# Biobehavioral Characteristics of Infants With Failure to Thrive

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Failure to thrive (FTT) is a syndrome of growth failure that results in an infant who is behaviorally difficult. The current thinking is that FTT results from a problematic infant-mother interaction, with the infant making a significant contribution to the interactional process. It is possible that the behavioral characteristics of the infant with FTT may be related to underlying physiologic response patterns, specifically, activity of the autonomic nervous system. The purpose of this study is to examine the relationships among behavioral responsiveness, heart rate variability as a marker of autonomic nervous system activity, and nutritional status in infants with FTT. Infants with FTT were matched with healthy growing infants ($n$ = 14 pairs). Results from the study indicated that infants with FTT exhibited considerably more negative behaviors and exhibited low heart rate variability. It appears that there may be a physiologic basis to the behaviors that are exhibited by infants with FTT. Prospective research is needed to further clarify this relationship.


FAILURE TO THRIVE (FTT) is a syndrome of growth failure in infants that develops secondary to undernutrition. The end result of FTT is an infant who is behaviorally difficult, exhibiting such behaviors as irritability, apathy, and disinterest in the environment (Bithoney, Dubowitz, & Egan, 1992). What is unclear and not well supported by empirical evidence is which factors contribute to undernutrition and ultimately result in the development of FTT. One hypothesis is that FTT results from a problematic infant-mother interaction in which the infant's contribution to the interactional process is significant (Bithoney et al., 1992; Drotar, 1991). Thus, there is a possibility that the infant with FTT may contribute to its own growth failure (Boddy & Skuse, 1994).

Low behavioral responsiveness has been described in infants with FTT (Black & Dubowitz, 1991) and could have a considerable impact on the infant-mother interaction. The infant with FTT who is apathetic and passive is ineffective in communicating with the mother. The mother, in turn, misinterprets the infant's cues and needs, and this results in the perpetuation of a problematic infant-mother interaction. Unfortunately, little is known about the etiology of the behavioral responsiveness of infants with FTT and whether this behavioral responsiveness precedes or is a result of the undernutrition associated with FTT (Bithoney, Van Sciver, Foster, Corso, & Tentindo, 1995).

Behavioral responsiveness in healthy infants is postulated to be related to underlying physiologic response patterns (Boyce, Barr, & Zeltzer, 1992). One physiologic system believed to contribute to the infant's behavioral responsiveness is the autonomic nervous system (ANS). Reactivity of the ANS is manifested in the behaviors exhibited by infants in response to interacting with environmental demands (Porges & Doussard-Roosevelt, 1997). Identification of physiologic markers of FTT has important implications for early recognition of infants at high risk for FTT and for understanding mechanisms that may contribute to FTT.

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## BACKGROUND

Infants react to environmental demands with their own individual style of behavioral responsiveness. The pattern of activity of the ANS is proposed to contribute to the infant's behavioral responsiveness (Fox, 1989). Individual differences in behavioral responsiveness may be related to individual differences in reactivity of the ANS (Porges, Doussard-Roosevelt, & Maiti, 1995). *Heart rate variability* (HRV) serves as a marker for ANS activity in infants (Richards & Cameron, 1989) and refers to the beat-to-beat fluctuations in heart rate that occur as a result of parasympathetic and sympathetic influences (Cowan, 1995). In examinations of the relationship between behavioral responsiveness and HRV, investigators have shown that the specific component of HRV that is related to infant behavior is respiratory sinus arrhythmia (RSA) (Porges, 1995; Richards & Cameron, 1989), which is the variability in heart rate that occurs at the same frequency as respiration and is under the control of the parasympathetic branch of the ANS (Bernston, Cacioppo, & Quigley, 1993; Van Ravenswaaij-Arts, Hopman, Kollee, Stoelinga, & Van Geijn, 1994). Specifically, RSA is under the control of the vagus nerve. One portion of the vagus nerve originates in the nucleus ambiguus, which is related to expression of motion, emotion, and communication. This same portion of the vagus nerve that originates in the nucleus ambiguus (Porges & Doussard-Roosevelt, 1997) also determines RSA.

