different studies,[51] and past research has shown high consistency by alpha coefficient of internal reliability to its items.[51,52] The four most common surrounding social support sources selected in this study included parents, other family members (such as siblings and relatives), peers and teachers, and the scores of different support sources were analyzed separately.

Psychological Characteristics

The diathesis factors in this study included impulsivity, self-esteem and attitude towards the future. Impulsivity was measured using the BIS-11, which is a 30-item self-report questionnaire.[53] The Chinese version of the BIS-11 has been shown to have good internal consistency in Taiwanese adolescents.[48] Self-esteem was measured using the Chinese version of the RSES,[49] which consists of 10 items on self-respect and self-acceptance. The reliability and validity of the Chinese version of the RSES have also been demonstrated.[54,55] Attitude towards the future was assessed by asking the question, "What is your attitude towards the future?" The results were coded as 0 for "positive", 1 for "neutral/no opinion", and 2 for "negative".

Tobacco and Alcohol Use

All participants were asked about their habits of tobacco use and alcohol drinking behavior. The frequency and history of tobacco use were asked, and whether he/she currently used tobacco was coded for analysis. Alcohol drinking was assessed by the Alcohol Use Disorder Identification Test-Consumption (AUDIT-C), which is comprised of the first three questions of the full AUDIT. Hazardous alcohol drinking was defined as an AUDIT-C score ≥ 4, which has been shown to have good reliability.[50]

Statistical Analysis

Descriptive and analytical statistics were obtained using Statistics Package for Social Sciences (SPSS) version 23.0 (IBM). In descriptive analysis, we also examined gender differences in demographic variables, social support, psychological characteristics and tobacco/alcohol use. Risk and protective factors for depression were analyzed first using univariate regression analysis. The joint effect of the independent variables that were significant in univariate analysis was then assessed using multiple hierarchical regression analysis. The stress-diathesis theory was incorporated into the multiple regression models with a hierarchical approach by adding variables from distal predictors to proximal predictors. The order of predictor entry was chosen based on early to late chronological development. To examine the effect of different variables on depression, gender and environmental stress factors (school ranking, living with biological parents, difficulty in basic family needs, parental health status, family discord) were entered first in order to control for their effects (model 1). MDSS scores of parents, other family members, peers and teachers were added in model 2. Psychological characteristics (BIS-11, RSES and attitude towards the future) were added in model 3, and tobacco/alcohol use was added in the final step (model 4). Based on a well-documented gender pattern in depression, the associations between depression and each identified factor were separately assessed for the girls and boys (model 5). Depression and tobacco use were found to be significantly related in the girls, but the relationship was not significant in the boys.

Due to the gender differences in the associations between depression and tobacco use, we performed additional interaction analysis between the BIS-11 score and tobacco use to explore other potential associations with adolescent depression. The BIS-11 score was centered to the grand mean in order to reduce multicollinearity, and variables with significance in the previous hierarchical regressions were controlled. Figures illustrating the form of interaction were then created using regression lines between PHQ-9 score, tobacco use and BIS-11 score among the females and males. The cut-off level between high and low impulsivity was defined as a BIS-11 score of 68 (mean + SD),[53] and previous studies have shown that people above this level tend to have more aggressiveness, faster cognitive tempo and instability on Conners continuous performance task.[56] Simple slope analysis was used to aid interpretation of the interaction plots.

