Psychiatric Comorbidities in Asian Adolescent Asthma Patients and the Contributions of Neuroticism and Perceived Stress

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Article history: Received May 29, 2013; Accepted January 8, 2014

Keywords: Asthma control; Psychiatric comorbidity; Risk factors; Perceived stress; Neuroticism; Adolescent

ABSTRACT

Purpose: Psychiatric comorbidity is reported to be common among adolescents with asthma, but little is known about its underlying psychological factors.

Objective: This study explored the profile of anxiety and depressive comorbidities among adolescents with well-controlled and poorly controlled asthma and the contribution of neuroticism and perceived stress.

Methods: The Revised Child Anxiety and Depression Scale, Neuroticism subscale of Big Five Inventory, Perceived Stress Scale, and Asthma Control Test were administered to 198 adolescents (aged 12–19 years) with well-controlled (n = 137) and poorly controlled asthma (n = 61) as well as 171 healthy neighborhood controls.

Results: Adolescents with poorly controlled asthma, compared with well-controlled asthma patients and healthy controls, had higher scores of depression (p = .006), panic attacks (p = .002), total anxiety (p = .038), and total internalizing symptoms (p = .017), after adjusting for gender, age, ethnicity, smoking status, and family housing type. Adolescents with asthma had higher neuroticism (p = .025), perceived stress (p = .022), and body mass index (p = .006) and lower self-rated health (p < .001) than healthy controls. No significant differences in psychiatric comorbidity scores were observed after accounting for differences in underlying psychological and physical factors. Among asthma patients, increased asthma control was associated with decreased scores of psychiatric comorbidity (p < .01), but the association was not significant after allowing for decreased neuroticism and perceived stress.

Conclusions: The diagnosis of asthma and poor asthma control in adolescents is associated with excess psychiatric comorbidity, which is likely due to increased neuroticism and perceived stress. Crown Copyright © 2014 Published by Elsevier Inc. on behalf of Society for Adolescent Health and Medicine. All rights reserved.

IMPLICATIONS AND CONTRIBUTION

Psychiatric comorbidity has been widely reported among adolescents with asthma. This study explored the syndrome profile of specific anxiety and depressive symptoms in adolescents with well-controlled and poorly controlled asthma and identified the major contribution of neuroticism and perceived stress to the observed excess psychiatric comorbidity.

Asthma is a common chronic disease in the pediatric population, with higher rates in adolescents than in younger children [1]. The prevalence of asthma has dramatically increased recently [2], concurrently with an increase in the prevalence of mental health problems worldwide [3]. The psychiatric comorbidity of asthma is therefore a subject of current clinical and research interest.
Our previous systematic review and meta-analysis in 2012 showed that the risk of developing depression and anxiety is about two times higher among adolescents with asthma than in their healthy peers (depression: pooled odds ratio, 2.09; 95% confidence interval, 1.65–2.64; p < .001 and anxiety: pooled odds ratio, 1.83; 95% confidence interval, 1.63–2.07; p < .001) [4]. The severity of psychiatric comorbidity is reportedly correlated with the severity of asthma symptoms, impaired functioning, and poorer adherence to treatment regimens [5,6]. However, the psychological and physical mechanisms underlying psychiatric comorbidity in asthma are not well understood. It remains unclear to what extent underlying psychological factors such as personality traits and their cognitive and behavioral correlates explain the presence of psychiatric comorbidities among children with asthma.