Infants are confronted by a variety of environmental demands to which they need to respond behaviorally. Facial expressions, vocalizations, and motor activity are the behavioral mechanisms by which infant responses to these demands are manifested (Porges & Doussard-Roosevelt, 1997). The amount of variability in activity of the parasympathetic branch is reflective of its ability to respond to demands from the environment (Porges, Doussard-Roosevelt, Portales, & Greenspan, 1996). The individual behavioral style an infant exhibits in response to environmental demands is related to this variability in parasympathetic activity (Jemerin & Boyce, 1990), so that appropriate behavioral responses to these demands are mediated by the infant's ability to regulate parasympathetic activity (Porges et al., 1996).

Behavioral responses require metabolic output (Porges et al., 1996). Increased variability in parasympathetic activity facilitates the transitory withdrawal of parasympathetic activity required to provide the metabolic output needed for the infant to react to environmental demands (Huffman et al., 1998; Porges, 1992). The resulting increase in metabolic output supports the behavioral and motor responses that are needed to appropriately engage or disengage with the environment (Porges et al., 1996). Therefore, infants with increased variability in parasympathetic activity will be able to appropriately regulate behavior in response to the environment. Infants with decreased variability lack the ability to appropriately respond to environmental demands (Fracasso, Porges, Lamb, & Rosenberg, 1994; Porges, 1992).

With the recognition that behaviors exhibited by an infant are linked to biologically based processes, researchers have begun to focus on understanding this linkage in infant behavior. In one study, healthy 5-month-old infants with higher vagal tone exhibited more positive facial expressions than infants with low vagal tone (Stifter, Fox, & Porges, 1989). Vagal tone and behavioral reactivity were measured in 5-month-old infants in response to a positive and a negative stimulus (Stifter & Fox, 1990). Infants who exhibited higher vagal tone also exhibited more behavioral reactivity in response to the negative stimulus. This same group of infants was measured again at 14 months (Fox, 1989). Infants with high vagal tone at 14 months had higher vagal tone and were more behaviorally reactive at 5 months. These infants were also better able to respond to novel stimuli and explore their environment. While HRV has not been examined in infants with FTT, similarities may be found in HRV measures of infants of mothers who are depressed because maternal depression influences the interaction between infant and mother. Compared with infants of nondepressed mothers, infants of mothers who were depressed exhibited low vagal tone and were less behaviorally reactive (Field et al., 1988; Field, Pickens, Fox, Nawrocki, & Gonzalez, 1995). These findings provide evidence for the relationship between HRV and behavioral reactivity.

A more balanced understanding of FTT would be achieved if more emphasis were placed on the contribution of infant characteristics to FTT (Bithoney et al., 1995; Boddy & Skuse, 1994). There is evidence to suggest that infants with FTT are behaviorally different from healthy infants. If behavioral characteristics unique to infants with FTT are present before the development of FTT, those characteristics may play a role in the development of the maladapted infant-mother interaction that is hypothesized to contribute to FTT (Bithoney et al., 1992).

Mothers of infants with FTT perceive their infants as behaviorally difficult and describe them as fussy, demanding, not cuddly, highly variable in moods, and less socially attractive (Bithoney & Newberger, 1987; Bithoney et al., 1995; Mathisen, Skuse, Wolke, & Reilly, 1989; Singer, Song, Hill, & Jaffe, 1990; Wolke, Skuse, & Mathisen, 1990). Infants with FTT are difficult to interact with, compared with healthy infants, because of their characteristic facial expressions, vocal responses, and motor activity. They have been described as exhibiting an emotionless face with poor eye contact and minimal smiling (Abramson, 1991; Powell & Low, 1983; Powell, Low, & Speers, 1987). When infants with FTT display facial expressions, negative affect is the predominant emotion displayed, with limited expression of positive affect (Abramson, 1991; Polan et al., 1991; Wolke et al., 1990). Abramson (1991) showed that infants with FTT display more negative facial expressions and use only the upper half of the face to express emotions. This is important in that infants with FTT, who are already limited in their repertoire of facial expressions, are further impeded in their ability to communicate during interactions by using only half of the face.

In addition, vocal expressions of the infant with FTT are often lacking during interactions. Spontaneously and in response to stimulation, infants with FTT exhibit diminished vocal responsiveness (Powell et al., 1987; Wolke et al., 1990). Vocalizations of the infant with FTT are often characterized by whining and fussing (Berkowitz & Senter, 1987; Wolke et al., 1990). Motor responsiveness of the infant with FTT also is diminished, and these infants demonstrate decreased motor activity and infantile posturing (Bithoney & Newberger, 1987; Powell et al., 1987). The described facial expressions, vocal responses, and motor activity of infants with FTT could be problematic within the context of the infant-mother interaction. From the mother's perspective, these behaviors could be misinterpreted as a lack of interest on the infant's part.

