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ABSTRACT

Examined were relations between concentrations and variability of hormones (testosterone, estradiol, follicle stimulating hormone, and leutenizing hormone) and mood intensity, mood variability (within and across days), energy, and restlessness in early adolescent girls. The study also considered the issue of whether hormones have effects on mood outcomes independent of the effects of perceived pubertal status. Hormone and mood measures were obtained 3 days a week for 4 weeks from 25 girls 9 and 10 years of age. Self-reported pubertal status was also measured. Findings indicated that follicle stimulating hormone (FSH) concentrations were positively associated with mood variability during the month, even when controlling for perceived pubertal status. FSH concentration also showed positive relationships to variability of energy and restlessness during the month. Lower estradiol concentrations and higher variability of estradiol and FSH predicted more "within day moodiness." Although FSH was positively related to intensity of moods, these associations disappeared when controlling for perceived pubertal status. Possible explanations for the relationships are discussed, as are models for understanding the associations among perceived pubertal status, hormonal activity, and mood and behavior outcomes. References and 11 tables are provided. (RH)

Hormone Concentrations and Variability: Associations with Self-Reported Moods and Energy in Early Adolescent Girls

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Abstract

The present study examined relations between concentrations and variability of hormones (testosterone, estradiol, follicle stimulating hormone, and leutenizing hormone) and mood intensity, mood variability (within and across days), energy, and restlessness in early adolescent girls. Hormone and mood measures were obtained from 25 nine and ten year old girls three days a week for four weeks. Self-reported pubertal status was also measured.

Follicle stimulating hormone (FSH) concentrations were positively associated with mood variability across the month, even when controlling for perceived pubertal status. FSH concentration also showed positive relationships to variability of energy and restlessness across the month. Lower estradiol concentrations and higher variability of estradiol and FSH predicted more within day moodiness. Although FSH was positively related to intensity of moods, these associations disappeared when controlling for perceived pubertal status.

Possible explanations for the relationships are discussed, as are models for understanding the associations among perceived pubertal status, hormonal activity, and mood / behavior outcomes.

Hormone Concentrations and Variability: Associations With Self-Reported Moods and Energy in Early Adolescent Girls

Both internal hormonal changes (Freud, 1969; Jacobson, 1961; Kestenberg, 1967a; 1967b; Lerner, 1987) and external bodily changes (Erikson, 1950; Lerner, 1987; Rosenbaum, 1979) have been argued as psychologically significant forces at adolescence. And although relations between pubertal status and adolescent behavior have been the focus of research for many years, investigators have only recently begun to examine relations between hormonal and psycho-emotional development, and to disentangle the complexities of those relationships. The present study was designed to look at relations between hormones, pubertal status, and moods in a way that had not been done previously.

The primary questions of interest in this study were: 1) Are concentrations and / or variability of hormones related to mood and energy outcomes? and 2) Do hormones have effects on mood outcomes independent of the effects of perceived pubertal status? In regard to these questions, the models in Figures 1, 2 and 3 are contrasted. According to Figure 1, even though hormones cause one's pubertal status, both hormones and pubertal status have independent direct effects on mood and energy outcomes. According to Figure 2, hormones cause one's pubertal development, and any measured effects of pubertal status on mood and energy are the consequence of its association with hormonal activity; only hormones have direct effects on mood and energy. Figure 3 suggests that although one's pubertal status is a direct result of hormone activity, it is perceived pubertal status that then has direct effects on moods and energy.

It is important to note that moods and behavior can also influence hormone concentrations and changes in concentration (e.g. Kalat, 1988). To truly establish causal relationships, it is necessary to closely examine time sequences of change in both hormone and mood variables. This study examines associations between hormonal and mood / energy variables that can only ultimately be interpreted as causal when they are examined with the appropriate time sequences.

Hormonal Events in Early Adolescent Girls

What is the progression of hormonal change for girls during the pre-pubertal and early pubertal years? During later childhood, follicle stimulating hormone (FSH) and leutenizing hormone (LH) from the anterior pituitary increase; this, in turn, results in increased estrogen and progesterone output from the ovaries in girls. It is believed that the increased gonadotropin output is due to decreasing sensitivity of hypothalamic control mechanisms to the negative feedback effects of estradiol. A neural inhibitory mechanism involving estradiol is believed to suppress hypothalamic-pituitary release of gonadotropins during childhood. Then at the onset of puberty, the ability of estradiol to suppress gonadotropins diminishes, with resulting increases in circulating concentrations of LH and FSH. Exactly how this mechanism works, and why it is suppressed at the onset of puberty, is uncertain (Grumbach, 1980; Johnson & Everitt, 1984). Maturation of this "hypothalamic-pituitary-gonadal" axis results in gradually increasing levels of gonadotropins and sex steroids (Burger & deKretser, 1981; Finkelstein, 1980). Prior to this, yet seemingly dissociable from it, the "hypothalamic-pituitary-adrenal" axis is activated, producing increased levels of adrenal hormones - dehydroepiandrosterone (DHEA), dehydroepiandrosterone sulfate (DHEAS), and androstenedione (Grumbach, Grave & Mayer, 1974; Grumbach, 1980; Sklar, Kaplan & Grumbach, 1980).

The gonadotropins and the sex steroids were chosen as the focus of this study because they are the major hormones responsible for the growth and development of the reproductive system. In addition, much theoretical and empirical work has been done relating the sex steroids to moods and behavior. However, in early adolescence estrogen and testosterone concentrations are still quite low; since the gonadotropins increase earlier chronologically than the sex steroids, they may be more useful indicators of the degree to which a child's hormonal system is active in the early pubertal years.

Sex steroids and gonadotropins are highly and positively correlated with pubertal indices such as pubic hair and breast development (Apter, 1980; Nottelmann, Susman, Dorn, Inoff-Germain, Loriaux, Cutler, & Chrousos, 1987b; Winter & Faiman, 1973). However, several hormonal changes begin before physical signs of puberty occur. Hormonal and physical change are not simultaneous, and are not perfectly correlated.

Conceptualization of Hormone-Mood Relations at Adolescence

Sex hormones may influence personality and behavior indirectly through their impact on early brain development (organizational effects); they may also have activational (or concurrent) effects. Activational effects refer to the immediate or slightly delayed effects of hormone concentrations or changes in concentrations at a certain point in time (Beach, 1975), and are the focus of this study.

How might one conceive of hormonal effects on behavior at early adolescence? After reviewing literature on hormone-behavior relations in animals and adult humans, Buchanan and Eccles (1989) suggest the following potential effects: 1) Activation effects - Rising tonic or average concentrations of hormones to which an individual is exposed might lead to heightened activation in moods and behavior (e.g. Baggerman, 1967; Kinsey, Pomeroy, Martin, & Gebhard, 1953; Bardwick, 1976; Asso, 1986); 2) Adjustment effects - Since early adolescence is a time when relatively constant and low concentrations of gonadotropins and sex steroids begin to be replaced by higher concentrations and more episodic and pulsatile patterns, mood and behavior might reflect an adaptation to this new, heightened hormone activity. 3) Irregularity effects: Irregular pulsatile activity has been associated with negative mood and behavioral symptoms in adult women (Dennerstein, Spencer-Gardner, Brown, Smith & Burrows, 1984). In early adolescence, the gonadotropins and sex steroids not only increase in concentration, but increase in variability. Pulsatile patterns of hormone release begin, and pulses may initially be irregular in pattern. It may be that fluctuation in hormones, especially if irregular, leads to instability of nervous functioning, with potential implications for mood and behavior. No study to date has examined patterns of fluctuation of hormones in adolescent children in relation to adolescent moods and behavior.

