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Effects of Stress After Hurricanes Katrina and Rita on Pubertal Disorders in Children

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ABSTRACT

Hurricanes Katrina and Rita caused widespread damage that resulted in increased stress levels for families living in the New Orleans area. This study examined the relationship between this stress and the onset of puberty in children by conducting a retrospective chart review of patients referred before and after the storm to a pediatric endocrine practice in New Orleans. The total number of new patients referred and the incidence of diagnoses that are unlikely to be affected by stress (ie, thyroid disease and premature adrenarche) were essentially unchanged. On the other hand, the incidence of central precocious puberty decreased by 52% after the storm, while the incidence of pubertal delay increased by 9% in the post storm period. This study thus provides evidence that stress delays the onset of puberty in children.

INTRODUCTION

Puberty refers to the physical and hormonal changes that typically begin in early adolescence and lead to reproductive maturity and completion of growth. In girls the physical changes include growth of the breasts, development of pubic hair, and onset of menstrual periods (menarche). In boys the physical changes include growth of the penis and testes, development of pubic hair, increased muscle mass and strength, and increased body and facial hair. The body changes are triggered by rising levels of the sex steroids (androgens and estrogens). These arise from parallel hormonal processes termed ''adrenarche'' and ''gonadarche.'' Adrenarche refers to maturation of the adrenal cortex with rising levels of adrenal androgens. These can produce early stages of pubic hair, underarm hair, adult-type body odor, and acne. This process is at least partly independent of gonadarche, which is initiated by the central nervous system via pulsatile release of gonadotropin-releasing hormone from the hypothalamus. This in turn causes the release amplitude of gonadotropins from the pituitary gland, which activates hormone-producing cells of the testes or ovaries, resulting in fertility. In boys, precocious puberty is defined as the development of pubic hair or genital enlargement before 9 years of age. In girls, precocious puberty is defined as pubic hair or breast development before 7 years of age. Premature adrenarche is pubic hair in the absence of gonadal activation in boys before 9 years of age or pubic hair in girls before 7 years of age.

Several disorders that typically lead to referral to a pediatric endocrinologist are known to be influenced by stress levels; these include precocious puberty, delayed puberty, and short stature. The effects of stress on growth have been well described, with activation of the hypothalamic/pituitary/adrenal axis increasing cortisol levels and impairing secretion of growth hormone from the pituitary gland in a syndrome referred to as psychosocial dwarfism.[1] This condition is temporary, lasting only as long as the stress remains. In addition, a relationship between hyperphagic short stature (a variant of psychosocial dwarfism) and stress has been suggested.[2] The effects of stress on puberty are less clear: some studies suggest that stress slows pubertal development and reduces reproductive function in adults,[1] while other studies suggest that increased stress may accelerate pubertal development,[3] and still others suggest that stress has no effect on puberty in children.[4]

Katrina and Rita devastated a region of the Gulf Coast extending from Texas to Florida. Due to the storm surge, 80% of New Orleans and the surrounding areas were flooded for weeks. Approximately 2 million people in this region were at least temporarily displaced by these disasters. The majority of these people were affected directly, sustaining signif-

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icant damage to their homes. Most of the remainder were affected indirectly, with disruptions in work and basic services (stores closed, gasoline stations closed, supermarkets closed, etc). This resulted in increased stress levels for both parents and children.[5,6] Specific stressors for children included loss of neighborhood connections, separation from friends and family, loss of schools, loss of homes, and loss of possessions. Furthermore, increased stress levels among the parents from ongoing posthurricane complications, such as finding stable living arrangements, finding new jobs, and recovery/rebuilding of damaged homes, would be expected to increase stress levels in their children as well. Increased incidence of posttraumatic stress disorder in children has been observed following other natural disasters including Hurricane Andrew,[7,8] the Marmara earthquake,[9] and the Kobe earthquake.[10,11] The geographic scope of the damage following Hurricanes Katrina and Rita is much larger than for any of the above disasters, and the extent of the damage has slowed the pace of recovery, with most individuals still working to repair damaged homes almost 2 years after the storm, prolonging the duration of the increased stress.

This study attempts to explore the relationship between stress and the onset of puberty in children by determining the storm's influence on the incidence of precocious and delayed puberty in a pediatric endocrine practice in the New Orleans area.