There is some evidence to suggest that there is a relationship between behavioral characteristics and nutritional status of the infant with FTT. Although the finding was not the major objective of various studies, infants with poorer nutritional status had more behavioral difficulties. Infants who were the most undernourished were less adaptive to and more easily distracted by environmental demands, exhibited less variability in mood, and exhibited more negative affect and minimal positive affect (Bithoney et al., 1995; Drotar, Nowak, Malone, Eckerle, & Negray, 1985; Polan et al., 1991; Singer et al., 1990). Taken together, these findings suggest that nutritional status may play a role in the behaviors exhibited by infants with FTT.

In summary, equal consideration of the infant's contribution to the development of FTT could result in a more comprehensive understanding of this disorder (Skuse, 1985). If credence is given to maternal reports of difficult infant behaviors before the development of FTT, then closer examination of infant behaviors and processes that facilitate these behaviors is needed. Researchers who focus on healthy infants have shown that the individual behavioral style of infants is related to underlying physiologic processes (Stifter et al., 1989; Stifter & Fox, 1990; Fox, 1989). Based on this assumption, it is plausible that the behavioral characteristics of the infant with FTT were present before the development of FTT and furthermore may have been an etiological factor. The relationship between behavioral responsiveness and changes in parasympathetic activity can be examined during periods of well-defined environmental demands (Porges, 1996). The purpose of this study was to examine the relationships among behavioral responsiveness, HRV as a marker of ANS activity, and nutritional status in infants with FTT, compared with infants with normal patterns of growth. In this present study the following research hypotheses and research question were addressed:

1. Infants with FTT have more negative behavioral responsiveness than infants with normal growth.
2. Infants with FTT have low heart rate variability as evidenced by no withdrawal of parasympathetic activity.
3. Infants with normal growth have high HRV as evidenced by a significant withdrawal of parasympathetic activity.
4. What are the relationships among behavioral responsiveness, HRV, and nutritional status for infants with FTT?

## METHOD

### *Sample*

Twenty-two infants with FTT and 25 healthy infants were recruited for this study from two pediatric primary care clinics. One clinic was located in a moderate-size Midwestern children's hospital, and the other was located in a rural setting in a

Midwestern state. Criteria for inclusion in the FTT group included: (a) weight-for-age that had fallen below the fifth percentile or weight-for-age that had fallen across two major percentiles, (b) absence of a disease process to explain the growth failure, (c) birthweight of greater than or equal to 2500 g, (d) no obvious recorded prenatal or postnatal complications, and (e) age of 2 to 12 months. Infants in the FTT group were matched for age, sex, and race with healthy infants who were growing appropriately. The final sample comprised 17 infants with FTT and 16 healthy growing infants. Because of missing data, statistical analyses were based on 14 pairs of infants. Attrition from the study appeared to be primarily related to three reasons: the mother changed her mind, the mother's significant other was opposed, or the mother was not available when the scheduled home visit was made.

### *Procedures*

The appropriate Human Subject Protection Committees approved this study. Parental consent for the infant to participate in the study was obtained. All data were collected during a visit to the infant's home. During the home visit, the mother completed a demographic questionnaire while the infant was measured for weight and length. After the anthropometric measurements were completed, a 2-channel, 24-hour Holter (Del Mar Avionics, Irvine, CA) recorder was attached to the infant. Following placement of the recorder, the infant was videotaped interacting with the mother during a 5-minute free-play situation. Mothers were instructed to play with their infant as they usually would during the free-play interaction. The videotaped interaction was scored later using the Parent-Child Early Relational Assessment (Clark, 1985).