Results

Description of the Sample

Among the 5879 participants, the mean PHQ-9 score was 5.7 (SD = 4.6). The female students (n = 3544) had significantly higher PHQ-9 scores ($p = 0.020$) than the male students (n = 3355), with means (SD) of 6.1 (4.6) and 5.2 (4.6), respectively. This result was consistent with the theory that females may be more vulnerable to depression than males.[57] Nearly one fifth of the participants did not live with their biological parents (Table 1). Compared to the girls' parents, the boys' parents had higher education levels (> 9 years, $p < 0.001$) better health status ($p = 0.002$ for the boys' fathers, p = 0.004 for the boys' mothers), suggesting that there may have been gender inequality in our study population. Compared to the boys, the girls received higher social support from their peers ($p < 0.001$) and teachers ($p < 0.001$). For diathesis, while there were no significant gender differences in trait impulsivity (BIS-11 score), the boys attained significantly higher self-esteem scores (RSES: 28.8 vs 27.9) and more positive attitude towards the future than the girls (53.7% vs 46%). Regarding substance use behaviors, significantly more of the boys had hazardous drinking (male: 13.5% vs female: 8%, p < 0.001) and current tobacco use (male: 5.7% vs female: 1.9%, p < 0.001) compared to the girls.

Univariate and Hierarchical Multiple Regressions

To reduce the number of variables, univariate regression analysis was used first to identify variables significantly associated with the PHQ-9. The results of univariate and hierarchical multiple regression analyses are presented in Table 2. In model 1, depression was predicted by female gender, living with biological parents, parents being unhealthy, having family discord, and difficulty in basic family needs. When MDSS scores were entered into the regression in model 2, depression was negatively associated with social support from the four most common sources (parents, other family members, peers and teachers).

In model 3, we studied the effects of diathesis on depression after controlling for sociodemographic and social support variables. Depression was significantly associated with trait impulsivity, negative attitude towards the future and

Table 1 Demographic Variables, Social Support, Psychological Characteristics and Substance Use Habits

	Total Sample	Gender	
	(N=5879)	**Male (n=3544)**	**Female (n=3355)**
Demographic variables			
School ranking >70th percentile, n (%)	1739(29.6)	749(29.4)	990(29.7)
School district, city	2501(42.5)	980(38.5)	1521(45.6)***
urban	3005(51.1)	1417(55.7)	1588(47.6)
rural	373(6.3)	147(5.8)	226(6.8)
Living with biological parents, n (%)	4824(82.1)	2116(83.2)	2708(81.2)
Father's education level >9 years	3152(53.6)	1431(56.3)	1721(51.6)***
Mother's education level >9 years	3347(56.9)	1512(59.4)	1835(55)***
Father is healthy, n (%)	4645(74)	3055(76.1)	2610(72.5)**
Mother is healthy, n (%)	1234(79)	489(80.8)	745(77.7)**
Difficulty in basic family needs, n (%)	571(9.7)	262(10.3)	309(9.3)
With family discord, n (%)	558(9.5)	242(9.5)	316(9.5)
Social support			
MDSS of parents, mean (SD)	5.3(1.4)	5.3(1.3)	5.3(1.4)
MDSS of relatives, mean (SD)	5.0(1.3)	5.0(1.3)	5.1(1.3)
MDSS of peers, mean (SD)	5.5(1.3)	5.3(1.3)	5.6(1.3)***
MDSS of teachers, mean (SD)	5.1(1.4)	5.0(1.4)	5.1(1.4)***
Psychological characteristics			
PHQ-9, mean (SD)	5.7(4.6)	5.2(4.6)	6.1(4.6)***
BIS-11, mean (SD)	60.1(8.5)	60.0(8.5)	60.1(8.4)
RSES, mean (SD)	28.3(5.4)	28.8(5.4)	27.9(5.4)***
Attitude towards the future,			
0 (Optimistic), n (%)	2899(49.3)	1366(53.7)	1533(46)***
1 (Neutral or no opinion), n (%)	2726(46.4)	1070(42.1)	1656(49.7)
2 (Pessimistic), n (%)	254(4.3)	108(4.2)	146(4.4)
Substance use habits			
Tobacco use, n (%)	226(3.8)	153(6)	73(2.2)***
AUDIT-C >4, n (%)	658(11.2)	370(14.5)	288(8.6)***