METHODS

To determine what effects the increased stress after Hurricanes Katrina and Rita had on pubertal development in children, referrals to the Ochsner for Children pediatric endocrine practice in New Orleans were examined, comparing new referrals that were made during a 4.5-month period immediately before the hurricanes, when the practice opened, with those made during the 4.5-month period after the practice had returned to normal operation (1 mo after hurricane Katrina). This practice is hospital-based in the largest surviving private hospital in the New Orleans area. The patient base is composed mainly of privately insured patients. In addition, this hospital was not closed during or after the storms. Any influence of storm-related stress on the incidence of precocious puberty or pubertal delay would be expected to result in changes in the number of referrals and thus the number of patients ultimately diagnosed with these disorders in this practice. Control measurements not expected to be affected by stress including total new referrals, thyroid disease, and premature adrenarche were evaluated in this study. A control diagnosis expected to be increased by stress (short stature) was also evaluated. This study tests the hypothesis that stress in children following Hurricanes Katrina and Rita caused the onset of puberty to be delayed, thus resulting in a decrease in the incidence of precocious puberty and an increase in the incidence of pubertal delay in the population.

After approval from the Institutional Review Board was obtained, a retrospective chart review was conducted of patients seen at the pediatric endocrine practice at Ochsner Clinic Foundation, a tertiary care center in New Orleans, La, during the period from April 15, 2005 to August 29, 2005 (prestorm) and from October 1, 2005 to February 14, 2006 (poststorm). Approximately 450 total patients were seen in each 4.5-month period.

The final diagnoses for each new patient were confirmed, and the information was encoded to comply with Health Insurance Portability and Accountability Act regulations. Diagnoses for each patient were determined by methods of standard clinical practice, including physical examination findings and laboratory test results. For precocious puberty and pubertal delay, physical examination findings included Tanner staging and testicular volume[12]; laboratory test results included gonadotropin levels and sex steroid levels, baseline and/or after stimulation with gonadotropin releasing hormone as necessary to establish the diagnosis. The total number of new referrals before and after the storm and the number of these patients who were diagnosed with precocious puberty, delayed puberty, short stature, thyroid disease, or premature adrenarche was determined. Incidences of each diagnosis in the prestorm and poststorm periods were determined, and the data were tabulated. Statistical significance was determined through relative risk analysis.

RESULTS

Of approximately 450 patient visits during each time period, 177 patients were newly referred in the prestorm period, and 169 patients were newly referred in the poststorm period (Figure 1 and Table 1). Wait times for new appointments never exceeded 2 weeks in either the prestorm or poststorm periods. The effects of the storms on overall practice volume and referral patterns of disorders less likely to be related to stress were first examined. The total number of newly referred patients did not appear to have changed significantly, and the incidence of thyroid-related diseases, which are minimally affected by stress, remained nearly the same as well, with only a 2% reduction (Figure 2, not significant [NS]). These results suggest that despite many inhabitants still

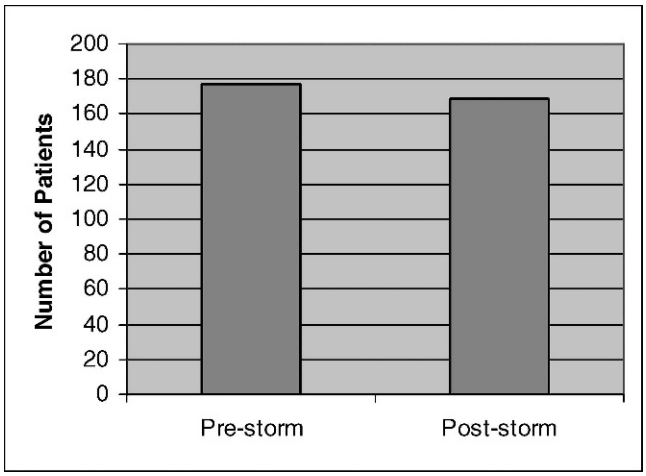

Figure 1. Total number of new referrals. The total number of new patients referred between April 15, 2005 and August 28, 2005 (prestorm) and those referred between October 1, 2005 and February 14, 2006 (poststorm) are shown.

being displaced from their homes, the overall constitution of the referral base was not significantly affected. On the other hand, there was a 52% decrease (Figure 3 and Table 2) ($P < .05$) in the incidence of precocious puberty, consistent with the hypothesis that stress inhibits onset of puberty. There was only a 4% decrease in the incidence of premature adrenarche (NS), a condition that bears clinical similarities to precocious puberty but is not believed to be affected by stress.[13] There was a 9% increase in the incidence of pubertal delay, a trend consistent with the hypothesis but that did not achieve statistical significance (Figure 4). However, pubertal delay is considered by patients and pediatricians to be a less urgent condition, and it is possible that the portion of individuals with this condition referred for additional evaluation was disproportionately lower in the post-

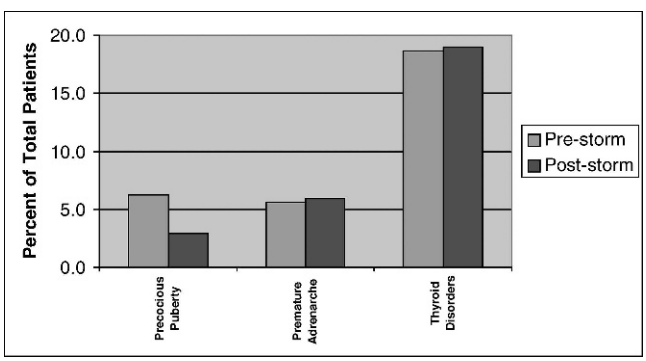

Figure 2. New diagnoses: precocious puberty. The percentages of new patients whose final diagnoses were precocious puberty, premature adrenarche, or thyroid disorders in the prestorm and poststorm periods are shown.