### *Instruments*

*Behavioral Responsiveness.* Behavioral responsiveness of the infant during an interaction with the mother was assessed using the Parent-Child Early Relational Assessment (PCERA) scale (Clark, 1985). The PCERA was designed to assess the quality of the affective and behavioral characteristics that an infant and mother bring to the interaction and includes mother, child, and dyad subscales (Clark, Paulson, & Conlin, 1993; Clark, Hyde, Essex, & Klein, 1997). Child subscales were used because infant responsiveness was the focus of this study. Items of the subscales provide a comprehensive assessment of the infant's contribution to the interaction through rating the amount, intensity, and duration of positive affect (such as expressions of pleasure and enjoyment), negative affect (such as expressions of displeasure, irritability, or frustration), and interactive behaviors exhibited (Burns, Chethik, Burns, & Clark, 1997; Clark et al., 1993). The subscales include expressed affect and characteristic mood, behavior/adaptive abilities, activity level, and communication. The expressed affect and characteristic mood subscale assesses the infant's affective states and manifestations of temperament. The behavior/adaptive abilities subscale assesses items such as social behavior, interest in the environment, cooperation, ability to focus appropriately on stimuli, and ability for self-regulation. The activity level subscale assesses the amount and appropriateness of the activity the infant exhibits during the interaction. The communication subscale assesses the infant's ability to communicate its needs through visual contact and vocalizations (Clark, 1985). These subscales comprised 28 items with behavioral anchors that are rated on a five-point Likert scale (Clark, 1985). Behavioral responses of the infant during the 5-minute free play interaction with the mother were videotaped. An expert trained in the use of the PCERA, who was blind to group membership, later scored the videotapes. Determining the average scores for each item of the subscale provided scores for each of the subscales. Higher scores were indicative of appropriate behaviors exhibited by the infants in response to their mothers. Internal consistency for the child subscales of the PCERA using coefficient alpha ranged from .88 to .91 (Clark, 1985). When used with a sample of infants with FTT and their mothers, the internal consistency for the instrument ranged from .84 to .89 (Black, Hutcheson, Dubowitz, & Berenson-Howard, 1994). Internal consistency in the current study for the child subscales ranged from .83 to .92.

*Heart Rate Variability.* Data to assess HRV were obtained from a 2-channel, 24-hour ambulatory Holter ECG recording (Zymed Multitrack, Del Mar Avionics, Irvine, CA). All Holter tapes were scanned in semiautomatic mode on a Zymed 1510. An expert technician visually confirmed ECG complexes, and beat labels were corrected as necessary (Woo, Stevenson, & Moser, 1996). The data obtained from the scanned tapes included time of beat, type of beat, and serial R-R intervals in milliseconds. The digitized data from these scanned recordings were stored on individual floppy disks.

Spectral analysis was used to decompose the pattern of HRV into its frequency components. This technique quantifies the components in terms of their relative intensity or power within specified frequency bandwidths and was used to determine the parasympathetic component of HRV (Cowan, 1995; Ori, Monir, Weiss, Sayhouni, & Singer, 1992). This measure, like all HRV measures, is based on normal sinus rhythm; thus only sinus beats were used in the analysis. All R-R intervals associated with artifact and ectopic beats and the R-R intervals immediately before and after these aberrant beats were deleted from the analysis (Woo et al., 1992). Spectral analysis requires a continuous time series of data (Woo et al., 1996). To ensure the accuracy of the spectral analysis, the assumptions of stability and stationarity between data points must be met (Schechtman, Kluge, & Harper, 1988). These assumptions are difficult to meet if long ECG recordings are used, because biologic systems are not stable for long periods of time (Jorna, 1992). Therefore, 5-minute epochs free of artifact were used (Akselrod, Gordon, Shannon, Barger, & Ubel, 1981).

Spectral analysis with Fast Fouier transform was performed using the Zymed Research Heart Rate Variability Analysis System on a Zymed 1510 Holter scanner (Zymed Medical Instrumentation Carmarillo, CA) to obtain the high frequency (HF) component of HRV because it is reflective of parasympathetic activity and thus respiratory sinus arrhythmia. Fast Fouier analysis provided a spectral density plot of HF power as a function of frequency (Pieper & Hammill, 1995). Spectral activity was expressed as the absolute power ($ms^2$) in the HF band (Pomeranz et al., 1985; Van Ravenswaaij et al., 1994). Power in the HF band was derived from R-R intervals in the frequency range of .15 to .40 Hz (Pieper & Hammill, 1995).