Neuroticism is a personality trait manifested as the tendency to experience negative and distressing emotions and is reportedly linked to psychiatric morbidity including anxiety, depression, and stress susceptibility, as well as exacerbation of asthma [7,8]. Perceived stress in relation to life events is a cognitive correlate of neuroticism that is determined by one’s own beliefs, values, and conditioning. According to reports, stress has a negative impact on the onset, severity, hospitalization, prolonged medication use, and prognosis of asthma [9]. The presence of neuroticism and perceived stress may therefore explain an excess of psychiatric comorbidities among asthma patients [10]. At the same time, studies suggest that neuroticism and perceived stress also contribute to higher body mass index (BMI) or obesity [11] and poor perceived health [8]. These physical factors are also reportedly associated with asthma relapse and more severe depressive and anxiety symptoms in asthma patients [12–14]. Although the temporal causal relationships are not well established, it is therefore possible that the excess of psychiatric morbidity associated with asthma could be due to the individual or combined effects of overweight—obesity, perceived health status, stress, and neuroticism. To our knowledge, no studies have examined the contributions of these major psychological and physical factors to the observed excess psychiatric comorbidities associated with asthma. We hypothesized that adolescents who were having asthma, especially those with poorly controlled asthma, would have more psychiatric symptoms in comparison with their healthy counterparts. Neuroticism, perceived stress, BMI, and perceived health status may be the mediating psychological and physical factors for excess psychiatric comorbidity in asthma.

The first objective of this study was to explore the symptom profile of specific anxiety and depressive comorbidity (panic attacks, social phobia, generalized anxiety, obsession and compulsion, separation anxiety, depression, total anxiety, and total internalizing [anxiety and depressive] symptoms) in adolescents with well-controlled and poorly controlled asthma. The second objective was to explore the roles of neuroticism and perceived stress, BMI, and perceived health status in explaining the association between asthma and psychiatric comorbidity.

Methods

Study design and participants

In this cross-sectional study, adolescents (aged 12–19 years) with asthma were diagnosed at the National University Hospital, Singapore, by a pediatrician (H.P.V.B.). Healthy controls (n = 171) who were age matched (±2 years) and gender matched with asthma patients were recruited from the same neighborhood. Adolescents who suffered from other chronic diseases were excluded from this study. The response rate was 92%. All participants and their parents signed written informed consent for the study, which was approved by the National Healthcare Group Domain Specific Review Board. The measurement instruments used in the study are briefly described below; additional details of the scales and procedures used can be found in the Supplementary Material. The self-administered questionnaires were completed in English with the interviewer’s assistance by the respondents who were multiethnic but received a common standard education in English as first language.

Asthma control and asthma quality of life

The Asthma Control Test (ACT) is widely used in clinical and research settings for assessing the degree of asthma control [15] and shows strong evaluative and discriminative properties in general and locally [16]. The ACT records the occurrences of dyspnea episodes, sleeping impairment, limitations in daily activities, use of rescue inhalational medications, and self-reported asthma control in the past 4 weeks. The ACT indicated 137 patients with well-controlled asthma (ACT ≥ 20) and 61 with poorly controlled asthma (ACT < 20) in this study. The Pediatric Asthma Quality of Life Questionnaire [17] measures the impact of asthma on children’s activity limitations, asthma symptoms, and emotional function (low Pediatric Asthma Quality of Life Questionnaire score indicates impaired quality of life), and its reliability and validity have been substantiated in multiple populations including Singaporeans [18].

Depression and anxiety

The Revised Child Anxiety and Depression Scale assesses a broad range of psychiatric symptoms of panic attacks, social phobia, generalized anxiety, obsession and compulsion, separation anxiety, and depression in adolescents. It has shown excellent psychometric properties in many cross validation studies including among Asian children [19]. T scores of total anxiety symptoms (sum of the five anxiety subscales) and total internalizing symptoms (sum of all the six subscales) were calculated. T scores of 65 or higher indicate borderline threshold of psychiatric comorbidity, and T scores of 70 and above indicate clinical threshold of psychiatric comorbidity.

Neuroticism

Neuroticism was measured by the Neuroticism subscale of the NEO Five-Factor Inventory that was designed to assess traits identified in the universal Five-Factor Model [20]. The neuroticism subscale has high reliability and validity with a Cronbach’s α of .85 and has been validated for use in Singapore [21]. A summed score of the 12 items on the neuroticism subscale was derived as a measure of neuroticism.