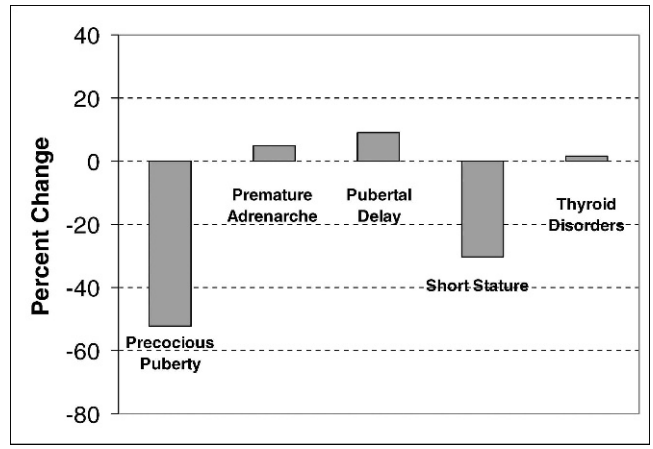

Figure 3. Percentage change after hurricane stress. The percentage reduction in the poststorm period of new patients with each of the indicated final diagnoses is shown.

storm period. Consistent with this explanation, we observed an unexpected 23% reduction in new patients diagnosed with short stature ($P < .05$), another less-urgent condition, in the poststorm period. This reduction runs contrary to the expected increased incidence of short stature in the population after the storm caused by the syndrome of psychosocial dwarfism, again suggesting that the portion of individuals referred for additional evaluation for this less-urgent condition was disproportionately lower in the poststorm period. In this context, it is also important to note that there has been an increase in patients seen with extreme short stature (height SD < -3.0) in the period 1 to 2 years after the storms, consistent with a delay in referral for additional evaluation. Interestingly, there were 2 patients in the poststorm period (vs none in the prestorm period) with alopecia areata, a condition known to be exacerbated by stress for which consultation is typically obtained on an urgent basis.[14]

DISCUSSION

Despite the widespread damage and displacement of individuals in the New Orleans area, the referral base for the Ochsner Clinic Foundation pediatric endocrine practice, which provided the source data for this study, was remarkably intact in the poststorm period. This referral base was composed mainly of privately insured patients who live primarily in suburban areas west of New Orleans, between Metairie and Lafayette, La. After being displaced by the hurricanes, most (>90%) of this population returned to their homes, thus accounting for the similar number of new referrals in the prestorm and poststorm periods. As an additional control

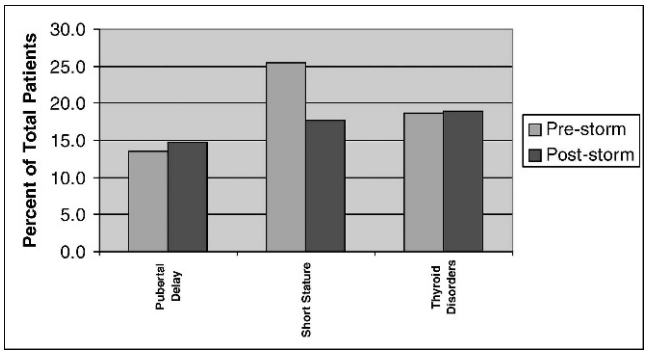

Figure 4. New diagnoses: delayed puberty. The percentages of new patients whose final diagnoses were either pubertal delay, short stature (not associated with pubertal delay), or thyroid disorders in the prestorm and poststorm periods are shown.

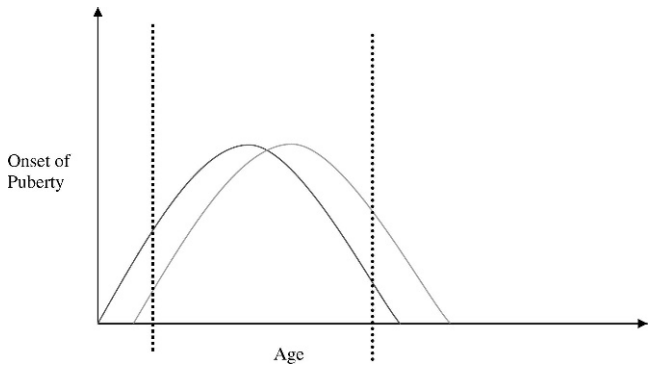

Figure 5. Change in the distribution of the onset of puberty.

measure, the incidence of thyroid diseases was examined. These disorders have been minimally linked to stress and can be characterized as an urgent diagnosis, requiring immediate medical attention. The incidence of thyroid disorders in this population remained nearly the same, supporting the conclusion that there was no significant change in the referral base in the prestorm and poststorm periods. Interestingly, there were 2 patients diagnosed with alopecia areata in the poststorm period (vs none in the prestorm period). This is an urgent condition and is well known to be influenced by stress.[14] The above finding thus serves as additional confirmation that the hurricanes did induce stress in the population under study.