*Nutritional Status.* Anthropometrics were used to assess nutritional status in infants (Metallinos-Katsaras & Gorman, 1999). Using computer software, Epi Info (Center for Disease Control; Dean et al., 1995), the current nutritional status of the infants with FTT was determined by using the anthropometric indicator of weight-for-length expressed as a percentage of the median of the reference population. Length-for-age, expressed as a percentage of the median of the reference population, was used to determine whether the infant with FTT was chronically malnourished. For descriptive purposes, the calculated percentages for weight-for-length and length-for-age were used to determine whether the infants were acutely or chronically malnourished. The calculated percentages were used to determine the influence of nutritional status on behavior and HRV in infants with FTT. All infants were weighed nude on a portable digital scale. Weight was recorded to the nearest 10 g (Fomon & Nelson, 1993). Length was measured as recumbent length using a wooden length board with a sliding foot piece, and was recorded to the nearest 0.5 cm (Fomon & Nelson, 1993).

### *Data Analysis*

Descriptive statistics were used to characterize the sample and summary scores on all variables. Equality between the FTT and normal growth groups on demographic variables was analyzed using independent *t* tests. Wilcoxon Signed Rank test was used to examine differences between the two groups on study variables, and Spearman Rho correlations were used to examine relationships among variables within the FTT group.

## RESULTS

Ages of the infants ranged from 2 to 12 months. In the total sample, there were 11 boys and 22 girls. Thirteen infants were African American, and 20 infants were Caucasian. The final sample comprised 14 pairs of infants (Table 1). Demographic variables are summarized in Table 2. No significant differences were found between the two groups for the maternal variables of age and education. The majority of the mothers were single. There was a significant difference between the two groups for infant birthweight ($t = -2.649$; $p <$ .013). The mean birthweight for the FTT group was 2822 g, whereas the mean birthweight for the healthy group was 3344 g. The majority of infants with FTT were mildly malnourished in the acute phase (Table 3). Four infants had both acute and chronic malnutrition.

Behavioral differences were found between infants with FTT and healthy infants based on two of the subscales of the PCERA: communication and mood/affect (Table 4). Infants with FTT scored significantly lower on the communication subscale ($z = -2.269$, $p < .02$). During interactions with the mothers, infants with FTT exhibited less visual

**Table 1. Characteristics of Sample**

| | Failure to Thrive | | Healthy Controls | | |
|---|---|---|---|---|---|
| | Boys | Girls | Boys | Girls | Totals |
| White | 3 | 6 | 3 | 6 | 18 |
| Black | 2 | 3 | 2 | 3 | 10 |
| Totals | 5 | 9 | 5 | 9 | 28 |

**Table 2. Study Demographics**

| | Group | *M* | *SD* | *p* |
|---|---|---|---|---|
| Maternal Age | | | | |
| (years) | FTT | 23.82 | 5.46 | .443 |
| | Healthy | 25.28 | 4.87 | |
| Maternal Education | | | | |
| (years) | FTT | 12.29 | 2.02 | .728 |
| | Healthy | 12.57 | 2.37 | |
| Birthweight (g) | FTT | 2822 | 533 | .013* |
| | Healthy | 3344 | 563 | |
| Infant Age (months) | FTT | 9.17 | 2.74 | .551 |
| | Healthy | 8.57 | 2.82 | |
| Infant Weight (kg) | FTT | 7.14 | 1.19 | .010* |
| | Healthy | 8.54 | 1.62 | |

* $p < .05$.
Abbreviations: FTT, failure to thrive.

contact or more gaze aversion and vocalized less often than the healthy infants. These infants also were more difficult to read because they gave ambiguous signals or cues to the mother. Infants with FTT also scored significantly lower on the mood/affect subscale ($z = -1.916$, $p = .05$). The infants with FTT expressed significantly less pleasure and enjoyment or positive affect and more negative emotions or negative affect. These infants also expressed an angrier mood or irritability and appeared more uninterested or apathetic. No significant differences were found between the two groups for the behavior/adaptive ability subscale ($z = -1.036$, $p < .30$).

Because the HRV data were positively skewed, transformation of the data was carried out using the natural logarithm to improve the normality of the data (Tabachnick & Fidell, 1996). When changes in HF activity between the full-day and the 30-minute intervention periods were examined within each group, infants in the FTT group exhibited no significant difference between the two time points ($z = -.909$, $p < .36$). Infants in the control group also exhibited no significant change ($z = -1.726$, $p < .08$).

Spearman Rho correlations were performed to examine relationships between the behavior and HRV of the infant with FTT. Scores on the Communication subscale were negatively correlated with HF values for the day, ($r_s = -.658$, $p = .02$), and during the data collection ($r_s = -.545$, $p = .05$). No other significant relationships were found between behavioral scores and HRV. Spearman Rho correlations also were used to examine the relationships between nutritional status/behavior and nutritional status/heart rate variability in the FTT group. No significant relationships were found between nutritional status/behavior and nutritional status/HRV.