Notes: *P*-value using the chi-square test for dichotomous/categorical variables (school ranking >70th percentile, school district, living with biological parents, difficulty in basic family needs, father's education level >9 years, mother's education level >9 years, father is healthy, mother is healthy, with family discord, tobacco use, AUDIT-C >4) and Student's *t*-test for continuous variables (MDSS of parents/relatives/peers/teachers, PHQ-9, BIS-11, RSES and attitude towards the future). Significance level: **p < 0.01, ***p < 0.001.
Abbreviations: MDSS, Multidimensional Scale of Perceived Social Support Scale; PHQ-9, Patient Health Questionnaire-9 item; BIS-11, Barratt Impulsiveness Scale Version 11; RSES, Rosenberg Self-Esteem Scale; AUDIT-C, Alcohol Use Disorders Identification Test-Consumption.

lower self-esteem. The MDSS scores of other family members/teachers lost their significance in model 3, while the other significant variables identified in model 2 remained significant. Model 4 included variables of substance use, and depression was significantly associated with current tobacco use and hazardous alcohol drinking. The three studied diatheses retained their significance after the adjustments.

    We further analyzed gender differences in depression in model 5. For both genders, the risk factors for depression included higher impulsivity, negative attitude towards the future, low self-esteem, family discord, and alcohol use, while the protective factors included social support from parents/peers, and mothers having a good health status. Good health status of the father was a protective factor against depression only in the boys, and the girls were more vulnerable to the influences of difficulty in basic family needs and current tobacco use.

Table 2 Univariate Analysis and Hierarchical Stepwise Regression Examining Multivariate Correlates of PHQ-9

	Univariate Analysis	Multivariate Analysis					
		Model 1	Model 2	Model 3	Model 4	Model 5 (male)	Model 5 (female)
	B(SD)	B(SD)	B(SD)	B(SD)	B(SD)	B(SD)	B(SD)
Female	0.88 (0.12)***	0.80 (0.12)***	0.91 (0.11)***	0.39 (0.13)**	0.55 (0.13)***	–	–
Living with biological parents	−0.78 (0.16)***	−0.88 (0.16)***	−0.76 (0.16)***	−0.55 (0.18)**	−0.50 (0.18)**		
Difficulty in basic family needs	1.37 (0.2)***	0.87 (0.2)***	0.67 (0.19)***	0.44 (0.21)*	0.47 (0.21)*		0.77 (0.28)**
With family discord	3.17 (0.2)***	2.75 (0.2)***	2.22 (0.2)***	1.66 (0.22)***	1.62 (0.22)***	1.62 (0.33)***	1.79 (0.28)***
Father is healthy	−1.34 (0.14)***	−0.92 (0.15)***	−0.83 (0.15)***	−0.75 (0.17)***	−0.70 (0.17)***	−0.86 (0.25)***	
Mother is healthy	−1.66 (0.15)***	−1.24 (0.16)***	−1.12 (0.16)***	−0.69 (0.18)***	−0.66 (0.18)***	−0.61 (0.28)*	−0.77 (0.21)***
MDSS of parents	−0.74 (0.04)***		−0.42 (0.05)***	−0.24 (0.05)***	−0.21 (0.05)***	−0.20 (0.08)*	−0.22 (0.07)***
MDSS of relatives	−0.59 (0.05)***		−0.16 (0.05)**				
MDSS of peers	−0.50 (0.05)***		−0.29 (0.05)***	−0.15 (0.05)**	−0.16 (0.05)**	−0.18 (0.08)*	−0.16 (0.07)*
MDSS of teachers	−0.41 (0.04)***		−0.15 (0.04)***				
BIS-11	0.17 (0.01)***			0.09 (0.01)***	0.08 (0.01)***	0.07 (0.01)***	0.09 (0.01)***
Attitude towards the future	2.75 (0.1)***			1.16 (0.12)***	1.14 (0.12)***	0.91 (0.19)***	1.36 (0.16)***
RSES	−0.41 (0.01)***			−0.24 (0.01)***	−0.24 (0.01)***	−0.25 (0.02)***	−0.24 (0.02)***
Tobacco use	2.66 (0.31)***				0.88 (0.32)**		2.00 (0.58)***
AUDIT-C >4	2.37 (0.19)***				1.51 (0.21)***	1.43 (0.27)***	1.75 (0.31)***

