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Effects of Developmental, Health Status, Behavioral, and Environmental Variables on Preterm Infants' Responses to a Gentle Human Touch Intervention

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Abstract: The purpose of this study was to determine whether there was a relationship between preterm infants' physiological and behavioral responses to a gentle human touch (GHT) intervention and selected developmental, health status, behavioral, and environmental variables. The data presented in this paper were from 42 infants who were part of a larger study evaluating effects of a GHT intervention that was provided for 10 minutes, three times daily, to preterm infants, beginning when the infants were 6–9 days old. The sample for the larger study included 84 infants who were between 27–33 weeks gestational age at birth, who had no congenital anomalies, and who were hospitalized in a neonatal intensive care unit (NICU) in the southern United States. The sample for the analysis reported in this paper included the 42 infants from the larger study who were randomly assigned to the GHT as opposed to a control group. The findings suggested that baseline behavioral state and baseline levels of motor activity and behavioral distress were significant predictors of change from baseline to touch intervention on behavioral, behavioral state, and physiologic variables. However, the amount of variation in the dependent variables that was explained by the independent variables was small, ranging from 1.2% to 8.6%. The findings suggest the need for further research to determine additional factors that influence preterm infants' responses to GHT and to other types of tactile stimulation, and that might be used by caregivers in the NICU in order to identify infants who may have problems tolerating supplemental tactile stimulation.

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Resumo: *Efeitos do desenvolvimento, saúde, comportamento e do ambiente na reposta de bebês pretermo ao toque humano suave, como intervenção.* O propósito deste estudo foi estabelecer se existe uma relação entre as respostas fisiológicas e comportamentais após uma intervenção chamada de toque humano suave (GHT) e desta com variáveis selecionadas de desenvolvimento, comportamento, ambiente e status de saúde. Os dados apresentados neste estudo são de 42 crianças que fizeram parte de um outro estudo com uma amostra maior, avaliando os efeitos da intervenção GHT que foi feita por 10 minutos, três vezes ao dia, crianças pretermo, começando quando as crianças tinham 6–9 dias de vida. A amostra maior incluiu 84 crianças entre 27–33 semanas de idade gestacional ao nascer, sem anomalia congenita, e estavam hospitalizadas numa unidade de tratamento intensivo (NICU) no sul dos Estados Unidos. A amostra de 42 crianças a ser analisada neste artigo foi designada aleatoriamente para o grupo GHT e o grupo controle. Os resultados sugeriram que a linha de base do comportamento do estado de consciência, do nível de atividade motora e de comportamento de estresse foram preditores significativos da mudança devido a intervencão tátil no comportamento, estado e fisiologia. Entretanto, a quantidade de variação nas variáveis dependentes que foram explicadas pelas variáveis independentes foi pequena, com um âmbito de 1.2% a 8.6%. Os resultados sugerem a necessidade de estudos adicionais a fim de que se possa determinar outros fatores que influenciam as respostas dos bebês pretermos ao GHT, bem como de outros tipos de estimulação tátil que poderão ser usadas em UTI neonatal, a fim de que os bebês que não toleram estimulação tátil suplementar, possam ser identificados.

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Introduction

Although there is general agreement that touch is important for the optimal development of human infants, there continue to be questions about the types and amounts of touch and tactile stimulation that are appropriate and beneficial for hospitalized preterm infants (Harrison and Bodin 1994). Peters (1998) recently suggested the need to identify "care milestones" in order to identify the point in time when infants demonstrate the ability to maintain behavioral and physiological stability in response to various forms of stimulation. The purpose of this study was to identify the relationship between preterm infants' physiological and behavioral responses to a gentle human touch (GHT) intervention and developmental, health status, behavioral, and environmental variables. Understanding factors that are associated with different patterns of responses to a type of tactile stimulation such as GHT may enable nurses to identify infants who may not be able to tolerate touch, and whose care should be adjusted accordingly. The analyses reported in this paper were part of a larger study evaluating effects of a GHT intervention that was provided for 10 minutes, three times daily, to 42 (experimental group) preterm infants, beginning when the infants were 6–9 days old (Harrison 1999).