Stressful life events and perceived stress

The Holmes–Rahe Social Readjustment Ratings Scale [22]—Children and Adolescent version provides a valid measure of the number of life events in the past 1 year that necessitated lifestyle changes and has been cross-culturally validated in Asian
populations [23]. The Perceived Stress Scale [24] is widely used to measure the level of perceived stress (a higher score indicating greater perceived stress) and has been validated in the local populations [25].

Sociodemographic data and self-rated health

These included gender, age, ethnicity (Chinese, Malay, Indian, or others), smoking status (nonsmoker, past, or current smoker), family housing type as a proxy for socioeconomic status (1- to 2-room, 3-room, or 4- to 5-room public housing, private housing, or detached house), and BMI based on physical measurements of weight and height. The self-rated health (SRH) status was assessed by a single question that was well validated in previous studies [26].

Statistical analyses

Data analysis was performed using Predictive Analytics Software (PASW/SPSS) Statistics version 18 (SPSS Corp., Chicago, IL). Unadjusted differences in sociodemographic status, measures of psychiatric comorbidity, underlying psychological factors and their correlates, and quality of life were evaluated among groups with poorly controlled asthma, well-controlled asthma versus healthy controls, using two-tailed chi-squared test and one-way analysis of variance, with pairwise comparisons between groups using Bonferroni-adjusted p values. Pearson correlational analysis was used to examine the relationship among asthma, psychological, and psychiatric variables, using Holm–Bonferroni-corrected p values of statistical significance to control Type I errors. The scores of psychiatric comorbidity were compared among the three groups of participants in generalized linear regression models, controlling for potential confounders (gender, age, ethnicity, smoking status, and family housing type). To evaluate the roles of the underlying psychological (perceived stress and neuroticism) and physical (BMI and SRH status) factors in mediating the observed difference in psychiatric comorbidities among the participants, we included these variables separately in sequential models, and all four variables in the final prediction model of psychiatric comorbidities, together with diagnostic checks for multicollinearity. The change in the strength of association, the level of statistical significance, and the R-squared value in various regression models were assessed.

Results

Subjects’ demographics

There were significant differences in the ethnicity (p < .01) and housing types (p < .01) among the three groups. Asthma patients had significantly higher proportions of Malays and Indians and were more likely to reside in smaller public housing as compared with healthy controls. There were no significant differences in age and gender among the three groups (p > .05). Higher proportions of smokers (p < .05), higher BMI (p < .01), and poorer SRH status (p < .01) were observed among asthma patients compared with healthy controls, especially among poorly controlled asthma patients.

Asthma control

Among asthma patients, the mean asthma control score was 22.6 (SD 1.80) for those with well-controlled asthma and 16.2 (SD 2.78) for those with poorly controlled asthma (p < .001). Participants with poorly controlled asthma had significantly lower scores (p < .001) on asthma quality of life than those with well-controlled asthma (Table 1).

Psychiatric comorbidities

Adolescents with poorly controlled asthma reported significantly more severe panic attacks, depressive symptoms, and total internalizing symptoms than subjects with well-controlled asthma and healthy controls (p < .05). Adolescents with poorly controlled asthma reported significantly more severe generalized anxiety symptoms in comparison with healthy controls (p < .05) and more severe obsession and compulsion and total anxiety symptoms than well-controlled asthma patients (p < .05). There was no significant difference in the symptom scores of social phobia and separation anxiety among the groups (p > .05; Table 1).

By classifying the number of participants with symptom scores above the borderline and reaching the clinical thresholds of psychiatric comorbidities, the number of subjects who were disturbed by severe panic attacks and depressive symptoms was found to be higher among participants with asthma, especially those with poorly controlled asthma (p < .05). No significant difference was observed in social phobia, separation anxiety, generalized anxiety, obsession and compulsion, total anxiety, and total internalizing symptoms (Table 1).

To control for confounding variables, we adjusted the mean psychiatric comorbidity score for the difference in gender, age, ethnicity, smoking status, and family housing type among the well-controlled and poorly controlled asthma and control groups in analysis of covariance (ANCOVA) models. As listed in Table 2 (base model), the same difference in scores for panic attacks, depression and total anxiety, and internalizing symptoms among the three groups remained statistically significant after adjustment.

