

Effects of Examination Stress on Psychological Responses, Sleep and Allergic Symptoms in Atopic and Non-Atopic Students

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Abstract

Background Recent findings indicate that atopics may be more vulnerable to stress than non-atopics. However, the roles of psychological well-being and sleep in this presumed increased sensitivity are not known.

Purpose To investigate the effects of a brief naturalistic stressor on psychological responses, sleep, and allergic symptoms and to compare those responses between atopic and non-atopic individuals.

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Methods We assessed atopic and non-atopic students during a period without and during a period with examinations.

Results For both atopic and non-atopic students, tension, anxiety, and depression deteriorated in response to examination, as did sleep latency and sleep quality. Overall, atopics were more tense, had more anxiety, longer sleep latencies, and were less well rested than non-atopics. Non-atopic students rose from bed later during the examination period. In response to examination, atopic students reported increased frequency of stress behaviors (e.g., eating fast), while decreased stress behaviors were reported by non-atopic students. Allergic symptoms were not affected.

Conclusion Atopic students were worse off in aspects of psychological well-being and sleep, but displayed only partly stronger responses to a stressor compared to non-atopic students. In spite of a broad negative response to examination, allergic symptoms were not affected.

Keywords Stress · Atopy · Allergy · Sleep · Anxiety · Depression

Introduction

Atopic diseases are highly prevalent in many western societies [1]. Lifestyle factors seem to have strong effects in the severity of allergic disease, and exposure to stressors may shift the immune system toward a more allergic type of inflammatory response, i.e., decreased T-helper type 1 cytokines/T-helper type 2 cytokines (Th1/Th2) ratio [2].

According to the allostasis model, stress involves challenge to homeostasis, which causes allostatic responses aimed at protecting the organism [3]. Potentially damaging

effects of these adaptive responses are denoted allostatic load, which thus connects exposure to stressors with health outcomes (e.g., expression of disease). In allergy, psychological and behavioral aspects of allostasis have not been adequately studied.

While exposure to stressors alters immune responses in atopic individuals, it is less known when this may lead to changes in physiological measures (e.g., lung function) or allergic symptoms. For instance, Kang et al. [4], found that students could undergo marked changes in immune function during an exam period without any significant deterioration in lung function. Also, recent findings suggest that stressors affect atopic individuals stronger than non-atopics with respect to allergy-related immune parameters [5], but little is known of how factors such as disturbed sleep (missed recovery) and/or negative psychological states (additional stressors) relate to these differences.

Studies have shown a close relation between self-rated stress and impaired sleep [6]. Allostatic load can occur when adequate recovery from stress responses does not take place [3], and sleep is important for restoring homeostatic and allostatic systems in the body, and the functioning of the immune system [7]. Several recent findings suggest that not only stress but also disturbed sleep, both experimentally and chronically (insomnia), may result in a decreased Th1/Th2 ratio [8, 9], and since studies show that disturbed sleep is common in atopic patients (e.g., [10]), it is urgent to further explore sleep in allergic disease.

Additional connections between stressors and atopy may also apply. For example, patients with allergic disorders display more negative affect, more anxiety, and more psychiatric disorders than the normal population (e.g., [11, 12]). These more negative psychological states, which are known to increase in response to stress, could add to the allostatic burden for atopic individuals compared to non-atopics. Furthermore, behavioral responses are clearly important parts of the stress response [3], but stress behaviors have been little explored in atopic individuals.

Taken together, relatively little is known about the interplay between stress, sleep, and psychological factors in allergic disease. Thus, the main aim of the present study was to investigate effects of a major examination—denoted a brief naturalistic stressor [5]—on psychological states, sleep, and allergic symptom parameters.

Our hypotheses were: (1) that examination stress will negatively affect both atopic and non-atopic students with regards to psychological states and sleep; (2) that atopic as compared to non-atopic students will display more negative psychological states and more disturbed sleep and show stronger changes in these parameters in response to examination; and (3) that atopics will experience more allergic symptoms during the examination period than during the non-examination period.

Methods

Participants

Forty-one medical students on their fourth semester participated in this study. Twenty-two had atopic disease (14 women and eight men, 21–31 years) and 19 had no history of atopic disease (ten women and 9 men, 21–27 years). Atopy was determined with Phadiatop, RAST, and medical examination. No participants were regular nicotine users. Two atopic participants used glucocorticoids regularly, and six during pollen season. All such medication was withheld at least 4 weeks before study start and throughout the study period. For a more detailed description of the participants and procedures, see Olgart-Hoglund et al. [13]. Three cases, one non-atopic and two atopic individuals, were excluded due to respiratory infection, resulting in 38 participants in the statistical analyses. The study protocol was ethically approved and all participants provided written informed consent.