**Table 3. Classification of Nutritional Status of Infants With FTT**

| | Mild Malnutrition | Moderate Malnutrition |
|---|---|---|
| Weight-for-Length | | |
| Acute/Wasting | 12 | 1 |
| Height-for-Length | | |
| Chronic/Stunting | 3 | 2 |

**Table 4. Comparison of Parent-Child Early Relational Scores**

| | Mood/Affect | Behavior/Adaptive | Communication |
|---|---|---|---|
| FTT (14) | 3.65 | 3.83 | 3.19 |
| Healthy (14) | 4.26 | 4.17 | 4.07 |
| *z* | −1.916 | −1.036 | −2.269 |
| *p* | .05 | .30 | .02 |

Abbreviations: FTT, failure to thrive.

## DISCUSSION

The purpose of this research was to examine the relationships among behavioral responsiveness, HRV, and nutritional status in infants with FTT. The results confirm the hypothesis that infants with FTT exhibit more negative behaviors when interacting with their mothers, as compared with healthy infants. Infants with FTT were significantly less communicative and expressed more negative mood behaviors. The results of this study supported the second hypothesis, as infants with FTT exhibited minimal change in parasympathetic activity. The results did not support the third hypothesis, as infants in the control group exhibited no significant change in parasympathetic activity. Nutritional status was not related to the behavioral characteristics or HRV of infants with FTT.

The difficult behaviors exhibited by the infants with FTT in this study are consistent with the findings from other investigators who examined the behavior of infants with FTT. The findings of more gaze aversion and less vocalizing are consistent with the findings of Berkowitz and Senter (1987), Powell and Low (1983), and Powell et al. (1987), who demonstrated that infants with FTT exhibited significantly less eye contact and diminished vocalizing during interactions with the mother. Abramson (1991) also found that, during interactions with the mother, infants with FTT displayed significantly more gaze aversion. Cues from the infants with FTT in this study also were more difficult for mothers to read. These findings are similar to several studies in which infants with FTT displayed poor cues and ambiguous signals to the mother during feeding interactions (Haynes, Cutler, Gray, & Kempe, 1984; Mathisen et al., 1989). The quality of the signals the infant gives to the mother contributes to the overall dynamics of the infant-mother interaction (Stallings, 1994). The poor signals and ambiguous cues exhibited by the infant with FTT make the infant an unattractive social partner (Wolke et al., 1990). The current thinking is that the development of FTT is related to the quality of the infant-mother interaction, with both the infant and mother making equal contributions to the success or failure of the interaction (Bithoney et al., 1992; Boddy & Skuse, 1994). Coupling the poor signaling ability of the infant with FTT with a mother who has difficulty interpreting infant signals (Ayoub & Milner, 1985; Haynes et al., 1984; Wolke et al., 1990) supports the hypothesis that the infant with FTT has the potential to play a role in its own growth failure.

Infants with FTT had significantly lower scores on the subscale of mood/affect. These findings are consistent with the behaviors displayed by infants with FTT during structured interactions with the mother. Compared with healthy infants, infants with FTT displayed more negative affect, less positive affect, more irritability, and more variability in mood (Abramson, 1991; Polan et al., 1991; Wolke et al., 1990). The findings from this study and the findings from previous studies portray a picture of an infant who is behaviorally difficult and provide evidence to support the perception that infants with FTT are unattractive as social partners. If these difficult behaviors were present before FTT developed, then the possibility exists that the behavioral qualities of the infant could contribute to the infant's growth failure because the mother may limit her interactions with the infant (Boddy & Skuse, 1994; Wolke et al., 1990).

Heart rate variability is reflective of ANS balance (Cowan, 1995; Pieper & Hammill, 1995). The ability of the infant to interact with the environment parallels the balance of the ANS such that the infant with a more balanced ANS is able to use appropriate behavioral responses to the environment (Stifter et al., 1989). As expected, infants with FTT did not show any evidence of withdrawal or suppression of parasympathetic activity. Although there were no statistically significant findings, healthy infants did exhibit a trend toward evidence of withdrawal of parasympathetic activity in response to environmental demands. Activities during data collection included the infant being subjected to a stranger in the home, being measured for weight and length, and participating in a free play activity with the mother.