The behavioral outcomes of interest in this study are mood intensity, mood variability (within and across days), and levels and variability of energy and restlessness. These outcomes were chosen because they have been theoretically and empirically linked with hormonal events (particularly in literature on the menstrual cycle), and because intensity and fluctuation in moods and energy are characteristics often ascribed to adolescents in both popular (Resource Monograph on the Middle Grades, 1987; "Teen Rage", 1987) and scientific (e.g. Cohen & Frank, 1975; Finkelstein, 1980; Katchadourian, 1977; Kestenberg, 1967b) literature. Despite these facts, these particular outcomes (with the exception of energy levels) have not been examined in studies of hormones and mood in adolescence. Concerning hormones and energy, Nottelmann, Susman, Inoff, Dorn, Cutler, Loriaux, & Chrousos (1985) reported that boys with lower androstenedione rated themselves as less tired and more energetic; boys with lower testosterone were rated in the same way by their mothers. However, high concentrations of androstenedione and low concentrations of DHEAS were positively related to mother reports of hyperactivity in boys (Nottelmann, Susman, Blue, Inoff-Germain, Dorn, Loriaux, & Cutler, 1987a; Nottelmann et al., 1987b). No relations between hormones and energy were found for girls.

Current Aims

In sum, this study investigates relationships between concentrations and variability in testosterone, estradiol, LH, and FSH and mood intensity, mood variability, energy, and restlessness in a sample of early adolescent girls. Because hormones at early adolescence are just beginning to rise and fluctuate, it is expected that higher and more variable hormones will be associated with more mood intensity, more mood variability, and more variability in energy and restlessness. Adjustment to early increases in hormone concentration may also lead to lower levels of energy and higher levels of restlessness.

Girls were selected as subjects for this study for a several reasons. First, Miller (1988) found relationships between early adolescent girls' pubertal status and the mood and energy outcomes being examined here; the current study is intended to shed light on whether those relationships were due in whole or in part to effects of hormones. Secondly, relations between hormones and moods / behavior have been reported for adult women; thus, it is important in understanding the etiology of those relationships to document whether or not they occur in younger girls. Third, although recent studies of hormones and behavior suggest that the effects of hormones may be stronger and more frequent for boys than for girls (Nottelmann et al., 1987a; Susman, Nottelmann, Inoff-Germain, Dorn, Cutler, Loriaux, & Chrousos, 1985; Susman, Inoff-Germain, Nottelmann, Loriaux, Cutler, & Chrousos, 1987) the methodology of the current study differs from earlier studies in that it: a) samples hormones several times over the course of a month; b) measures intensity of mood, and fluctuations in mood, energy, and restlessness directly and through repeated assessments over the course of a month, and c) focuses on girls in the earliest stages of puberty (and therefore, early hormonal change).

Method

Sample

Fifty-three early adolescent girls participated in a larger study of hormones and behavior; information on pubertal status and hormone concentrations was available for 25 of these girls. The age of the girls ranged from 9.1 to 10.2 years. Twenty-nine percent of subjects' families had annual incomes over $50,000; 38% had incomes between $30,000 and $50,000; 21% had incomes between $10,000 and $30,000.[1] Eighty-eight percent of the families were intact first marriages and 12% were divorced. The sample was 68% white, 12% black, 4% Asian, and 16% other.

Design

Girls participated in this study for one month, during which they: 1) filled out brief questionnaires three evenings a week for each of four weeks; 2) provided first-morning samples of urine and saliva on the mornings following questionnaire administration (these samples were frozen immediately after collection); and 3) participated in an extensive interview once at the end of the four weeks of participation. This interview was conducted in the subject's home, and a variety of psychosocial information was collected, as well as information about physical development.

Measures

The mood and energy outcome variables, as well as the measures of pubertal status were those used and described in detail by Miller (1988). The following summarizes how each variable was defined.

Mood intensity.

The daily questionnaire that children filled out asked how the child felt on a variety of moods over the course of the day. Items were presented on 5 point Likert type scales where one end indicated that a child did not feel that mood at all and the other end indicated she felt that mood very much. Moods asked of the child and used in present analyses were : anger, impatience, nervousness, shame, happiness, pride, excitement, friendliness, sadness, and confidence. The meaning of each mood was not defined for the subject; thus, subjects responded according to their own interpretations of the meanings of these words. Mood intensity was defined as the absolute value of one's deviation from the population mode.[2] While this does not, and was not meant to, account for whether the extreme was in the positive or negative direction, in most cases deviations (especially if they were large) had to be in the direction of a negative mood simply because of a tendency for moods to be positive.

An intensity score was obtained for each mood for each day that a child participated by subtracting the child's response on that day from the population mode and taking its absolute value. Following this, an average of the extremity scores for the entire month of participation was calculated for each child. Thus, mood intensity was defined as average deviation from the population mode over the course of a month.

Mood variability across the month.

The variance of each of the specific moods listed under "mood intensity" was calculated for each child. This index indicated how much feelings of anger, impatience, etc. fluctuated from day to day over the month.

Mood variability within day.

Moodiness (i.e. change in mood) within each day was measured by asking the girls "How often did your moods change today?" ("1" = not at all, "5" = very often) and "My feelings seemed to change suddenly at times today?" ("1 = not at all, "5" = several times). A composite of these two items was taken by averaging them for each day. Reliability of the two items as calculated by

Cronbach's alpha was .78. As with the mood intensity variables, daily moodiness scores were then averaged over the month for analysis.

Energy and restlessness.

Reports of energy represented a composite of the following items asked in the daily questionnaire: "Today I was mostly tired ("1") / energetic ("5")", "Today I felt mostly like doing something very quiet/relaxing ("1") / very active ("5")", and "Today I had less energy ("1") / more energy ("5") than usual". Cronbach's alpha for the three items was .87. Daily measures of energy were averaged over the month. In addition, variance in energy over the month was calculated.

Reports of restlessness represented a composite of the following items asked in the daily questionnaire, all on 5 point scales where "1" = never and "5" = almost always: a) "How often today did your mind wander from what you were supposed to be paying attention to?", b) "Today, how often was it easy to sit still?"; c) "Today it was easy to pay attention to what we were learning in school" (with scores reversed for composite measure), d) "Today I had a hard time trying to concentrate". Cronbach's alpha for these items was .63. Daily measures of restlessness were averaged over the month. In addition, variance in restlessness over the month was calculated.

Puberty.