A number of studies have demonstrated that physiologically stable preterm infants benefit from supplemental stroking, massage, and kinesthetic stimulation (Adamson-Macedo 1985/1986, 1998; Scafidi, Field, Schanberg, Bauer, Tucci, Robert, Morrow, Kuhn 1990; White-Traut, Goldman 1988). However, findings from other studies suggest that some physiologically fragile preterm infants may have problems tolerating touch that involves stroking or massage (Harrison, Leeper, Yoon 1990; McGehee, Eckerman 1983; Oehler 1985; Oehler, Eckerman, Wilson 1988). Therefore the GHT intervention that was evaluated in the present study involved placing the hands on the infant's head and lower back for 10 minutes without providing stroking or massage.

It was hypothesized in the larger study (Harrison, 1999) that the GHT would provide comfort and reduce stress as evidenced by maintenance of oxygen (O_2) saturation and heart rate (HR) values within normal limits, and reduction of motor activity and behavioral distress signs. Results indicated that there were no significant changes in mean HR levels comparing baseline (B), touch (T), and post-touch (P) phases. Although there was a slight increase in O_2 saturation levels from T to P phases, this increase was not clinically significant. There were significantly lower mean levels of motor activity and behavioral distress during the T and P compared to B phases, confirming the soothing and positive immediate effects of the GHT intervention. Although most infants demonstrated decreased levels of motor activity and behavioral distress during the T compared to the B and P phases, there was considerable variability in the infants' physiological and behavioral responses to the GHT. It was necessary to discontinue the touch prior to the end of the 10-minute intervention period for one or more of the 30 touch sessions for eight of the 42 infants because the infants had abnormal HR or O_2 saturation levels that persisted for 30 seconds during the touch. A total of 19 touch sessions (out of a total of 1260 possible sessions for the 42 infants) had to be discontinued early because of abnormal levels of HR or O_2 saturation (Harrison 1999).

The purpose of the analysis reported in this paper was to identify variables that were related to physiological and behavioral responses to individual GHT sessions and that might be used by nurses and NICU caregivers to predict when infants might have problems tolerating even the minimum stimulation associated with GHT. The physiological and behavioral responses to the GHT that were examined as dependent variables were the changes from the 10-minute B to the 10-minute GHT phase in levels of O_2 saturation, HR, motor activity, behavioral distress, quiet sleep, active sleep, and REM sleep. Independent variables that were evaluated as possible predictors of responses to the GHT included developmental variables (gestational age and birthweight); health status indicators (morbidity score, whether the infant was receiving aminophylline or phototherapy, and HR and O_2 saturation levels during the B phase); behavioral variables (level of motor activity, behavioral distress, and behavioral state during the B phase); and environmental variables (mean level of noise and supplemental oxygen during the B phase).

Materials and Methods

The sample for the larger study consisted of 84 preterm infants (40 females, 44 males; 25 Caucasian and 59 African-American) who were hospitalized in a Level III neonatal intensive care unit (NICU) in the southeast United States. Sample exclusion criteria included maternal history of substance abuse, presence of congenital anomalies, or history of surgery in the neonatal period. Infants were between 27–33 weeks gestational age at birth (mean = 30.7 weeks), with birthweights ranging from 796–1998 grams (mean = 1310 grams), and were randomly assigned to either a GHT or control group. This paper presents data from the 42 infants who were assigned to the GHT group.

The study was approved by the Institutional Review Board of the study hospital and of the university where the authors were employed. A more detailed explanation of the study procedures has been described elsewhere (Harrison 1999), but the main procedures will be summarized here. Infants in the control group received the usual NICU care. In addition to the usual care, infants in the GHT group received 10 minutes of GHT provided three times a day for 10 days, beginning when the infants were 6–9 days of age. The GHT consisted of the nurse placing one hand on the infant's head and the other hand on the infant's lower back, and maintaining this contact for up to 10 minutes without restraining the infant's movements. The infants were in a prone position unless their conditions prevented placing the infant prone. Infants were in prone, supine, and sidelying positions during 92%, 5%, and 3% of the GHT sessions, respectively.