Study Design

The study included two conditions: a non-examination period (without oral or written exams ± 2 weeks, carried out in late September) and an examination period [1 or 2 days after a major written examination and 1 day before or the day of a major oral examination, carried out in December or January, i.e., 96 (SD=16.5) days after the non-examination assessment]. In order to recruit a sufficient number of participants, the same protocol was used for two consecutive years (2002/2003 and 2003/2004). During both conditions, participants completed a diary on sleep and allergic symptoms each morning and evening for 7 days, and participants also filled out questionnaires on day 7 (the assessment day). As reported previously, self-reported acute stress (measured by a visual analogue scale) was markedly increased (76%) during the examination period compared to the non-examination period [13]. The study was conducted out of pollen season, and none of the allergic participants reported being exposed to animals in their home environment.

Psychological Variables

Tension was measured with “How do you feel right now” on a nine-step scale (anchored at 1: *very relaxed and calm*, 5: *neither [relaxed] nor [tense]*, and 9: *very tense and pressed, on the verge of what I can handle*). Trait anxiety was measured with the State-Trait Anxiety Inventory (STAI-T; [14]). State anxiety and depression were measured with the Hospital Anxiety and Depression Scale (HADS; [15]). Stress behaviors were measured with The Everyday

Life Stress Scale [16]; 20 statements referring to stress behaviors in everyday life situations (e.g., “I do two or more things at a time” and “I eat fast and finish the meal before anyone else”) with four response alternatives (coded as 0–3): 0: *almost never*, 1: *sometimes*, 2: *often*, and 3: *almost always*. All forms were filled out in both conditions, except the STAI-T, which was only included in the non-examination assessment.

Diary on Sleep and Allergic Symptoms

Questions on sleep (from the Karolinska Sleep Diary; [17]) were filled out every morning and included subjectively reported sleep quality and the feeling of being well rested (rated 0–4), bed time, rise time, and sleep latency. The diary also included two types of questions concerning subjective symptoms of allergy phrased to cover asthma, rhinitis, and eczema respectively, e.g., “How often did you experience asthma [eczema] symptoms [from the eye and nose] today?” with response alternatives 0: *not at all*–6: *all the time* and “Have you been troubled by wheezing [itching eczema/symptoms from eyes and nose/] during the night or morning/day or evening?” with response alternatives 0: *not at all troubled*–3: *seriously troubled*. Individual questions were combined to represent symptoms of asthma, eczema and rhinitis, respectively (see below) and analyzed for atopic participants only.

Compliance

Of the 38 participants, no one dropped out. No participant failed to turn in or fill out any full day of diary, or any full questionnaire, and in total, 99.4% of diary items were recorded.

Statistical Analyses

Repeated measures analyses of variance (ANOVAs) were conducted to test for main effects of condition (non-examination vs. examination period) and group (atopic vs. non-atopic participants) as well as interactions. Z-transformations were made before exploratory factor analyses were performed on symptom data producing three composite indices, reflecting symptoms of asthma, rhinitis, and eczema, respectively. Individual items from the symptom diary on which no participant had reported symptoms were excluded from the composite indices. *T* tests were calculated to test for differences in allergic symptom between the conditions. Effect sizes are given as η_p^2 , which is interpreted as explained variance in the sample. All analyses were made with SPSS 15.0 for Windows [18], and the alpha level was set to 0.05.

Results

Main Effects of Condition

During the examination period, tension, anxiety, and depression increased as compared to the non-examination period (see Table 1). Large effect sizes were seen in these measures (η_p^2 s = 0.24, 0.42, and 0.27 respectively).

Sleep timing was slightly altered during examination (Table 2). Overall, bed times were similar to the non-examination period, but rise times were later ($\eta_p^2 = 0.13$). Time spent in bed increased ($\eta_p^2 = 0.19$), but the examination also resulted in longer sleep latencies ($\eta_p^2 = 0.28$) and worse sleep quality ($\eta_p^2 = 0.18$), although this was not reflected in lower ratings of being less well-rested (Table 2).