In this study, the definition of puberty used is that derived from a cluster analysis of the girls' own responses to questions about growth spurt, body hair, skin changes, and breast development on the Pubertal Development Scale (Petersen, Crockett, Richards, & Boxer, 1988). Thus, the measure of puberty represents the girls' perceptions of their own development. Miller (1988) and others have argued that perceived status and timing of puberty may be more important in adolescent psychological development than actual development; however, it is also the case that girls' reports of their own development correspond rather closely to ratings of their development by parents and doctors (Miller, Tucker, Pasch, & Eccles, 1988). In the subset of girls used for this study, 17 were pre-pubertal and 8 were early pubertal. None of the girls had begun to menstruate.

Hormone concentrations and variability.

Hormones from the saliva (testosterone) and urine (estradiol, FSH, and LH) samples were measured using standard radioimmunoassay procedures in a laboratory at the University of Michigan's Developmental and Reproductive Biology unit. Concentrations of hormones measured in urine were adjusted for concentration of creatinine. The radioimmunoassays used to measure testosterone and estradiol are known to be specific for the designated hormones in serum; since in the current study these hormones were measured in saliva and urine, the possibility exists that some related metabolites were also measured. However, the measures represent predominantly the sex steroid they are said to represent, and will thus be referred to as "testosterone" and "estradiol".

For the purposes of the current study, mean hormone concentration over the month and mean hormone variability over the month were calculated for each hormone and used as the measures of hormone activity. Data for all 25 girls were available for FSH, data from 24 girls were available for LH and estradiol, and data from 23 girls were available for testosterone. Means, ranges, and standard deviations for the hormone measures can be found in Table 1. Correlations among the various hormone measures are shown in Table 2.

Analyses

Analysis of variance was used to test for significant differences in hormone concentration or variability by pubertal status group. Regression analyses were used to examine whether or not the hormone concentration and / or variability variables predicted the mood and energy outcomes. To control for perceived pubertal status, multiple regression analyses were conducted with the hormone variables and pubertal status (entered as a dummy variable).

Results

Perceived Pubertal Status and Hormones

Girls' reports of pubertal status were significantly related to LH and FSH concentrations (see Table 3). Girls who perceived themselves to be in the early stages of puberty had higher concentrations of LH ($F(1,22)=3.34$, $p \leq .10$) and FSH ($F(1,23)=6.12$, $p \leq .05$). Self-reported pubertal status was not significantly related to concentrations of testosterone or estradiol, or variability of any measured hormone.

Hormones and Self-Reported Moods, Energy, and Restlessness

Mood intensity.

Because several analyses were performed for mood intensity and variability, results are only reported if a hormone variable related to at least two mood intensity / variability outcomes at less than .05.

The only hormone with a significant relationship to child reported mood intensity was FSH concentration (see Table 4). FSH concentration was positively related to intense nervousness ($F(1,23)=4.88$, $p \leq .05$), shame ($F(1,23)=4.50$, $p \leq .05$), friendliness ($F(1,23)=3.59$, $p \leq .10$), sadness ($F(1,23)=4.06$, $p \leq .10$), and to intensity over all moods ($F(1,22)=6.38$, $p \leq .05$).

Mood variability across the month.

Again, only FSH concentration showed significant relationships to mood variability outcomes (see Table 5). FSH concentration was positively related to variability of anger ($F(1,23)=10.46$, $p \leq .01$), impatience ($F(1,23)=5.36$, $p \leq .05$), nervousness ($F(1,23)=4.19$, $p \leq .05$), shame ($F(1,23)=12.55$, $p \leq .01$), friendliness ($F(1,23)=5.14$, $p \leq .05$), sadness ($F(1,23)=6.71$, $p \leq .05$), and confidence ($F(1,22)=4.71$, $p \leq .05$). FSH concentration was also positively related to variability over all moods ($F(1,22)=10.47$, $p \leq .01$).

Mood variability within day.

FSH variability was positively related to moodiness within a day ($F(1,23)=6.82$, $p \leq .05$). Estrogen concentration was slightly negatively related to within day mood variability ($F(1,22)=3.42$, $p \leq .10$), and estrogen variability was slightly positively related to this outcome ($F(1,22)=2.94$, $p \leq .10$). See Table 6 for complete regression results.

Energy and restlessness.

FSH concentration was the only hormone measure significantly related to energy and restlessness outcomes (see Table 7). Girls with higher concentrations of FSH had more variable energy ($F(1,23)=8.51$, $p \leq .01$) and more variable restlessness ($F(1,23)=12.14$, $p \leq .01$) over the month.

Predicting Self-Reported Mood and Energy Outcomes With Girls' Reports of Pubertal Status and Hormone Variables

For the following analyses, perceived pubertal status was entered as a dummy variable into multiple regression equations along with those hormone variables that showed significant relationships to the mood and energy / restlessness outcomes. Thus, results for pubertal status are controlled for the effects of hormone variables, and results for hormone variables are controlled for the effects of pubertal status / timing. Emphasis is placed on regression results where the overall equation is significant. However, in cases where pubertal status or hormone concentrations alone had been significantly associated to the mood or energy outcome of interest but the overall equation using both as predictors is not significant, the relative predictive power (beta weights) of the two predictors are compared.

In a few cases the overall equation was significant and none of the individual predictors were significant. Since the predictor variables were not correlated highly enough to cause concern for multicollinearity (Lewis-Beck, 1980), it is likely that the overall significance was due to marginal significance in both predictors. In these cases, the results are reported, with emphasis on relative predictive power (beta weights), and acknowledging that the relationships might be unstable and should be interpreted cautiously.

Mood intensity.

When both perceived pubertal status and FSH concentration were used to predict mood intensity, the overall equation was significant for intensity of nervousness ($F(2,22)=4.67$, $p \leq .05$), shame ($F(2,22)=5.40$, $p \leq .01$), friendliness ($F(2,22)=2.53$, $p \leq .10$), sadness ($F(2,22)=3.56$, $p \leq .10$), and a composite of intensity over all moods ($F(2,21)=5.43$, $p \leq .01$). FSH concentrations no longer significantly predicted any of the mood intensity outcomes. Pubertal status, however, was a significant predictor of intense nervousness ($t(1)=-1.97$, $p \leq .10$), shame ($t(1)=-2.23$, $p \leq .05$), and intensity over all moods ($t(1)=-1.92$, $p \leq .10$). As reported by Miller (1988), perceived early pubertal girls were more intense than perceived pre-pubertal girls. Although the overall equations predicting sadness and friendliness were significant, in both cases neither predictor alone reached significance. In the case of sadness, pubertal status had the higher beta weight; for friendliness, the beta weights for FSH and pubertal status were similar (see Table 8).

Mood variability across the month.

See Table 9. Mood variability was significantly predicted by pubertal status and FSH concentration together for anger ($F(2,22)=5.26$, $p \leq .01$), impatience ($F(2,22)=3.08$, $p \leq .10$), nervousness ($F(2,22)=3.76$, $p \leq .05$), shame ($F(2,22)=7.73$, $p \leq .01$), sadness ($F(2,22)=4.70$, $p \leq .05$), and a composite of all moods ($F(2,21)=5.21$, $p \leq .01$). In the case of anger ($t(1)=3.10$, $p \leq .01$), shame ($t(1)=7.73$, $p \leq .01$), and all moods ($t(1)=2.53$, $p \leq .05$), FSH concentration was a significant predictor, whereas pubertal status was not. In the case of nervousness ($t(1)=-1.73$, $p \leq .10$) pubertal status was a significant predictor of mood variability (with early pubertal girls showing more variability) whereas FSH concentration was not.