The touch was provided by a research nurse or occupational therapist who had NICU experience. If the infant demonstrated abnormal heart rate (≤ 100 beats per minute [bpm], or ≥ 200 bpm) or O_2 saturation levels less than 90 mg% for more than 30 seconds during the GHT, the touch was discontinued earlier than 10 minutes. It was necessary to discontinue the GHT early for one or more of the 30 sessions provided to 8 of the 42 infants in the GHT group. A total of 19 of the 1260 possible GHT sessions had to be discontinued early because of adverse HR or O_2 saturation responses during the GHT intervention. Data on heart rate and O_2 saturation levels were collected on a portable computer that was mounted on a cart and rolled to the infants' bedsides. The computer was interfaced with a Nellcor pulse oximeter, a Corometric cardiac monitor, and a Panasonic portable video camera, using the data collection system that has been described elsewhere (Harrison 1999). Baseline data on HR and O_2 saturation levels were recorded every 5 seconds during a 10-minute B phase, during the GHT intervention, and during a 10-minute P phase. The researcher observed and recorded motor activity and behavioral distress during the three phases using a time-sampling observational procedure. Data on a variety of morbidity and developmental indices were recorded throughout the infants' hospital stay based on review of the infants' hospital records.

Reliability of the heart rate data was assessed prior to each data collection period by ensuring that there was an adequate electrocardiograph tracing on the Corometric monitor, and by ensuring that there was no more than a 5 bpm difference between the pulse rates recorded on the Corometric monitor and Nellcor pulse oximeter. In order to minimize errors in O_2 saturation due to motion artifact, a computer program was written to detect instances during the data collection period in which the heart rates on the two monitors differed by more than 5 bpm. O_2 saturation values collected when the two heart rate values differed by more than 5 bpm were replaced with the most recent valid measurements.

It was recognized that infant responses to stimuli such as touch might be influenced by the presence of other environmental stimuli. Therefore, measures of the noise level in the NICU were collected every 5 seconds throughout the B, T, and P phases with a Quest noise meter that was placed next to the infant's head. To later assess the influence of supplemental oxygen on the infant's responses to

GHT, average measures of the concentration of oxygen (21% to 100%) that the infant was breathing during the B, T, and P phases were also recorded.

Activity levels, behavioral signs of distress, and behavioral state were coded using a modification of the categories described previously (Scafidi, Field, Schanberg, Bauer, Tucci, Robert, Morrow, Kuhn 1990). The percentage of intervals during the B, T, or P phases during which the following motor activities occurred were summed to calculate an overall motor activity score for that phase: single limb, multiple limb, gross body, and head movement, and startle. The percentage of intervals during which the following behavioral distress signs occurred were summed to provide an overall measure of behavioral distress: mouthing, yawning, facial grimace, tremor, sneeze, hiccough, and clenched fist. A modified behavioral distress score was computed by summing the percentage of intervals with all of the above behaviors except mouthing, since mouthing may not be an indicator of distress. Periods during which infants demonstrated no motor activity or behavioral distress were coded as "no movement."

Behavioral states were coded using definitions similar to those previously used by Scafidi, Field, Schanberg, Bauer, Tucci, Robert, Morrow and Kuhn (1990) and included quiet sleep, active sleep, REM sleep (active or quiet sleep), drowsy, inactive alert, active alert, and fuss/cry. Table 1 includes the definitions that were used for each of these behavioral state categories. The researcher recorded the behavior state that comprised the majority of the 15-second observational interval, in the event that more than one state occurred during a given interval. Interrater reliability on all behavioral measures averaged 96% throughout the study.

Morbidity status was assessed using a revision of the Neonatal Morbidity Scale (NMS) (Minde, Whitelaw, Brown, Fitzhardinge, 1983). Content validity of this revised scale has been reported previously (Harrison, Leeper and Yoon 1990). An NMS score was calculated daily for each infant based on review of the infant's hospital record. Interrater reliability on this scale averaged 90% throughout the study. During the daily review of the infant's hospital record, data were also collected to indicate whether the infant was receiving aminophylline, or whether the infant was under phototherapy.