Psychological and physical predictors

Adolescents with poorly controlled asthma scored significantly higher on neuroticism than those with well-controlled asthma and healthy controls (p < .05). Although no significant difference was observed in the number of stressful life events among the three groups, participants with poorly controlled asthma scored significantly higher on perceived stress than the other two groups (p < .05). Poorly controlled and well-controlled asthma patients showed significantly lower score on SRH status (p < .01) but significantly higher BMI (p < .01) in comparison with healthy controls.

Contribution of neuroticism and perceived stress to psychiatric comorbidity

Correlational analyses for the whole sample revealed that neuroticism, perceived stress scores, and SRH status were significantly correlated with scores of all psychiatric comorbidity (Holm–Bonferroni-adjusted p < .0001; Table 3). BMI did not correlate with the symptom score of any psychiatric comorbidity (p > .05) but was negatively correlated with the SRH status (p < .01). Among asthma patients, asthma control score was positively correlated with SRH status and negatively correlated with neuroticism, perceived stress, and symptom scores of all.
psychiatric comorbidities (p < .05), except for social phobia (p > .05).

Multivariate analyses were performed to determine the extent to which the difference in symptom scores of panic attacks, depression, total anxiety, and total internalizing scales among the well-controlled and poorly controlled asthma, and control groups were explained by the levels of neuroticism, perceived stress, BMI, and SRH status. Table 3 lists the estimates...
of adjusted mean scores for panic attacks, depression, total anxiety, and total internalizing symptoms in sequential models in which BMI, SRH status, perceived stress, and neuroticism were added individually and all together.

The contribution of BMI to symptom scores of psychiatric comorbidities was minimal as indicated by the small changes in $R^2$ values ($R^2$ changed from $1\%$ to $5\%$), and its inclusion into the model did not alter the significant differences in symptom scores of psychiatric comorbidities between the asthma patients and healthy controls. SRH status appeared to make relatively more contributions ($R^2$ changed from $5\%$ to $10\%$) to symptom scores of psychiatric comorbidities, particularly depression, and its inclusion into the model reduced the significant difference in scores for depression and panic attacks between the two groups. Perceived stress made a large contribution ($R^2$ changed from $18\%$ to $29\%$), and neuroticism made an even larger contribution ($R^2$ changed from $29\%$ to $40\%$) to the variations in symptom scores of psychiatric comorbidities, and their inclusion in the model resulted in substantial decrease in the differences for total anxiety and total internalizing symptoms. Altogether, neuroticism, perceived stress, BMI, and SRH status accounted for $32\%$–$44\%$ of the total variance in scores of depression, panic attacks, total anxiety, and total internalizing symptoms. No significant differences were found in the scores of the four psychiatric comorbidities between the asthma and healthy controls after accounting for the differences in the underlying psychological and physical factors (Table 3).

Among asthma patients, increasing asthma control score was associated with lower scores in total anxiety, depression, and internalizing symptoms ($p < .05$; Table 2). In the analyses accounted for the presence of neuroticism and perceived stress remained significant with the symptom scores of psychiatric comorbidities, and its inclusion into the model reduced the significant differences in symptom scores compared to the healthy control group. +++$p < .001$, +++$p < .01$, and +++$p < .05$ versus the healthy control group. $+$+$p < .001$, $+$+$p < .01$, and $+$+$p < .05$ versus the well-controlled asthma group. BMI = body mass index; SRH = self-rated health.