The prediction equations for variability of friendliness and confidence did not reach overall significance even though they had previously been related to FSH concentration. However, FSH concentration remained a significant predictor of each in each case, while pubertal status was not significant, suggesting that FSH is a more important predictor of variability of friendliness and confidence than pubertal status. Lastly, although the individual predictors of impatience and sadness did not reach significance, examination of the beta weights may be informative given the significance of the overall equations. FSH and pubertal status seemed equally strongly related to sadness, while FSH seemed more strongly related to impatience than pubertal status.

Mood variability within day.

When both FSH variability and pubertal status were used to predict within day mood swings, the overall prediction equation reached significance ($F(2,22)=3.79$, $p \leq .05$), and FSH variability was the only significant predictor ($t(1)=2.75$, $p \leq .01$) (see Table 10). This indicates that FSH variability is a more important predictor of within day mood changes than perceived pubertal status. When pubertal status and estradiol concentration or estradiol variability were used to predict within day mood variability, the overall equations were not significant. However, the substantially higher beta weights for the estradiol variables than pubertal status in these equations also suggests that hormonal activity may play an important role in mood variability within day.

Energy and restlessness.

When both perceived pubertal status and FSH concentration were used to predict energy variability, the overall equation was significant ($F(2,22)=4.07$, $p \leq .05$), and only FSH remained a significant predictor ($t(1)=2.51$, $p \leq .05$) (see Table 11). When both pubertal status and FSH concentration were used to predict restlessness variability, the overall equation was significant ($F(2,22)=10.64$, $p \leq .01$). Pubertal status ($t(1)=-2.52$, $p \leq .05$) and FSH ($t(1)=2.28$, $p \leq .05$) both remained significant predictors. Girls who perceived themselves to be in the early stages of puberty showed more variable restlessness.

Discussion

Perceived Pubertal Status and Hormones

The nine and ten year old girls in this sample who perceived some pubertal events to be taking place also had higher FSH and LH concentrations (averaged over a month) than the girls who perceived themselves as pre-pubertal. There were no differences between the pubertal groups on testosterone or estradiol concentration, or variability of the hormones measured. That differences occurred for the gonadotropins and not for testosterone or estradiol is not surprising given evidence that the gonadotropins are most likely to be rising and changing (especially during the night) in girls of this age (Cheek, 1974; Faiman & Winter, 1974; Grumbach, 1980; Vihko & Apter, 1981) and in the earliest stages of puberty (Faiman & Winter, 1974; Nottelmann et al., 1987b).

In contrast to the gonadotropins, testosterone rises gradually, and in small amounts over puberty in girls (Apter, 1980; Apter & Vihko, 1977; Grumbach, 1980; Gupta, Attanasio, & Raaf, 1975; Nottelmann et al., 1987b; Yen & Jaffe, 1978). Estradiol rises following the gonadotropins, with increases in and scattering of values occurring approximately in the age range of the current sample (nine to ten) (Apter, 1980; Cheek, 1974; Faiman & Winter, 1974; Kinsey et al., 1953; Vihko & Apter, 1981), but with significant increases occurring mostly after the appearance of external pubertal signs (Gupta et al., 1975; Nottelmann et al., 1987b; Reiter & Root, 1975). Thus, in a sample of girls nine and ten years old who are in pre- or early puberty, the gonadotropins would be expected to most differentiate pubertal groups. Of course, puberty in this study is self-reported, and not expected to correspond exactly to hormone values; however, the general progression of pubertal events as described suggests that the relationships found here are reasonable.

Predicting Mood and Energy Outcomes with Hormones and Perceived Pubertal Status

Of the hormones measured, only FSH concentration was significantly related to mood intensity, mood variability, and variability of energy and restlessness. Although the regression analyses used in this study do not establish causality, given the present interest with the effects of hormones on an early adolescent's moods, what evidence is there that FSH might influence the moods of early adolescents? Unlike for the sex steroids, there are no known receptors for FSH in the brain. Thus, if the results reported here do reflect hormonal influence on moods, it is likely that the association found for FSH reflects the relationship of FSH with another steroid that is acting on the brain. One possibility is that the relationships picked up between FSH and mood actually reflect the effects of estradiol on mood. FSH concentration was not correlated significantly with estradiol concentration, but was positively correlated estradiol variability, indicating a potential relation between FSH and estradiol activity. In predicting within day moodiness, both FSH and estradiol variables were significant predictors of the outcome.

If estradiol is the actual hormone at work on the brain, why were there no consistent significant associations between the estradiol values and mood intensity, mood variability, and energy or restlessness variables? As has been pointed out, and as is evident from the mean concentrations of estradiol in the current sample, estradiol concentrations are quite low in 9 to 10 year old girls. In fact, the concentrations and pulses might be so low as to go undetected with established assay methods. Since FSH is detectable in early adolescent girls, and since FSH is related to estradiol pulses (however small) it is possible that measures of FSH allow one to pick up on otherwise undetectable estradiol activity. Girls with higher FSH concentrations may be experiencing more, or more frequent, estradiol pulses than girls with lower FSH concentrations. It is also possible that the results obtained here reflect an adjustment to new and heightened hormone activity in general; such effects may be seen best by examining a hormone that is not only most easily detectable, but shows the most variation across subjects within this early age range.

If there are causal relationships between early hormonal activity and mood intensity, mood variability, and restlessness, these might be explained by an adjustment hypothesis: girls with rising FSH (and related steroids) are adjusting to higher concentrations of hormones than they have previously experienced, and this may be demonstrated in intense and variable moods, and variable energy and restlessness. Although past research has not examined FSH and these mood and restlessness outcomes directly, FSH has been associated with negative affect and poor CNS functioning in adult men (Houser, 1979), as well as higher levels of vigor (Houser, 1979). Because intensity and variability of mood in this sample essentially meant more extreme or frequent instances of negative moods, it may be that the effects seen here are due to increased negative affect as a result of rising FSH, or steroids with which it is associated. In support of this adjustment hypothesis, Brooks-Gunn and Warren (1989) found positive relations between estradiol and depression in a sample of 9 to 14 year old girls, but only among girls experiencing the most rapid increases in estradiol.

When both pubertal status and FSH concentration were used to predict the mood and restlessness outcomes, some of the effects of FSH on the outcome variables were no longer significant. Controlling for pubertal status, FSH concentration was not significantly related to any of the mood intensity variables. However, mood variability across the month was often predicted better by FSH concentrations than pubertal status (although pubertal status was a better predictor of variable nervousness and an equally strong predictor of variable sadness). Thus, for intensity of mood (and perhaps variability of nervousness), it seems that the model in Figure 3 is a better model of moods than Figure 1 or 2. Pubertal status predicts these outcomes while hormones do not. On the other hand, Figure 2 best depicts the relation between biological change and mood variability across a month, mood variability within a day, and variability of energy. For these outcomes, hormonal variables were stronger predictors than perceived pubertal status. Figure 1 may be a viable model for variability of some moods, and variability of restlessness.