Data Analysis

Separate regression analyses were run for the level of change (T minus B values) for the following nine dependent variables: quiet sleep, REM sleep, active sleep, motor activity, behavioral distress, modified behavioral distress, no movement, heart rate, and O_2 saturation. A positive coefficient indicated that higher levels of the independent variable were associated with increases in the dependent variable from B to T phases. A negative coefficient indicated that higher levels of the independent variable were associated with decreases in the dependent variable from the B to T phases. For example, the coefficient predicting change in level of motor activity from B to T phases for the independent variable of "baseline level of no movement" was .49. This positive coefficient suggests that increased levels of "no movement" during the baseline phase were associated with an increase in motor activity from the B to T phase.

The independent variables included in the nine regression analyses can be categorized as to frequency of measurement. Gestational age and birth weight were

Table 1. Definitions of Behavioral State Variables

Behavioral State	Check only if infant has been in the state for the majority of the 15 second interval
Quiet Non-REM Sleep (State 1)	The infant's eyes are closed and still. There is little or no motor activity except for an occasional startle, limb movement or nonrhythmic mouthing. Breathing should be smooth and regular (but not deep gasping respiration). If breathing is a deep gasp or irregular, score state 2 or 3. Also, if there is continuous movement or continuous rhythmic mouthing, code as active sleep.
Active sleep w/o REM (State 2)	The infant's eyes are closed and still. Motor activity is noted throughout most of the interval or deep gasping, irregular respirations are present.
REM Sleep (State 3)	The infant's eyes are closed (although they may open briefly). Darting or rolling of the eyes can be detected through closed or open eyelids. Motor activity may or may not be present. Generally eyebrow movements in this state are part of REM sleep and are not coded as grimace.
Drowsy (State 4)	The infant's eyes may be opening and closing *or* may be opened but have a dull, glazed appearance and are not darting or rolling. There is little or no motor activity except for an occasional startle, single limb movement or mouthing.
Alert Inactive (State 5)	The infant's eyes are wide open and bright. The infant is relatively inactive although slight movements may occur in conjunction with looking/tracking behaviors.
Awake Active (State 6)	The infant's eyes are open but are not bright, and are not darting or rolling. Motor activity is present for the major part of the interval.
Fussing/Crying (State 7)	Fussing sounds or negative vocalization is present. Body movement may or may not be present.

variables that were constant across all sessions. Morbidity score, whether receiving phototherapy, and whether receiving aminophylline were variables that changed each day but were constant across the three sessions during that day. Levels of motor activity, behavioral distress, modified behavioral distress, quiet sleep, active sleep, REM sleep, no movement, O_2 saturation, heart rate, noise and oxygen concentration changed during each session.

Maximum likelihood (ML) estimation was used because it retains most cases with partially missing data rather than employing listwise deletion. Another advantage of the ML analysis is that it allows a variety of error structures, including compound symmetry (CS) and autoregressive order 1 (AR1) structures. Compound symmetry assumes that correlations among all occasions are equal. Because it was plausible that correlations among the residuals from the 30 sessions for each infant were not equal, but rather that occasions nearer in time would exhibit higher positive correlations among residuals, separate regression analyses were run using CS and AR1 error structures for each of the nine dependent variables. In general, the conclusions from the analyses using CS and AR1 error structures were similar, and thus the data presented here are those from the analyses using the less restrictive AR1 error structure. The results from each of the regression analyses were examined to determine the percentage of standardized residual values that had values greater than 2, to verify that the assumption of normality was met. The percentage of standardized residual values greater than 2 ranged from 2 to 6% across the nine separate regression analyses. (A perfect normal curve has 5% of values outside of the $\pm$ 1.96 standard deviation range). Standardized Beta Coefficients were computed for all independent variables using the following formula: $Beta_k = B_k \times SD$ (dependent variable)/SD (independent variable) values of the maximum likelihood R^2 values were computed using the formula $R^2 = 1 - L_1/L_0$, where L_1 is the maximum REML log likelihood from the regression analysis, and L0 is the maximum REML log likelihood for the null model (Judge et al. 1985, p. 767).

Results

Tables 2, 3, and 4 illustrate the significant predictor variables and the Maximum Likelihood R^2 values for the nine regression analyses. Two-sided probability values of $p < .05$ were considered significant. The findings for each of the nine analyses are discussed separately. Table 2 presents findings related to the behavioral state dependent variables; Table 3 presents findings related to the motor activity and behavioral distress dependent variables, and Table 4 presents findings related to the heart rate and oxygen saturation dependent variables.