Premature adrenarche is another diagnosis that is typically referred on an urgent basis, as it may cause the growth plates to fuse prematurely and reduce adult stature, it causes significant social problems, and it may indicate the presence of a tumor; however, it is not expected to be affected by stress, as the condition originates with the adrenal gland as opposed to the hypothalamus. As expected, the number of referrals for this condition remained relatively constant before and after the storms. Precocious puberty is also an urgently referred diagnosis for the same reasons; however, this diagnosis showed a 52% decrease in incidence after the storms, supporting the hypothesis that stress inhibits puberty.

Pubertal delay is often seen as less urgent because it presents no immediate medical problems. Families coping with significant loss might delay seeking medical care for this condition. In spite of this apparent referral bias, a modest 9% increase in pubertal delay was observed in this population. Short stature, another relatively nonurgent diagnosis, experienced a 23% decrease, even though previous studies indicate that the actual incidence of this diagnosis in the population should have increased with the exposure to stress.[1] Referral bias likely accounts for the apparent decrease in incidence of this disorder. When compared with the decreased referrals for short stature, the 9% increase in referrals for pubertal delay likely reflects an even larger increase in the actual incidence of pubertal delay in the population.

Our findings that stress reduces the incidence of diagnosis of precocious puberty and increases the incidence of diagnosis of delayed puberty suggest that stress delayed the onset of pubertal development in our population. The transition from childhood to the reproductive competency of adulthood occurs across a wide range of ages in normal, healthy adolescents. Using clinical assessments and milestones as indices, the onset of puberty in humans approximates a normal or Gaussian distribution, with the peak of the curve representing the mean age of onset of puberty, a standard deviation of less than -2 representing precocious puberty, and a standard deviation of greater than $+2$ representing delayed puberty.[15] We observed that precocious puberty was less prevalent after the storm and delayed puberty was more prevalent, consistent with a shift in the Gaussian distribution and a delay in the average age of onset of puberty in the affected population (Figure 5). Our findings that stress delays puberty are different from those reported by another study, which concluded that stress accelerates pubertal maturation.[3] The stress in this study was self-reported and was not associated with a major life event; with this observational study design causality cannot be determined. An association between early puberty and stress would not be surprising, as the pubertal changes themselves would be expected to increase stress levels in the affected individuals. Another, similar study found no association between puberty and stress.[4]

Our results support the hypothesis that stress delays the onset of pubertal development in children. Based on the biochemical data collected in the patients diagnosed with precocious and delayed

Table 1. Effects of Hurricane Stress on the Pubertal Development of Children

Diagnosis	Prestorm		Poststorm	
	Number	Percentage	Number	Percentage
Total referred	177		169	
Precocious puberty	11	6.2	5	3.0
Premature adrenarche	10	5.6	10	5.9
Pubertal delay	24	13.6	25	14.8
Short stature	45	25.4	30	17.8
Thyroid disorders	33	18.6	32	18.9
Alopecia	0	0.0	2	1.2

puberty, the mechanism for this delay appears to be through suppression of the hypothalamic/pituitary/gonadal axis. This finding advances our knowledge of the physiology of growth and development. Furthermore, this phenomenon has clinical importance, as individual life events could mimic the stress induced by the hurricanes in our population, and therapeutic options (treatment with low-dose sex steroids to induce pubertal changes) exist for pubertal delay. Thus it may be important to screen children with major stressor events for pubertal delay. Similar suppression of the hypothalamic/pituitary/gonadal axis in adults would be expected to cause infertility, which was anecdotally observed in this institution after the hurricanes and is currently under investigation. Again, this association would be important to recognize, as treatment options are available for infertility. Overall, by utilizing the database of patient visits in the pediatric endocrine practice of a tertiary care facility in New Orleans, we have been able to find evidence to support the hypothesis that stress delays the onset of pubertal development in children by suppressing the hypothalamic/pituitary/gonadal axis.

Table 2. Percent Change in the Pubertal Development of Children After the Hurricane Stress

Diagnosis	Percent Change
Precocious puberty	−52.39
Premature adrenarche	4.73
Pubertal delay	9.09
Short stature	−30.17
Thyroid disorders	1.55

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