Main Effects of Group

Levels of tension and state anxiety were higher in the atopic group than in the non-atopic group (η_p^2 s = 0.13 and 0.14 respectively), although trait anxiety did not differ between atopics and non-atopics (Table 1).

The atopic group had longer sleep latencies ($\eta_p^2 = 0.15$) and felt less well-rested ($\eta_p^2 = 0.17$) than non-atopics, although sleep quality did not differ between the groups (Table 2).

Interaction Effects

An interaction ($\eta_p^2 = 0.16$) showed that atopic students increased their self-reported stress behaviors during the examination period, while the opposite response was seen in non-atopic students (Table 1).

An interaction ($\eta_p^2 = 0.12$) was also seen for rise time, as non-atopic participants rose from bed later during the examination period than during the non-examination period, whereas no change was seen in atopic participants (Table 2).

Allergic Symptoms

None of the allergic symptom indices were significantly affected by examination stress in atopic individuals neither in the morning nor the evening (r 's < 0.70, df = 19, p 's > 0.49, not shown).

Discussion

The present study showed that examination had large negative effects on both atopic and non-atopic students

Table 1 Psychological variables; means ($\pm$ SD) and ANOVAs for the effects of examination and atopy

Variables	Non-examination		Examination		Condition <i>F</i>	Group <i>F</i>	Interaction <i>F</i>
	Atopics <i>M</i> (SD)	Non-atopics <i>M</i> (SD)	Atopics <i>M</i> (SD)	Non-atopics <i>M</i> (SD)			
Tense	4.6 (1.5)	3.7 (1.5)	5.6 (1.5)	4.7 (1.5)	11.59***	5.48**	0.03
HADS—anxiety	5.2 (2.8)	4.1 (2.3)	8.3 (3.6)	5.5 (2.6)	25.96****	5.76**	3.31*
HADS—depression	3.2 (2.1)	2.6 (2.2)	5.8 (3.4)	3.6 (3.2)	13.44****	3.25*	2.84
STAI-T α	36.9 (6.53)	34.2 (6.98)	— (—)	— (—)	—	1.51	—
Stress behaviors	38.6 (4.90)	37.8 (7.18)	40.4 (5.70)	36.3 (7.26)	0.081	1.52	7.07**

$df=1, 36$ on all variables but STAI-T, where $df=1, 37$. Tense was measured on a 1–9 scale (1=very relaxed and calm, 9=very tense and pressed, on the verge of what I can handle). HADS Hospital Anxiety and Depression Scale, scales 0–21 (0–7=normal, 8–10=mild, 11–14=moderate, 15–21=severe), STAI-T State Trait Anxiety Inventory-Trait, scale 20–80 (normal controls tend to score around 35), Stress behaviors, scale 0–60 (higher scores indicate more self-rated stress behaviors)

* $p<0.10$, ** $p<0.05$, *** $p<0.01$, **** $p<0.001$

with regards to psychological parameters and sleep parameters, i.e., the first hypothesis was supported. Atopics displayed higher general levels of anxiety and were worse off in some aspects of sleep compared to non-atopics, partly confirming the second hypothesis. However, there was only limited support for atopics to be more sensitive to a stressor in the form of an examination, and the strongest interaction effect was seen in stress behaviors. Data from this study did not support the third hypothesis, i.e., that allergic symptoms would increase in atopic participants during stress.

Effects of examination were generally larger than effects of atopy. Between 13% and 42% of the variance was explained by examination and 13% to 17 % by atopy in the significantly affected variables. The interaction effect observed in stress behaviors explained 16% of the variance. Thus, moderate to large effect sizes were observed in relation to both examination and atopy.

Independent of atopy, examination was accompanied by highly elevated levels of anxiety and depression. These

results concur with previous studies where mood has been shown to deteriorate in response to stress and to improve in response to stress-reducing techniques [19].

The finding that atopic students (despite mild atopy) displayed higher state anxiety and a tendency towards more depression may correspond to notions that, e.g., asthma is connected to an increased vulnerability for psychiatric problems, including anxiety disorders and depression (e.g., [11]). However, trait anxiety did not differ between groups in the present study.