Change in Levels of Quiet Sleep

Five independent variables were significant predictors of change in level of quiet sleep from the B to T phase: baseline levels of behavioral distress and modified behavioral distress, active sleep, REM sleep, no movement, and baseline mean heart rate (see Table 2). The strongest predictors were levels of REM sleep and levels of no movement during baseline, with standardized coefficient values of 0.49 and −0.38, respectively. Increases in levels of quiet sleep from B to T phases were associated with higher baseline levels of REM sleep, active sleep, and behavioral distress. Higher baseline levels of no movement and HR were associated with decreased levels of quiet sleep during GHT. These variables accounted for 8% of the variance in the change in percentage of quiet sleep from B to T phases.

Changes in Levels of REM Sleep

Nine independent variables were significant predictors of change in levels of REM sleep from B to T phases (see Table 2). Baseline levels of quiet sleep, no movement, motor activity, and behavioral distress demonstrated the highest predictive power (standardized coefficients of 0.73, 0.36, 0.35, and 0.31, respectively). Increases in levels of REM sleep from B to T phases were associated with higher baseline levels of quiet sleep, no movement, motor activity, behavioral distress, heart rate, active sleep, and oxygen concentration. Decreased levels of REM sleep during touch were associated with higher baseline levels of modified behavioral

Table 2. Summary of standard coefficients of significant predictor variables in regression analyses for behavioral state variables

Significant Predictors	Quiet sleep	REM sleep	Active sleep
Developmental variables			
Gestational age			
Birthweight			
Health status variables			
Morbidity Score		–.11	
Whether receiving phototherapy			
Whether receiving aminophylline			
Mean oxygen saturation level during baseline			
Mean heart rate during baseline	–.09	.15	
Behavioral variables			
Level of motor activity during baseline		.35	
Level of behavioral distress during baseline	.19	.31	
Level of modified behavioral distress baseline		–.11	
Level of quiet sleep during baseline		.73	.62
Level of active sleep during baseline	.10	.14	
Level of REM sleep during baseline	.49		.79
Level of no movement during baseline	–.38	.36	
Environmental variables			
Mean noise rate during baseline			
Mean oxygen concentration level during baseline			
Maximum likelihood R^2	.083	.085	.068

(1) All Standardized coefficients listed in this table were significant at $p = .05$.
(2) Every regression exhibited an overall level of fit that was highly significant ($p < .0001$) as determined by a likelihood ration test ($-2 \times$ log likelihood).

distress and with higher daily morbidity scores. These variables accounted for 8% of the variance in change of levels of REM sleep from B to T.

Changes in Levels of Active Sleep

Two independent variables were significant predictors of change in levels of active sleep from B to T (see Table 2): baseline levels of REM sleep (standardized coefficient = 0.79), and baseline levels of quiet sleep (standardized coefficient = 0.62). Increases in levels of active sleep were associated with higher baseline levels of REM and quiet sleep. These two variables accounted for 6.8% of the variance in the change in levels of active sleep.

Changes in Levels of Motor Activity

Five variables were significant predictors of change in levels of motor activity from B to T phases (see Table 3). The two variables with the highest predictive power were baseline levels of no movement and REM sleep, with standardized coefficients of 0.49, and 0.35, respectively. Increases in levels of motor activity from B to T were associated with higher baseline levels of no movement, REM sleep, quiet

Table 3. Summary of standardized coefficients of significant predictor variables in regression analyses for motor activity and behavioral distress dependent variables

Significant predictors	Motor activity	Behavioral distress	Modified behavioral distress	No movement
Developmental variables				
Gestational age				.09
Birthweight				
Health status variables				
Morbidity Score	.08			
Whether receiving phototherapy				
Whether Receiving Aminophylline				
Mean oxygen saturation level during baseline		–.07		
Mean heart rate during baseline		.12		–.13
Behavioral variables				
Level of motor activity during baseline				.28
Level of behavioral distress during baseline			–.66	
Level of modified behavioral distress baseline		–.4		
Level of quiet sleep during baseline	.12		–.16	
Level of active sleep during baseline	–.06		–.20	
Level of REM sleep during baseline	.35			
Level of no movement during baseline	.49	.37		
Environmental variables				
Mean noise level during baseline				.11
Mean oxygen concentration level during baseline				
Maximum likelihood R^2	.083	.082	.086	.065

(1) All Standardized coefficients listed in this table were significant at $p = .05$.
(2) Every regression exhibited an overall level of fit that was highly significant ($p < .0001$) as determined by a likelihood ration test ($-2 \times \log$ likelihood).

sleep, and higher daily morbidity scores. Decreased levels of motor activity during touch were associated with higher baseline levels of active sleep. These variables accounted for 8% of the variance in the dependent variable.