The withdrawal of parasympathetic activity is an expected phenomenon when the infant is confronted by demands from the environment. Behavioral responsiveness of the infant is dependent upon the availability of metabolic activity. The decrease in parasympathetic activity provides the infant with the necessary metabolic output needed to regulate the behavioral and physiologic processes required to effectively deal with environmental demands (Porges et al., 1996; Fracasso et al., 1994). Behavioral expression of the infant is related to the tone of the parasympathetic branch. In response to environmental demands, the greater the amplitude of phasic changes in parasympathetic activity, the greater the potential for behavioral responses (Porges, 1992). The attenuated variability of the parasympathetic branch limits the infant's flexibility in responding to the environment and may be evidence of a less than optimal physiologic state (Porges, 1992). Infants with FTT may not have the physiologic ability to behaviorally respond appropriately to environmental demands.

The finding that nutritional status in this study was not significantly correlated with the infant's behavior is inconsistent with other findings. Polan et al. (1991) demonstrated that a sub-group of infants with FTT who were both acutely and chronically malnourished exhibited more negative affect than the remainder of the infants with FTT. The differences in this study and the study by Polan et al. (1991) may be related to sample size. Their study comprised 28 infants, of whom 13 had evidence of acute and chronic malnutrition. This study may not have had a large enough sample size to detect true differences. In this sample, of 17 infants with FTT, only 5 had evidence of acute and chronic malnutrition. It is also possible that the lack of support for a relationship between nutritional status and behaviors exhibited by infants with FTT in this study may be explained by the hypothesis that the infant's difficult behavioral characteristics are not strictly the direct result of poor nutrition, but rather are the result of the transactional nature of FTT (Bithoney et al., 1992), of which nutrition is a major component.

One finding that deserves further study is the significant difference in birthweights between the two groups. This finding is consistent with others who have found a significant difference in birthweights between infants with FTT and healthy infants (Abramson, 1991; Mathisen et al., 1989; Valenzuela, 1990; Wilensky et al., 1996; Wolke et al., 1990); however, the relationship between birthweight in full-term infants and the development of FTT has not been explained (Frank, 1985). It may be that birthweight makes these infants biologically vulnerable and at risk for the development of FTT (Wilensky et al., 1996). The lower birthweights found in infants with FTT most likely result in the infant beginning life with compromised nutritional stores (Beattie & Johnson, 1994; Rosenfeld, 1997) that render the infant vulnerable to the lack of growth-fostering support that is characteristic of the environments of infants with FTT.

Several limitations are associated with this study. An important limitation was the sample size. A large effect size was originally predicted to determine the sample size based on findings from previously reported research related to behavioral differences. Because of the small sample size and a lack of a normal distribution among the scores, nonparametric statistics were used. The differences between the groups also were smaller than anticipated. Therefore the present sample size may not have had enough power to detect significant differences. A limitation within the FTT group was the difficulty in getting mothers to maintain a sustained interest in the interaction with their infants. The reaction to being asked to interact with their infants may be indicative of the ongoing problematic dynamics that occur between infants with FTT and their mothers.

## CONCLUSION

Infants with FTT are behaviorally different from infants with age-appropriate growth. These findings have important implications for intervening with infants and mothers. In the assessment and management of infants with FTT, a strong emphasis should be placed on understanding the dynamics of the infant-mother interaction. Assessment of the infant-mother interaction should occur during feeding and nonfeeding situations. Each situation provides different information related to the dynamics of the infant-mother interaction. Following assessment of the infant, the unique behavioral characteristics of the infant can be pointed out to the mother. The mother can then be equipped with strategies to manage her infant's individual behavioral style. The long-term growth outcome of the infant is dependent upon successfully intervening with the infant and mother as a dyad.

The behavioral characteristics of infants with FTT may have a physiologic basis. If individual differences in behavior are present at birth and are physiologically driven, more research is needed to understand the physiologic processes that underlie the behavior of infants with FTT. It may be that the infant who ultimately develops FTT is biologically vulnerable and, coupled with a less than optimal environment, is at risk for FTT. Prospective research is needed in order to understand the infant's contribution to the development of FTT. Future research also should be focused on the dynamics of the infant-mother interaction. Although it is hypothesized to be central to the development of FTT, little is actually known about how the dynamics of the infant-mother interaction results in FTT (Hutcheson, Black, & Starr, 1993).

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