Atopic individuals displayed longer sleep latencies and felt less well-rested as compared to non-atopic individuals. Except for rise time, the pattern of changes in sleep parameters in response to examination, e.g., increased sleep latency and impaired sleep quality, were generally similar in atopics and non-atopics. Both sleep latency and sleep quality have previously been shown to be affected by stress (e.g., [20]). Further efforts to elucidate the relations between allergy and sleep are motivated by studies indicating disturbed sleep in allergy, drifts towards a Th2

Table 2 Sleep variables; means ($\pm$ SD) and ANOVAs for the effects of examination and atopy

Variables	Non-examination		Examination		Condition <i>F</i>	Group <i>F</i>	Interaction <i>F</i>
	Atopics <i>M</i> (SD)	Non-atopics <i>M</i> (SD)	Atopics <i>M</i> (SD)	Non-atopics <i>M</i> (SD)			
Bedtime (hh:mm)	24:19 (1:04)	24:06 (0:44)	24:00 (0:57)	24:22 (1:12)	0.02	0.07	3.41*
Rise time (hh:mm)	08:00 (1:01)	07:54 (0:37)	08:00 (0:38)	08:30 (0:51)	5.54**	0.90	4.80**
Time in bed (h:mm)	7:41 (0:26)	7:48 (0:30)	8:00 (0:50)	8:08 (0:37)	8.46****	0.64	0.00
Sleep latency (min)	21 (13)	12 (8.5)	32 (21)	18 (16)	14.21****	6.49**	0.93
Sleep quality	4.2 (0.53)	4.3 (0.47)	3.8 (0.69)	4.1 (0.47)	7.66****	1.56	0.53
Well rested	3.3 (0.46)	3.7 (0.59)	3.1 (0.71)	3.6 (0.69)	1.04	7.27**	0.23

$df=1, 36$ on all variables. Sleep quality was measured on a 1–5 scale (1=very poorly, 5=very well), Well rested was measured on a 1–5 scale (1=not at all, 5=completely)

* $p<0.10$, ** $p<0.05$, *** $p<0.01$, **** $p<0.001$

inflammatory pattern with impaired sleep (e.g., [8]), and the fact that sleep disturbances can worsen the course of chronic inflammatory diseases, such as asthma [21]. Such efforts would also benefit from experimental manipulation or treatment of either sleep or stress and should ideally include objective measures of sleep function, such as polysomnography or actigraphy.

An intriguing, and to our knowledge novel, observation was the finding that atopic individuals responded differently to the examination in terms of self-reported stress behaviors. Both groups started at similar levels, but atopics reported an increase, while non-atopics reported decreased stress behaviors during the examination period. Although this finding needs replication, one could theorize that since behavioral and psychological responses are integrated parts of the stress response [3], an increase in stress behaviors in atopic individuals in times of high demands, in addition to increases in impaired sleep and negative psychological states, could ultimately result in increased disease expression.

However, despite more anxiety, worse sleep, and changes in allergy-related immune parameters (e.g., Th1/Th2 ratios, NK cell numbers, and proportion of regulatory T cells) during exams in the present subjects [13], this study did not reveal any worsening of allergic symptoms. Possibly, the timing was inadequate, since previous studies have sometimes found delayed exacerbations in symptoms in response to stressors. For instance, Sandberg et al. [22] reported aggravations in asthma symptoms in response to stress 2 to 6 weeks after the reported event. Nevertheless, other studies have found changes in subjective symptoms in direct response to stress. For instance, Rietveld et al. [23] reported that subjective symptoms—shortness of breath—deteriorated in response to stress. Still, other studies that have shown changes in subjective stress parameters as well as in immune functions have also not shown significant changes in, e.g., lung function [4]. Thus, in well-managed mildly atopic individuals studied out of pollen season and without allergen challenge, changes such as those reported here and previously in Olgart-Hoglund et al. [13] may rather represent increased dispositions for potentiated allergic responses if and when exposed to allergen (see [24] for a review of similar arguments).

The present study has several limitations. Due to logistics, atopic individuals could not be matched to non-atopic students. However, our data from thorough screening of individuals do not indicate any general group differences in, e.g., age or sex. There is a possible effect of time. Since using a balanced order of conditions was not possible, we relied on a non-atopic comparison group to control for possible time effects. The present study is based on self-report measures and it is possible that more objective measurements (e.g., actigraphs, clinical interviews, and behavioral observations) would yield different results.

Conclusion

The present study indicates that atopic individuals display more negative psychological states and worse sleep and respond to challenge with more stress behaviors as compared to their non-atopic counterparts, factors which have not been adequately studied in previous investigations. We suggest that future studies should further investigate relations between stress, affect, and sleep in allergy preferably in prospective designs that may include antigen challenge after experimental manipulation of either stress or sleep.

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