**Table 2**

<table>
<thead>
<tr>
<th></th>
<th>Poorly controlled (n = 61)</th>
<th>Well controlled (n = 137)</th>
<th>Healthy control (n = 171)</th>
<th>$F$</th>
<th>$p$</th>
<th>$R^2$ change</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Base model: Gender, age, ethnicity, smoking status and family housing type</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depression</td>
<td>52.57 ± 1.81***+++</td>
<td>47.18 ± 1.53</td>
<td>46.87 ± 1.56</td>
<td>5.152</td>
<td>.006</td>
<td></td>
</tr>
<tr>
<td>Panic attacks</td>
<td>56.49 ± 1.96***+++</td>
<td>49.77 ± 1.64</td>
<td>50.03 ± 1.68</td>
<td>6.229</td>
<td>.002</td>
<td></td>
</tr>
<tr>
<td>Social phobia</td>
<td>47.81 ± 1.56</td>
<td>47.21 ± 1.32</td>
<td>47.59 ± 1.34</td>
<td>.084</td>
<td>.92</td>
<td></td>
</tr>
<tr>
<td>Separation anxiety</td>
<td>56.92 ± 1.82</td>
<td>53.55 ± 1.52</td>
<td>55.11 ± 1.55</td>
<td>1.649</td>
<td>.194</td>
<td></td>
</tr>
<tr>
<td>Generalized anxiety</td>
<td>50.05 ± 1.76</td>
<td>47.87 ± 1.48</td>
<td>4.71 ± 1.51</td>
<td>1.722</td>
<td>.180</td>
<td></td>
</tr>
<tr>
<td>Obsession and compulsions</td>
<td>53.32 ± 1.57</td>
<td>50.02 ± 1.32</td>
<td>50.33 ± 1.35</td>
<td>2.221</td>
<td>.110</td>
<td></td>
</tr>
<tr>
<td>Total anxiety symptoms</td>
<td>50.76 ± 2.56+</td>
<td>44.33 ± 2.15</td>
<td>48.05 ± 2.19</td>
<td>3.294</td>
<td>.038</td>
<td></td>
</tr>
<tr>
<td>Total internalizing symptoms</td>
<td>52.99 ± 2.37+++</td>
<td>46.20 ± 2.02</td>
<td>49.01 ± 1.98</td>
<td>4.110</td>
<td>.017</td>
<td></td>
</tr>
</tbody>
</table>

Data shown are Bonferroni-adjusted mean ± standard errors estimated from ANCOVA models.

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**Discussion**

In this study, we found higher levels of depression, panic attacks, total anxiety, and total internalizing symptoms among
adolescents with asthma when compared with healthy controls. Our findings further support the association between adolescent asthma and psychiatric comorbidities that have been reported from previous studies [27]. The results from this study revealed no associations among social phobia, separation anxiety, and adolescent asthma, whereas previous studies have reported that social phobia and separation anxiety were associated with adolescent asthma [3,28].

Among psychiatric comorbidities, the scores of panic symptoms and number of participants reaching clinical threshold of severe panic symptoms appeared to be highest, particularly for adolescents with poorly controlled asthma. This finding is consistent with previous studies [29]. Studies that carefully discriminated between symptoms of panic attacks and asthma attacks [30] have supported the observed excess comorbidity of panic attacks in asthma patients [31]. Patients with panic disorder were reported to have a three times higher risk of respiratory illnesses (such as asthma, bronchitis, and emphysema) in comparison with patients with other psychiatric illnesses [32]. Nevertheless, the exact relationship between asthma and panic attacks requires further investigation.

In this study, adolescents with asthma had not only higher severity of psychiatric comorbidities but also higher frequencies of known sociodemographic and physical variables that are known to be associated with both asthma and psychiatric comorbidities. Higher proportions of Malay and Indian ethnicities, history of smoking, higher BMI, and lower housing status were more common among adolescents with asthma, especially poorly controlled asthma as compared with healthy controls. This finding is consistent with previous studies of the association of sociodemographic factors and smoking with asthma and depression. Previous reports have also shown that higher body weight and BMI were associated with relapse and more severe depressive and anxiety symptoms in asthma patients [14]. Both asthma and obesity may individually worsen psychiatric comorbidities, but in this study, we observed that the contribution of BMI to the excess psychiatric comorbidities in asthma patients was minimal.

The present study extends previous research findings by examining the major psychological factors of neuroticism personality trait and perceived stress, and physical factors of BMI and perceived health status as contributors to the observed excess of psychiatric comorbidities associated with asthma. Our findings indicate that adolescents with asthma had higher neuroticism, perceived stress, BMI, and lower SRH than healthy controls. No significant differences in psychiatric comorbidities were observed after allowing for differences in these psychological and physical factors.