Changes in Levels of Behavioral Distress

Four independent variables were significant predictors of changes in levels of behavioral distress from B to T phases (see Table 3). The largest predictive power resided in B levels of modified behavioral distress and of no movement (standardized coefficients of −0.40 and 0.37, respectively). Increases in levels of behavioral distress from baseline to touch were associated with higher B levels of no movement and mean HR. Decreased levels of behavioral distress during GHT were associated with higher B levels of modified behavioral distress and O_2 saturation. These variables accounted for 8% of the variance of the independent variable.

Changes in Levels of Modified Behavioral Distress

Three independent variables were significant predictors of change in levels of modified behavioral distress from B to T (see Table 3). The most significant predictor was the baseline level of behavioral distress (standardized coefficient = −.66). Decreases in levels of modified behavioral distress from B to T were associated with higher B levels of behavioral distress, active sleep, and quiet sleep, accounting for 8% of the variance in the dependent variable.

Changes in Levels of No Movement

Five independent variables were significant predictors of change in levels of no movement from B to T (see Table 3). The most significant predictor was B levels of motor activity (standardized coefficient = 0.28). Increases in levels of no movement from B to T were associated with higher baseline levels of motor activity, active sleep, and noise levels, and with higher gestational age. Decreased levels of no movement during GHT were associated with higher B mean HR. These variables accounted for 6.5% of the variance in the dependent variable.

Changes in Levels of Heart Rate

Six independent variables were significant predictors of change in levels of heart rate from B to T (see Table 4). The most significant predictor was the B level of quiet B levels of quiet sleep, REM sleep, and with higher gestational age. Decreased levels of HR during GHT were associated with higher baseline levels of motor activity and behavioral distress, and with higher birth weight. These variables accounted for 1.2% of the variance in the dependent variable.

Changes in Levels of O_2 Saturation

Only one independent variable was a significant predictor of change in levels of O_2 saturation from B to T (see Table 4). Higher levels of B motor activity were associated with increases in levels of O_2 saturation from B to T (standardized coefficient = 0.16). However, the R^2 value for this analysis was nearly 0.

Discussion

The findings from the regression analyses suggest that baseline behavioral state and baseline levels of motor activity, no movement, and behavioral distress were the most significant predictors of change from B to T phases on the nine dependent variables that were examined, although the amount of variation in the dependent variables that was explained by the independent variables in the analyses was small, ranging from 1.2% to 8.6%. Increased levels of baseline motor activity were associated with B to T increases in levels of REM sleep, no movement, and O_2 saturation and with decreases in HR. These findings suggest that the GHT was particularly soothing to infants who were more active during the baseline period.

Table 4. Summary of standardized coefficients of significant predictor variables in regression analyses for heart rate and O_2 saturation dependent variables

Significant predictors	Heart rate	O_2 saturation
Developmental variables		
Gestational age	–.06	
Birthweight	.06	
Health status variables		
Morbidity Score		
Whether receiving phototherapy		
Whether Receiving Aminophylline		
Mean oxygen saturation level during baseline		
Mean heart rate during baseline		
Behavioral variables		
Level of motor activity during baseline	–.09	.16
Level of behavioral distress during baseline	–.08	
Level of modified behavioral distress baseline		
Level of quiet sleep during baseline	1.14	
Level of active sleep during baseline		
Level of REM sleep during baseline	.11	
Level of no movement during baseline		
Environmental variables		
Mean noise level during baseline		
Mean oxygen concentration level during baseline		
Maximum likelihood R^2	.012	0

(1) All Standardized coefficients listed in this table were significant at $p = .05$.
(2) Every regression exhibited an overall level of fit that was highly significant ($p < .0001$) as determined by a likelihood ration test ($-2 \times \log$ likelihood).