Note: Model 1 adjusted for all sociodemographic variables. Model 2 adjusted for model 1 and MDSS of parents/relatives/peers/teachers. Model 3 adjusted for model 3 and diathesis (BIS-11, attitude towards the future and RSES score). Model 4 adjusted for model 3 and substance use behaviors (tobacco use and AUDIT-C > 4) Model 5 analysis of model 4 by gender. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.
Abbreviations: MDSS, Multidimensional Scale of Perceived Social Support Scale; PHQ-9, Patient Health Questionnaire-9 item; BIS-11, Barratt Impulsiveness Scale Version 11; RSES, Rosenberg Self-Esteem Scale; AUDIT-C, Alcohol Use Disorders Identification Test-Consumption.

Interaction and Slope Analyses

Our results showed that trait impulsivity and substance use were highly correlated, and that trait impulsivity and depression may involve common neural substrates. Consequently, in order to explore why the correlation between girls' tobacco use was significantly correlated with depression (B = 2, SD = 0.58) while boys' tobacco use was not after controlling for the confounding variables, interaction analysis between impulsivity and tobacco use was carried out to further understand the gender differences. We found an interaction between trait impulsivity (BIS-11 score) and tobacco use in the girls rather than in the boys. The result was significant after controlling for potential interfering variables ($p < 0.001$, Table 3). The interactions were plotted separately by gender (Figure 1), and the figure illustrating females showed that when impulsive trait was superimposed with current tobacco use, the girls had a higher level of depression (female

Table 3 Analysis of Interactions Between Tobacco Use and Impulsivity in Terms of Gender

	Analysis of Interactions					
	Female			Male		
	Univariate Analysis	Multivariate Analysis		Univariate Analysis	Multivariate Analysis	
		Model 1	Model 2		Model 1	Model 2
	B(SD)	B(SD)	B(SD)	B(SD)	B(SD)	B(SD)
Tobacco use	4.94(0.54)***	3.65(0.65)***		1.91(0.38)***	0.42(0.42)*	
BIS-11 (centered)	0.18(0.01)***	0.17(0.01)***	0.08(0.01)***	0.15(0.01)***	0.01(0.01)***	0.07(0.01)***
BIS-11 (centered) x tobacco use			0.26(0.06)***			

Notes: Model 1 tested the association between tobacco use and BIS-11 (centered). Model 2 tested the interaction term (BIS-11 [centered] x tobacco use). In model 2, variables with significance in the hierarchical regressions were controlled. *$p < 0.05$, ***$p < 0.001$.
Abbreviation: BIS-11 (centered), the centered score of Barratt Impulsiveness Scale Version 11.
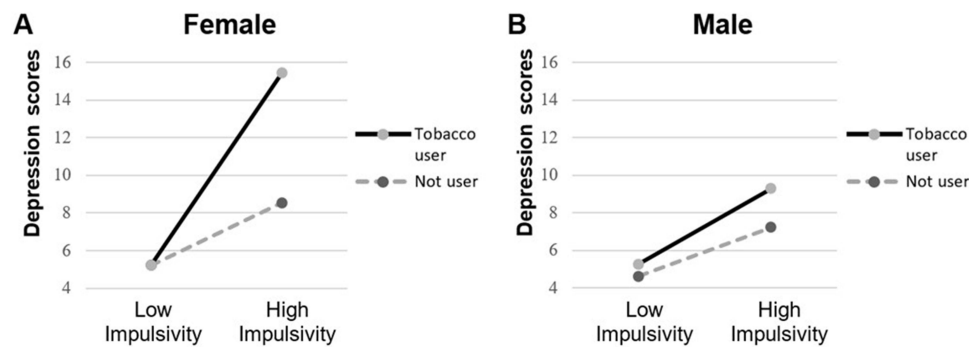
Figure 1 The Synergistic Effect of Impulsivity and Tobacco Use on Adolescent Female Depression.
Note: Depression symptom scores of the Patient Health Questionnaire-9 were plotted as a function of impulsivity. Females (**A**) had significantly stronger interaction of impulsivity × tobacco use than males (**B**).

tobacco users: B = 5.154, standard error [SE] = 1.548, p = 0.002; female non-users: B = 1.943, SE = 0.215, p < 0.001). We also analyzed the alcohol use behavior, but we did not find similar differences between genders.