A greater relative association of hormones than pubertal status with energy, and an equally strong association of pubertal status and hormones with restlessness may make sense given the relatively greater psychological component potentially involved in measures of restlessness (ability to pay attention, sit still, etc.) in contrast to measures of energy (e.g. feeling tired). Additionally, these data suggest a fairly strong biological component to <u>changes</u> in mood, with the <u>intensity</u> of moods that occur being more strongly associated with psychological variables.

<u>Summary, Implications, and Directions for Future Research</u>

As stated earlier, the current study does not establish that the direction of effect is from hormones to mood, energy, or restlessness. Further research that closely examines different time sequences in hormone and mood changes is needed to clarify causality. Throughout this paper, however, evidence has been presented for effects of hormones on moods. Additionally, one study that has compared associations between hormones and moods using different time lags found that, in most cases, stronger relationships were obtained when hormones were used to predict moods at a later point in time than when moods were used to predict hormones at a later point in time (Eccles, Miller, Tucker, Becker, Schramm, Midgley, Holmes, Pasch, & Miller, 1988). Thus, although the relationships documented in the current study between hormones and behavior cannot be assumed to reflect the effects of hormones on moods, the possibility of such causation exists and will need to be clarified by further research.

This study represents an initial step in the study of hormone-mood-behavior relationships in early adolescence. The relations found in this study are intriguing, but need to be examined further with a larger sample in order to see if the results are replicated. Further, there are other ways to conceptualize hormone activity than those measures chosen for this study. Extreme hormone values might be important in predicting behavior, as might be ratios of hormones to each other (e.g. testosterone to estrogen or estrogen to progesterone). Although variability of hormones was examined, whether or not the variability was regular or irregular was not; this may be important. Additionally, the way in which urine and saliva samples were collected in the present study did not allow examination of pulsatile hormone activity. Individuals with similar concentrations of hormones in a morning urine or saliva sample may have experienced quite different pulsatile activity during the preceding hours. Large but infrequent pulses of a hormone might have different effects on the brain and on moods than smaller but frequent pulses. Further, examination of relationships between hormones and moods within days (or with particular lags of one or more days) might yield stronger relationships than examination of monthly averages of hormones and moods.

In addition, future research can cast light on the hormone-mood relationships described here by extending the age of the sample. In order to clarify if the effects of hormones on mood variability, energy, and restlessness are due to an adjustment process, one could compare the effects of these hormones on the psychological outcomes in early, mid, and late pubertal girls. If the effects of FSH and estradiol that were documented here only occurred among early pubertal girls, the adjustment hypothesis would be supported.

References

Apter, D. (1980). Serum steroids and pituitary hormone in female puberty: A partly longitudinal study. Clinical Endocrinology, 12,107-120.

Apter, D., & Vihko, R. (1977). Serum pregnenolone, progesterone, 17-hydroxy-progesterone, testosterone and 5a-dihydrotestosterone during female puberty. J. of Clin. End. and Meta., 45(5), 1039-1048.

Asso, D. (1986). The relationship between menstrual cycle changes in nervous system activity and psychological, behavioural and physical variables. Biological Psychology, 23, 53-64.

Baggerman, B. (1967). Some endocrine aspects of fish migration. In R.E. Whalen (Ed.), Hormones and behavior. Princeton, N.J.: D. Van Nostrand Co., Inc.

Bardwick, J.M. (1976). Psychological correlates of the menstrual cycle and oral contraceptive medication. In E.J. Sachar (Ed.), Hormones, Behavior, and Psychopathology (pp. 95-103). New York: Raven Press.

Beach, F.A. (1975). Behavioral endocrinology: An emerging discipline. American Scientist, 63, 178-187.

Brooks-Gunn, J., & Warren, M.P. (1989). Biological and social contributions to negative affect in young adolescent girls. Child Development, 60, 372-375.

Buchanan, C.M. & Eccles, J.S. (1989). Evidence for relations between hormones, moods and behavior at early adolescence. Unpublished manuscript.

Burger, H.B., & deKretser, D. (Eds.). (1981). Comprehensive endocrinology: The Testis. New York: Raven Press.

Cheek, D.B. (1974). Body composition, hormones, nutrition and adolescent growth. In M.M. Grumbach, G.D. Grave, & F.E. Mayer (Eds.), Control of the onset of puberty. New York: John Wiley and Sons.

Cohen, D., & Frank, P. (1975). Preadolescence: A critical phase of biological and psychological development. In D.V. Siva (Ed.), Mental health in children (Vol. 1). Westbury, N.Y.: PJD Publications, Ltd.

Dennerstein, L., Spencer-Gardner, C., Brown, J.B., Smith, M.A., & Burrows, G.D. (1984). Premenstrual tension-hormonal profiles. Journal of Psychosomatic Obstetrics and Gynecology, 3, 37-51.

Eccles, J.S., Miller, C.L., Tucker, M.L., Becker, J., Schramm, W., Midgley, R., Holmes, W., Pasch, L., & Miller, M. (1988, March). Hormones and affect at early adolescence. In J. Brooks-Gunn (Chair), Hormonal contributions to adolescent behavior. A symposium conducted at the second bienniel meeting of the Society for Research on Adolescence, Alexandria, Va.

Erikson, E.H. (1950). Childhood and society. N.Y.: Norton.

Faiman, C., & Winter, J.S.D. (1974). Gonadotropins and sex hormone patterns in puberty: Clinical data. In M.M. Grumbach, G.D. Grave, & F.E. Mayer (Eds.), Control of the onset of puberty. N.Y.:Wiley.

Finkelstein, J.W. (1980). The endocrinology of adolescence. Pediatric Clinics of North America, 27, 53-69.

Freud, A. (1969). Adolescence as a developmental disturbance. In G. Kaplan & S. Lebovici (Eds.), Adolescence: Psychosocial perspectives (pp. 5-10). New York: Basic Books.

Grumbach, M.M. (1980). The neuroendocrinology of puberty. In D.T. Krieger & J.C. Hughes (Eds.), Neuroendocrinology (pp. 249-258). Sunderland, Ma.: Sinauer Assoc. Inc.

Grumbach, M.M., Grave, G.D., & Mayer (Eds.). (1974). Control of the onset of puberty. New York: John Wiley and Sons.

Gupta, D., Attanasio, A., & Raaf, S. (1975). Plasma estrogen and androgen concentrations in children during adolescence. J. Clin. Endocrin. Metab., 40, 636-643.

Houser, B.B. (1979). An investigation of the correlation between hormonal levels in males and mood, behavior, and physical discomfort. Hormones and Behavior, 12, 185-197.

Jacobson, E. (1961). Adolescent moods and the remodeling of psychic structures in adolescence. The psychoanalytic study of the child, 16, 164-183.

Johnson, M., & Everitt, B. (1984). Essential reproduction (2nd ed.). Oxford: Blackwell Scientific Publications.