Neuroticism appeared to be the major contributor to the observed excess psychiatric comorbidities among adolescents with asthma, suggesting that neuroticism may be a key vulnerability factor for psychiatric comorbidities in adolescent asthma. Prior studies have indicated that neuroticism is correlated with negative perception of asthma symptoms [33]. At the same time, neuroticism is related to stress vulnerability and negative emotion [8], which in turn are reportedly associated with altered inflammatory immune responses, as well as to airway inflammations that characterize asthma and allergic diseases [34,35].

Consistent with previous studies [28], our results showed that asthma was associated with a higher level of perceived stress. In population-based studies, stressful life events were reported to

<table>
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<th>Table 3: Correlation coefficients of asthma, physical, psychological, and psychiatric variables</th>
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<tr>
<td><strong>BMI</strong></td>
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</tr>
<tr>
<td>BMI</td>
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<tr>
<td>Self-rated health</td>
</tr>
<tr>
<td>Neuroticism</td>
</tr>
<tr>
<td>Perceived asthma control score</td>
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<tr>
<td>Asthma control score</td>
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<td>Social phobia score</td>
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<td>Obsession and compulsion anxiety</td>
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<tr>
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<td>Total externalizing symptoms</td>
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</table>
be associated with an increased risk of asthma-related hospital admissions [36], but daily hassles did not predict the onset of asthma [15]. In adults with established asthma [37], distinct types of stress were not found to be associated with asthma morbidity, but early traumatic life events were shown to predict asthma at adult age [38]. A meta-analysis concluded that exposure to stressors alone does not increase the risk of allergic disorders, but only exposure to stressors that evoke negative cognition leads to an adverse impact on asthma patients [39]. These findings highlighted the importance of individual variation in perception of stressors, and the importance of perceived stress in the course of asthma. Neuroticism and perceived stress influence the actual stress response in asthma. Recent evidence suggests that high levels of neuroticism and perceived stress may

Table 4
Analyses of neuroticism, BMI, SRH, perceived stress, and asthma control score as predictors of psychiatric comorbidity among asthma patients in regression models (n = 198)

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Individual model entry</th>
<th>Simultaneous model entry</th>
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<tbody>
<tr>
<td></td>
<td>B ± SE</td>
<td>β</td>
</tr>
<tr>
<td>Neuroticism</td>
<td>.91 ± .11</td>
<td>.52</td>
</tr>
<tr>
<td>BMI</td>
<td>−.06 ± .18</td>
<td>−.02</td>
</tr>
<tr>
<td>SRH status</td>
<td>−5.69 ± 1.43</td>
<td>−.28</td>
</tr>
<tr>
<td>Perceived stress score</td>
<td>1.11 ± .15</td>
<td>.47</td>
</tr>
<tr>
<td>Asthma control score</td>
<td>−.84 ± .25</td>
<td>−.23</td>
</tr>
<tr>
<td>Neuroticism</td>
<td>.92 ± .08</td>
<td>.53</td>
</tr>
<tr>
<td>BMI</td>
<td>−.17 ± .15</td>
<td>−.07</td>
</tr>
<tr>
<td>SRH status</td>
<td>−2.95 ± .99</td>
<td>−.16</td>
</tr>
<tr>
<td>Perceived stress score</td>
<td>.93 ± .12</td>
<td>.39</td>
</tr>
<tr>
<td>Asthma control score</td>
<td>−.87 ± .29</td>
<td>−.22</td>
</tr>
<tr>
<td>Neuroticism</td>
<td>1.34 ± .14</td>
<td>.59</td>
</tr>
<tr>
<td>BMI</td>
<td>.05 ± .19</td>
<td>.01</td>
</tr>
<tr>
<td>SRH status</td>
<td>−5.16 ± 1.29</td>
<td>−.21</td>
</tr>
<tr>
<td>Perceived stress score</td>
<td>1.63 ± .14</td>
<td>.53</td>
</tr>
<tr>
<td>Asthma control score</td>
<td>−.84 ± .35</td>
<td>−.17</td>
</tr>
<tr>
<td>Neuroticism</td>
<td>1.25 ± .13</td>
<td>.59</td>
</tr>
<tr>
<td>BMI</td>
<td>.01 ± .18</td>
<td>.00</td>
</tr>
<tr>
<td>SRH status</td>
<td>−5.31 ± 1.16</td>
<td>−.24</td>
</tr>
<tr>
<td>Perceived stress score</td>
<td>1.52 ± .13</td>
<td>.54</td>
</tr>
<tr>
<td>Asthma control score</td>
<td>−.91 ± .32</td>
<td>−.21</td>
</tr>
</tbody>
</table>