Discussion

This study has three major findings. First, an association between impulsivity and adolescent depression was confirmed after controlling for confounding variables. Second, a synergistic effect between tobacco use and trait impulsivity was found in the female participants. Third, social support, especially from parents/peers, may protect adolescents from depression.

Associations Between Depression, Impulsivity and Other Diathesis

Of the etiologies of adolescent depression, diathesis (or personality trait) has been proposed to be an important factor. Among our studied diatheses, negative attitude towards the future is well-known as Beck's model of cognitive triad of depression.[58] The role of low self-esteem in depression is more complicated. Current evidence has shown that low self-esteem may be a precursor and a prolonging factor for adolescent depression, and low self-esteem may persist after depression remits.[20,59,60] Our findings also support that these two diatheses are important factors for adolescent depression.

As the core of externalized spectrum of developmental disorders,[61] impulsivity is present in many adolescent mental disorders, including substance use disorder, attention deficit/hyperactivity disorder, and bipolar spectrum. Nevertheless, the relationship between adolescent depression and trait impulsivity has not been fully elucidated. Our results are similar to past studies conducted in French and Tunisian populations, in that impulsive adolescents had higher levels of depression.[29,31] In the previous studies, the sample sizes were relatively small, and only a limited number of confounders were controlled. A strength of this study is the large number of cases and potential predictors were controlled in the analysis. In our study, the correlations between depressive symptoms and impulsivity scores were significant in both genders after controlling for other depression-prone diatheses, substance use behavior and sociodemographic variables. This result is also compatible with other studies which have suggested that trait impulsivity and depression may share similar neural substrates, such as mesolimbic dopamine activity or aberrant connections between frontal pole and other brain areas.[9,62,63] Therefore, trait impulsivity should also be considered when managing adolescent depression and pursuing the underlying etiologies.

Interactions Between Trait Impulsivity, Gender and Tobacco Use

Substance misuse was once viewed as a male-predominant problem due to its high incidence rate among males. The increasing rate of female addiction in recent years suggests that adolescent and young adult females are also vulnerable to addictive substance use.[64,65] To explain the rising rate, some researchers have postulated that female users tend to experience higher pleasure responses on exposure to addictive substances and become addicted faster than males once

they initiate substance use.[66] The association between depression and adolescent tobacco smoking and alcohol drinking has been documented, and some researchers have speculated that males and females may have different pathways,[67–71] however, the underlying pathophysiology of gender differences has not been fully explored.

Our findings may provide new insights into this issue. In our study population, when controlling for other predictors, tobacco use was associated with depression in the girls, but a similar association was not found in the boys. In order to understand why female tobacco users were more prone to depression, we performed interaction analysis, and the results showed a synergistic effect between trait impulsivity and female tobacco use. The synergic effect may suggest that, if trait impulsivity and tobacco use are superimposed, girls may have a higher level of depression. In past studies, impulsivity has been found to be a predisposing factor for tobacco use,[71] and moderating effects between impulsivity, substance use and depression have been reported.[46,72,73] However, few studies have examined gender differences. We speculate that the gender difference may be driven by both socio-contextual and biological factors. The higher incidence of tobacco use in boys may result from the influence of peer behavior, and their tobacco use behavior tends to be normalized in male subculture.[74] Thereby, boys face lower psychosocial pressure if they initiate tobacco use. However, in the traditional value judgement of Taiwanese, girls are more discouraged from using tobacco and can face criticism if they do. This traditional value may be a protective factor for non-users from initiating tobacco use,[75] but girls with higher impulsivity may be left as a vulnerable subgroup in young female population. Once initiating tobacco use, these girls may face higher pressure or even emotional problems. The above pressures and the depression-prone tendency of impulsivity result in a higher incidence of dysphoric mood and higher need for the stimulating and euphoric effects of tobacco. These effects can also accelerate the addictive cycle for these girls. The cross-sectional design of our study only allows for testing associations, and more comprehensive and longitudinal studies are needed to examine the causal relationships.