Kalat, J.W. (1988). Biological Psychology (3rd. ed.). Belmont, Ca.: Wadsworth Publishing Co.

Katchadourian, H. (1977). The biology of adolescence. San Francisco: W.H.Freeman.

Kestenberg, J.S. (1967a). Phases of adolescence: Part I. J. of Amer. Acad. Child Psych., 6, 426-463.

Kestenberg, J.S. (1967b). Phases of adolescence: Part II. J. of Amer. Acad. Child Psych., 6, 577-614.

Kinsey, A.C., Pomeroy, W.B., Martin, C.E., & Gebhard, C.E. (1953). Sexual behavior in the human female. Philadelphia: Saunders.

Lerner, H. (1987). Psychodynamic models. In V.B. Van Hasselt & M. Hersen (Eds.), Handbook of adolescent psychology (pp. 53-76). New York: Pergamon Press.

Lewis-Beck, M.S. (1980). Applied regression: An introduction. Beverly Hills: Sage Publications.

Miller, C.L. (1988). Pubertal development in early adolescent girls: Relationships to mood, energy, restlessness, and certainty about self. Unpublished doctoral dissertation, The University of Michigan.

Miller, C.L., Tucker, M.L., Pasch, & Eccles, J.S. (1988, March). Measuring pubertal development: A comparison of different scales and different sources. Poster presented at the bienniel meetings of the Society for Research on Adolescence, Alexandria.

Nottelmann, E.D., Susman, E.J., Inoff, G.E., Dorn, L.D., Cutler, G.B., Loriaux, D.L., & Chrousos, G.P. (1985, May). Hormone level and adjustment and behavior during early adolescence. Paper presented at the annual meeting for the Advancement of Science, Los Angeles, California.

Nottelmann, E.D., Susman, E.J., Blue, J.H., Inoff-Germain, G., Dorn, L.D., Loriaux, D.L., & Cutler, G.P. (1987a). Gonadal and adrenal hormone correlates of adjustment in early adolescence. In R.M. Lerner & T.T. Foch (Eds.), Biological-psychosocial interactions in early adolescence (pp. 303-323). Hillsdale, N.J.: Erlbaum.

Nottelmann, E.D., Susman, E.J., Dorn, L.D., Inoff-Germain, G., Loriaux, D.L., Cutler, G.B., & Chrousos, G.P. (1987b). Developmental processes in early adolescence: I. Relations among chronologic age, pubertal stage, height, weight, and serum levels of gonadotropins, sex steroids, and adrenal androgens. Journal of Adolescent Health Care, 8, 246-260.

Petersen, A.C., Crockett, L., Richards, M., & Boxer, A. (1988). Self-report measure of pubertal status: Reliability, validity, and initial norms. Journal of Youth and Adolescence, 17, 117-133.

Reiter, E., & Root, A. (1975). Hormonal changes of adolescence. Medical Clinics of North America, 59(6), 1289-1303.

Resource Monograph on the Middle Grades (1987). Albany, N.Y.: New York State Department of Education.

Rosenbaum, M. (1979). The changing body-image of the adolescent girl. In M. Sugar (Ed.), Female adolescent development (pp. 234-252). New York: Brunner / Mazel Publishers.

Sklar, C.A., Kaplan, S.L., & Grumbach, M.M. (1980). Evidence for dissociation between adrenarche and godanarche: Studies in patients with idiopathic precocious puberty, gonadal dysgenisis, isolated gonadotropin deficiency, and constitutionally delayed growth and adolescence. Journal of Clinical Endocrinology and Metabolism, 51(3), 548-556.

Susman, E.J., Nottelmann, E.D., Inoff-Germain, G.E., Dorn, L.D., Cutler, G.B.Jr., Loriaux, D.L., & Chrousos, G.P. (1985). The relation of relative hormone levels and physical development and socio-emotional behavior in young adolescents. Journal of Youth and Adolescence, 14(3), 245-264.

Susman, E.J., Inoff-Germain, G., Nottelmann, E.D., Loriaux, D.L., Cutler, G.B.Jr., & Chrousos, G.P. (1987). Hormones, emotional dispositions, and aggressive attributes in young adolescents. Child Development, 58, 1114-1134.

Teen Rage. Detroit Free Press, March 19, 1987, p. 1B

Vihko, R., & Apter, D. (1981). Endocrinology in the course of female puberty. In M.C. Pike, P.K. Siiteri, & C.W. Welsch (Eds.), Hormones and breast cancer (Banbury Report, Vol. 8, pp. 57-68). Cold Spring Harbor Laboratory.

Winter, J.S.P., & Faiman, C. (1973). Pituitary-gonadal relations in female children and adolescents. Pediatric Research, 7, 948-953.

Yen, S.S.C., & Jaffe, R.B. (1978). Reproductive endocrinology: Physiology, pathophysiology and clinical management, Philadelphia: Faunders.

Footnotes

[1]One percent of income data was missing.

[2]Miller (1988) examined intensity defined as both deviation from the mode and deviation from the mean. Results using the two different definitions were similar, thus only deviation from the mode is used here.

Table 1

Means, Ranges, and Standard Deviations for Concentration and Variability of Hormones

	N	Minimum	Maximum	Mean	Standard Deviation
Testcsterone Concentration	23	44.54	737.83	262.55	175.77
Testosterone Variability	23	743.06	177,530.00	31,169.00	51,863.00
Estradiol Concentration	24	70.18	294.82	137.44	39.70
Estradiol Variability	24	397.61	30,073.00	3,048.20	6,945.40
LH Concentration	24	0.83	[illegible]	1.61	0.54
LH Variability	24	0.03	32.10	1.92	6.63
FSH Concentration	25	1.71	11.09	3.31	1.80
FSH Variability	25	0.58	65.10	5.38	13.16

Note. Testosterone is measured in pg / ml. Estradiol is measured in pg / mg. LH and FSH are measured in mIU / mg.

Table 2

Correlations of Hormone Variables

	1 Testosterone Concentration	2 Testosterone Variability	3 Estradiol Concentration	4 Estradiol Variability	5 LH Concentration	6 LH Variability	7 FSH Concentration	8 FSH Variability
1	1.00	.75	.26	-.10	.01	-.14	-.38	-.19
2		1.00	.02	-.14	-.13	-.15	-.36	-.16
3			1.00	.50	.13	.04	-.09	.03
4				1.00	.16	.13	.41	.79
5					1.00	.64	.58	.36
6						1.00	.20	.18
7							1.00	.39
								1.00

Note. N=25 for FSH concentration and variability; N=24 for all estradiol and LH variables, and N=23 for testosterone concentration and variability. A correlation of .39 is significant at .05; a correlation of .51 is significant at .01.