Data were adjusted for gender, age, ethnicity, smoking status, and family housing type.
BMI = body mass index; SE = standard error; SRH = self-rated health.
* Individually: each independent variable (neuroticism, BMI, SRH, perceived stress score, and asthma control score) was entered individually into the regression models; simultaneously: all independent variables (neuroticism, BMI, SRH, perceived stress score, and asthma control score) were entered simultaneously at the regression model.
contribute to higher BMI or obesity [11] and increased smoking rates [40] in adolescents with asthma, which are closely related to poor coping and psychiatric comorbidities. Recurrent and unpredictable asthma attacks in poorly controlled asthma may cause neurotic asthma patients to perceive higher levels of stress, leading to psychiatric comorbidities.

Furthermore, the findings from this study showed that poor asthma control was associated with severe psychiatric comorbidities. This is consistent with previous findings that comorbid anxiety and depression among asthma patients were associated with more days of asthma symptoms [6], poor treatment adherence, and greater functional impairment [21]. The association between the level of asthma control and psychiatric symptoms was not significant after accounting for neuroticism and perceived stress, indicating the role of underlying psychological factors in the control of asthma symptoms and psychiatric comorbidities.

The present study has strengths and limitations. The asthma status of the participants was based on clinical diagnosis of asthma made by pediatricians, thus enhancing clinical accuracy and reducing symptom association bias [23]. We adjusted for important confounding by sociodemographic and smoking variables [21] in multivariate analyses. The healthy controls were age- and gender-matched adolescents residing in the same community as the patients to ensure good comparability. A major limitation of the study is that causal inferences cannot be determined from this cross-sectional study. Caution in interpreting significant results in this study is required given the large number of significance tests. Further studies are required to examine the longitudinal relationship among personality, stress, asthma, and psychiatric comorbidities. Because measures of psychiatric comorbidities, neuroticism, and stress were based on self-reports, possible bias from differential recall and social desirability among the study participants cannot be ruled out.

The findings from this study have important clinical implications. Asthma treatment and control should seriously consider the excess rates of comorbid depression and anxiety, which is especially higher in patients with poorly controlled asthma. High levels of neuroticism and perceived stress are key vulnerability factors for comorbid psychiatric comorbidity, and it is advisable to screen patients for psychological treatment. Cognitive behavior therapy can target cognitive bias such as the tendency to overestimate stress and negative experience. Relaxation therapy, as well as peer group support among adolescent asthma patients, can be included to reduce the risks of panic attacks, negative emotions, and stress levels.

In conclusion, the diagnosis of asthma and poor asthma control in adolescents are associated with psychiatric comorbidity, especially depression, panic attack, total anxiety, and total internalizing symptoms. Psychological factors such as a neuroticism personality trait and perceived stress contribute to the observed excess psychiatric comorbidity associated with asthma, especially in poorly controlled asthma patients.

Acknowledgments

We gratefully acknowledge the assistance of asthma nurses Rafiah Omar and Michelle Melling Tan and the support of staff in the Department of Pediatrics, National University Hospital, Singapore.

Supplementary Data

Supplementary data related to this article can be found, in the online version, at http://dx.doi.org/10.1016/j.jadohealth.2014.01.007.

References