The Role of Social Support

In preventing depression, the main sources of social support may shift from childhood to later life,[39] and some researchers suggest that the effects of different social relationships may differ according to one's age.[39,40] Earlier studies have proven the importance of social support for adolescents, and adolescents are known to receive social support from various sources.[76,77] Nonetheless, there still remains a research gap of which supporting sources are more influential or crucial for adolescents to pass the transition period.

In our studied adolescents, four main sources of social support were analyzed, including parents, other family members, peers and teachers. Only support from parents and peers retained significance after controlling for covariates. Comparing our results with past research, we propose that there may be cultural variations between relationship-specific social support sources. In an Australian study, lack of family/teacher support predicted depression rather than lack of peer support,[41] whereas in a study from the Mid-Atlantic United States, adolescent depression was associated with less parental/sibling/peer communication, and gender differences were found.[78] In an Israeli study comparing the effects among family, friends, and school personnel, only family social support was prominent in protecting adolescents from depression. In a Japanese study focusing on the classroom, the role of teacher support was also important in reducing depressive score,[34,79] but support from other sources was not compared. In past studies, parental support was mostly analyzed within the scope of family support, and this approach may hinder our understanding of the difference between them. Our results showed that parental support, as the pillars of most families, seemed to be different and more influential than support from other family members in buffering adolescents against depression. Combining our results with past research, it also seems that parental support plays a pivotal role in preventing adolescents from depression across most cultures. Social support from other sources is still crucial, but the effects vary according to the ethnicity or nationality of the youths. Advances in neuropsychiatry have also revealed that receiving social support or not may modulate neural responses in the amygdala and striatum activity,[80,81] and that these circuits are related to happiness and reward sensitivity.[82,83] Since different social support intertwine in one's developmental trajectory, how they affect the adolescent development is a critical issue to be explored in future studies.

Limitations and Future Directions

This study has several limitations. First, while the sample size was large, the cross-sectional design only allows for the examination of correlations, but not the causal relationship or potential underlying mechanisms. Second, illicit substances were not included in our study, which limits the generalizability of our findings to other addictive substances. Third, self-report surveys are prone to response bias, including recall bias and social desirability bias.[84] However, some evidence has demonstrated that young people are more inclined to report their emotional problems and substance use habits through anonymous school-based surveys, and this method has been proven to have higher validity.[85,86] Fourth, although the recruited school-based population may represent the majority of adolescents in Taiwan, adolescents who dropped out of school may represent another population with different characteristics.[87,88] Fifth, the studied population only included adolescents from 14 senior high schools in Taipei, and this may not fully represent the diversity of adolescent populations in other regions, countries or cultures. Further research and replication studies are needed to confirm our findings. Finally, early, middle and late adolescents have been considered to be different groups,[21] and only the first grade of senior high school students were included in our study. In the Taiwanese education system, this age group has just passed the joint entrance examination and been assigned to different schools. Namely, they were just adapting to different environments, and this background made them appropriate candidates to be investigated.

Conclusion

Overall, our findings suggest that impulsivity is a non-negligible factor in the research field of adolescent depression. The interaction between trait impulsivity and tobacco use in female depression implies that girls and boys may have different pathways or pathophysiology in the process of developing depression.[44,89,90] To manage the complex and unmet needs of adolescent depression, how social support protect adolescents from depression should also be a focus in clinical practice and future investigations.[23,33]

Ethics Approval and Informed Consent

This study was approved by the Institutional Review Board of Mackay Memorial Hospital. Written informed consent was obtained from all participants and their parents.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors declare that there are no conflict of interests.

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