Table 3

Means and Standard Deviations of Hormone Concentrations and Variabilities by Perceived Pubertal Status Group

	Pre-pubertal [a]		Early Pubertal [b]			
	Mean	S.D.	Mean	S.D.	F	eta^2
Testosterone Concentration	274.28	172.33	235.74	194.52	.23	.01
Testosterone Variability	34931.00	53155.00	29143.00	52646.00	.06	.00
Estradiol Concentration	141.70	43.66	127.11	27.57	.66	.03
Estradiol Variability	2166.00	4616.90	5190.50	10978.00	.94	.04
LH Concentration	1.49	.57	1.91	.34	3.34*	.13
LH Variability	2.09	7.74	1.53	2.98	.03	.00
FSH Concentration	2.75	.70	4.48	2.77	6.12**	.21
FSH Variability	2.61	4.35	11.25	22.20	2.49	.10

Note. Testosterone is measured in pg / ml. Estradiol is measured in pg / mg. LH and FSH are measured in mIU / mg.

[a] N=17, except for testosterone concentration and variability where N=16. [b] N=7, except for FSH concentration and variability where N=8.

* $p \leq .10$. ** $p \leq .05$.

Table 4

Results of Regression Analyses for Mood Intensity and FSH Concentration

	Partial Correlation	Coefficient	b	F	R^2
Angry	.31	39	.08	2.41	.09
Impatient	.29	.61	.13	2.06	.08
Nervous	.42	.16	.13	4.88**	.18
Ashamed	.40	-.00	.12	4.50**	6
Happy	.22	.47	.05	1.19	.05
Proud	.12	.92	.05	.33	.01
Excited	.17	.91	.06	.70	.03
Friendly	.37	.30	.10	3.59*	.14
Sad	.39	.05	.13	4.06*	.15
Confident	.30	.67	.09	2.21	.09
All Moods	.47	.45	.09	6.38**	.22

Note. The sample mean of FSH is 3.31 mIU / mg. N=25 for all analyses except conf dent and all moods, where N=24.

*$p \leq .10$. **$p \leq .05$.

Table 5

Results of Regression Analyses for Mood Variability Across thc Month and FSH Concentration

	Partial Correlation	Coefficient	b	F	R^2
Angry	.56	-.10	.31	10.46***	.31
Impatient	.43	.31	.23	5.36**	.19
Nervous	.39	.25	.24	4.19**	.15
Ashamed	.59	-.38	.32	12.55***	.35
Happy	.21	.48	.08	1.01	.04
Proud	.22	.65	.10	1.16	.05
Excited	.25	.83	.13	1.48	.06
Friendly	.43	-.02	.19	5.14**	.18
Sad	.48	-.13	.28	6.71**	.23
Confident	.42	.43	.22	4.71**	.18
All Moods	.57	.23	.22	10.47***	.32

Note. The sample mean of FSH concentration is 3.31 mIU / mg. N=25 for all analyses except confident and all moods, where N=24.

*p≤.10. **p≤.05. ***p≤.01.

Table 6

Results of Regression Analyses for Mood Variability Within Day and Hormones

	Partial Correlation	Coefficient	b	F	R^2
Testosterone Concentration	-.31	2.77	-.001	2.23	.10
Testosterone Variability	-.08	2.44	-.000	.13	.01
Estradiol Concentration	-.37	3.43	-.007	3.42*	.13
Estradiol Variability	.34	2.30	.000	2.94*	.12
LH Concentration	-.15	2.77	-.221	.51	.02
LH Variability	.13	2.39	.016	.40	.02
FSH Concentration	.11	2.26	.048	.28	.01
FSH variability	.48	2.26	.028	6.82**	.23

Note. N=25 for FSH concentration and variability; N=24 for all estradiol and LH variables; N=23 for testosterone concentration and variability.

*$p \leq .10$. **$p \leq .05$.

Table 7

Results of Regression Analyses for Energy and Restlessness Levels and Variability and FSH Concentration

	Partial Correlation	Coefficient	b	F	R^2
Energy Level	-.10	3.67	-.041	.21	.01
Restlessness Level	.24	1.67	.110	1.46	.06
Energy Variability	.52	.21	.321	8.51***	.27
Restlessness Variability	.59	.01	.118	12.14***	.35

Note. The sample mean of FSH concentration is 3.31 mIU / mg. N=25.

***$p \leq .01$.

Table 8

Results of Regression Analyses for Mood Intensity, Perceived Pubertal Status, and FSH Concentration

	Partial Correlation	β	t	F	R^2
Angry				1.22	.10
FSH	.25	.27	1.20		
Pre-pubertal	-.07	-.08	-.34		
Impatient				1.35	.11
FSH	.19	.20	.89		
Pre-pubertal	-.17	-.19	-.82		
Nervous				4.67**	.30
FSH	.24	.24	1.18		
Pre-pubertal	-.39	-.40	-1.97*		
Ashamed				5.40***	.33
FSH	.21	.19	.99		
Pre-pubertal	-.45	-.46	-2.23**		
Happy				1.01	.08
FSH	.12	.12	.54		
Pre-pubertal	-.19	-.21	-.92		
Proud				.93	.08
FSH	-.01	-.01	-.05		
Pre-pubertal	-.25	-.29	-1.23		
Excited				.35	.03
FSH	.14	.15	.65		
Pre-pubertal	-.04	-.04	-.18		
Friendly				2.53*	.19
FSH	.24	.25	1.16		
Pre-pubertal	-.25	-.26	-1.18		
Sad				3.56**	.24
FSH	.23	.23	1.10		
Pre-pubertal	-.33	-.35	-1.66		
Confident				1.26	.11
FSH	.21	.23	.99		
Pre-pubertal	-.13	-.14	-.60		
All Moods				5.43***	.34
FSH	.29	.29	1.41		
Pre-pubertal	-.39	-.39	-1.92*		

Note. N=25 for all analyses except confident and all moods, where N=24.

*$p \leq .10$. **$p \leq .05$. ***$p \leq .01$.

Table 9

Results of Regression Analyses for Mood Variability Across the Month, Perceived Pubertal Status, and FSH Concentration

	Partial Correlation	β	t	F	R^2
Angry				5.26***	.32
FSH	.55	.61	3.10***		
Pre-pubertal	.13	.12	.59		
Impatient				3.08*	.22
FSH	.33	.35	1.63		
Pre-pubertal	-.19	-.19	-.91		
Nervous				3.76**	.25
FSH	.23	.23	1.10		
Pre-pubertal	-.35	-.36	-1.73*		
Ashamed				7.73***	.41
FSH	.48	.47	2.55**		
Pre-pubertal	-.30	-.28	-1.50		
Happy				.78	.07
FSH	.11	.13	.54		
Pre-pubertal	-.16	-.17	-.75		
Proud				.58	.05
FSH	.22	.24	1.03		
Pre-pubertal	.04	.05	.21		
Excited				.73	.06
FSH	.24	.27	1.15		
Pre-pubertal	.04	.05	.21		
Friendly				2.47	.18
FSH	.40	.44	2.04**		
Pre-pubertal	.03	.03	.15		
Sad				4.70**	.30
FSH	.34	.34	1.67		
Pre-pubertal	-.31	-.30	-1.52		
Confident				2.25	.18
FSH	.37	.41	1.82*		
Pre-pubertal	-.02	-.02	-.08		
All Moods				5.21***	.33
FSH	.48	.51	2.53**		
Pre-pubertal	-.12	-.11	-.54		

Note. N=25 for all analyses except confident and all moods, where N=24.