Higher baseline levels of behavioral distress were associated with B to T increases in levels of quiet sleep and REM sleep, and with decreases in levels of modified behavioral distress and HR. This finding suggests that the GHT intervention was particularly soothing to infants who were more distressed during the baseline period.

Higher baseline levels of active sleep were associated with B to T increases in quiet and REM sleep, and decreases in levels of motor activity and modified behavioral distress, again suggesting that the GHT was particularly soothing to infants who were more active during baseline.

Higher baseline HR levels were associated with B to T increases in REM sleep and motor activity, and with decreased levels of quiet sleep and no movement. This finding is contrary to the findings from some of the other regression analyses that suggested that infants who were more active during baseline (as evidenced by higher levels of motor activity, behavioral distress, and active sleep) were more soothed by the GHT as evidenced by decreases in levels of motor activity and behavioral distress. This finding suggests that different physiological and behavioral variables may have unique effects on infant responses to stimulation such as GHT.

Higher baseline levels of quiet sleep were associated with B to T increases in levels of REM sleep, active sleep, motor activity, and heart rate, and with decreases in levels of modified behavioral distress. These findings suggest that providing GHT to infants who were already in a state of quiet sleep may have aroused the infants, resulting in higher activity levels. This arousal was not associated, however, with increased levels of behavioral distress. In fact, increased levels of quiet sleep during baseline were associated with decreases in the level of modified behavioral distress during GHT.

Higher baseline levels of no movement were associated with B to T increases in REM sleep, motor activity, and behavioral distress, and with decreases in the levels of quiet sleep. This finding again suggests that infants who were in a quiet state during baseline tended to become more aroused and distressed during the GHT than did infants who were more active during baseline.

Contrary to expectations, infant gestational age predicted B to T change in only two dependent variables (no movement and heart rate). Higher gestational age was associated with increased levels of no movement, and with decreased levels of HR from B to T. This finding suggests that older infants were soothed by the GHT intervention more than were younger infants. Birth weight only predicted change in HR, although the change was in the direction opposite to that predicted by gestational age. Higher birth weight was associated with increased levels of HR during touch. The reason for the different direction of the relationship between gestational age and birth weight with heart rate changes from B to T is not clear.

Also surprising was the finding that daily morbidity score predicted changes in only two of the nine dependent variables (REM sleep and motor activity levels). Higher morbidity scores were associated with a decrease in level of REM sleep, and with increased levels of motor activity from B to T. This finding suggests that the sicker infants tended to become more agitated during GHT.

Baseline noise levels predicted only one dependent variable (change in levels of no movement). Higher noise levels during baseline were associated with a greater increase in periods of no movement during touch, suggesting that infants were particularly soothed when the environment was noisy during baseline.

In general, the findings suggest that the soothing effects of GHT noted in the larger study (Harrison 1999) and in previous studies (Harrison, Olivet, Cunningham, Bodin, Hicks 1996; Modrcin-McCarthy 1992; Tribotti 1990) may be more pronounced when infants are initially in a more aroused state, as evidenced by increased levels of motor activity, behavioral distress, active sleep, and heart rate. In contrast, when infants are in a state of quiet sleep, or have low levels of motor activity, providing a GHT intervention may result in arousal as evidenced by increased levels of REM and active sleep, increased motor activity, increased heart rate, and increased levels of behavioral distress.

The finding that gestational age, birthweight, and morbidity status predicted relatively few B to T changes in the dependent variables that were examined suggests that responses to a GHT intervention are more influenced by physiological and behavioral variables at the moment when the intervention is provided, than by general demographic characteristics or morbidity level. This finding supports the importance of continuous individualized assessment of preterm infants' responses to specific environmental stimuli.

The amount of variance in the dependent variables explained by the independent variables that were examined in this study was only 1.2% to 8.6%, suggesting the need for further research to determine other variables that are related to preterm infants' responses GHT and to other types of tactile stimuli. The results of these studies can help nurses and other NICU caregivers predict when infants may have problems tolerating supplemental stimulation such as GHT.

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