*$p \leq .10$. **$p \leq .05$. ***$p \leq .01$.

Table 10

Results of Regression Analyses for Mood Variability Within Day, Perceived Pubertal Status, and Hormones

	Partial Correlation	β	t	F	R^2
Mood Swings					
Testosterone Level	-.31	-.31	1.46	1.07	.10
Pre-pubertal	.02	.02	.09		
Mood Swings					
Testosterone Variability	-.08	-.08	-.35	.06	.01
Pre-pubertal	-.01	-.01	-.04		
Mood Swings					
Estradiol Level	-.37	-.38	-1.84	1.70	.14
Pre-pubertal	.07	.07	.34		
Mood Swings					
Estradiol Variability	.35	.36	1.72	1.48	.12
Pre-pubertal	.08	.08	.38		
Mood Swings					
LH Level	-.16	-.17	-.74	.27	.03
Pre-pubertal	-.05	-.06	-.24		
Mood Swings					
LH Variability	.13	.13	.62	.19	.02
Pre-pubertal	.001	.001	.003		
Mood Swings					
FSH Level	.13	.14	.60	.18	.02
Pre-pubertal	.07	.07	.31		
Mood Swings					
FSH Variability	.51	.53	2.75***	3.79**	.26
Pre-pubertal	.19	.18	.91		

Note. N=25 for FSH concentration and variability; N=24 for all estradiol and LH variables; N=23 for testosterone concentration and variability.

**$p \leq .05$ ***$p \leq .01$.

Table 11

Results of Regression Ar alyses for Energy and Restlessness Levels and Variability, Perceived Pubertal Status, and FSH Concentration

	Partial Correlation	β	t	F	R^2
Energy Level				.47	.04
FSH	-.002	-.002	-.01		
Pre-pubertal	.18	.20	.86		
Restlessness Level				.70	.06
FSH	.21	.23	1.00		
Pre-pubertal	-.02	-.02	-.10		
Energy Variability				4.07**	.27
FSH	.47	.51	2.51**		
Pre-pubertal	-.01	-.01	-.06		
Restlessness Variability				10.64***	.49
FSH	.44	.39	2.28**		
Pre-pubertal	-.47	-.43	-2.52**		

Note. N=25.

**$p \leq .05$. ***$p \leq .01$.

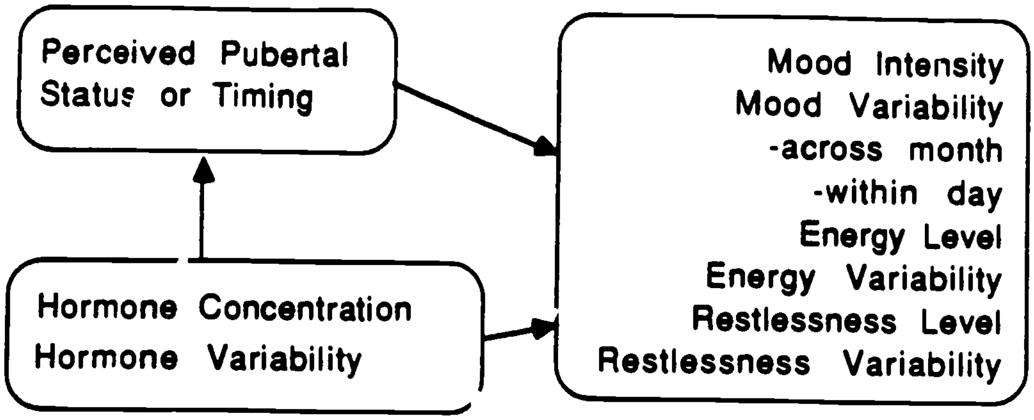

Figure 1. Model of Mood Outcomes at Adolescence Predicted by Direct Effects of Both Perceived Pubertal Status or Timing and Hormone Activity

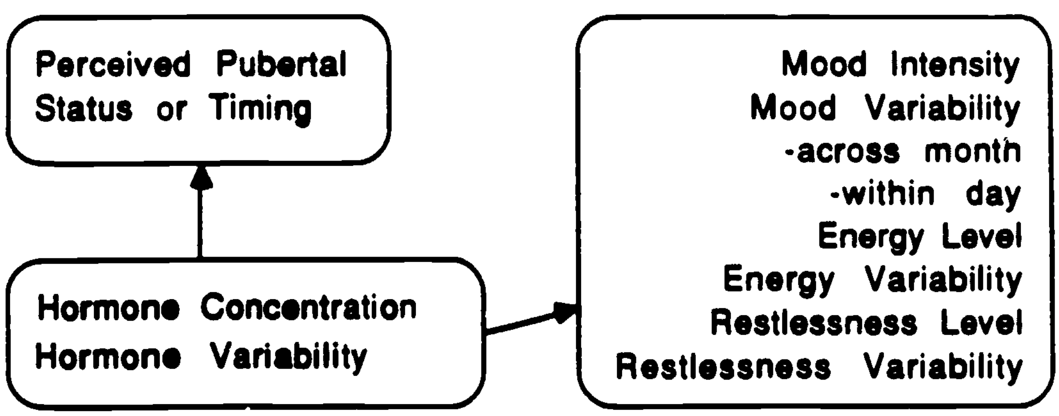

Figure 2. Model of Mood Outcomes at Adolescence Predicted by Direct Effects of Hormone Activity Only

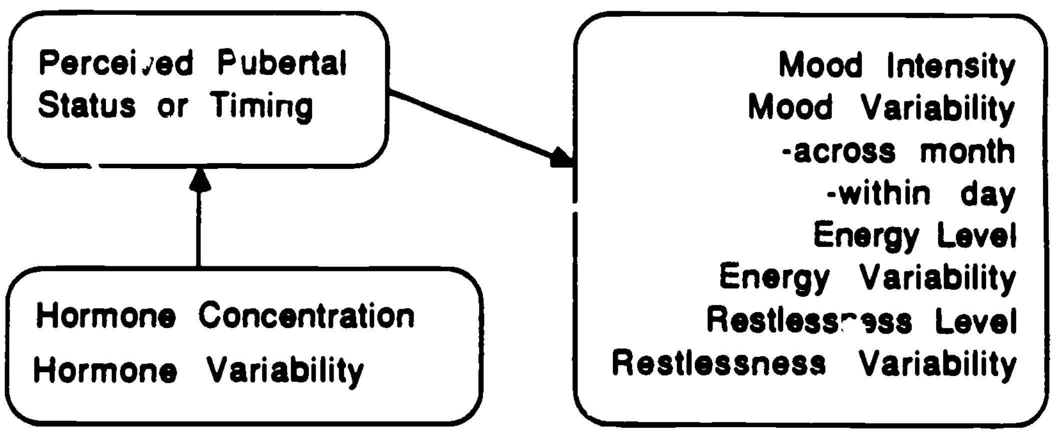

Figure 3. Model of Mood Outcomes at Adolescence Predicted by Direct Effects of Perceived Pubertal Status or Timing Only