Assessment of Mothers' Shaking Behavior of their Babies and Related Factors: An Experimental Approach Using an Accelerometer and an Infant Manikin

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ABSTRACT

Background: Our study aimed to investigate the factors associated with mothers' shaking behavior of their babies.

Methods: Sixty-three mothers who stated that they shook their babies (Group B) and 91 mothers who stated that they did not (Group A) among those who applied to or were followed up from the Pediatric Outpatient Clinics of our University Hospital were included. The mothers (with a baby aged 0-30 months) completed the Brief Symptom Inventory (BSI) and psychiatric rating scales measuring attachment styles, empathic tendency, perceived social support, and self-esteem. The severity of the simulated shaking of the mothers was measured by an accelerometer placed on an infant manikin and separately scored on a Numerical Rating Scale by the researchers and an Illustrated Numeric Rating Scale by the mothers.

Results: In group B, babies' crying frequency was higher (*P* = .008); soothing the babies when they cried was more difficult (*P* = .019), mothers reported that they were exposed to physical violence more in their childhood (*P* = .003), BSI hostility scores (*P* = .004) and BSI-anxiety scores (*P* = .034) of the mothers were higher when compared with the group A. The age of the babies (*P* = .002, OR = 1.096), moderate crying frequency (*P* = .035, OR = 2.900), the mothers' difficulty in soothing their babies (sometimes *P* = .018, OR = 3.705, often/always *P* = .014, OR = 7.777), and the mothers' experience of physical violence in childhood (*P* = .002, OR = 5.674) were found to be factors affecting the shaking behavior.

Conclusion: Clarifying the factors associated with the mothers' shaking behavior of their babies would be helpful in terms of protecting future generations.

INTRODUCTION

Shaken baby syndrome (SBS) is a severe form of child abuse that may lead to death and severe brain damage.[1,2] As cited by Miehl,[3] SBS was first defined in 1946 by Dr. John Caffey, a pediatric radiologist. With the term "whiplash shaken baby syndrome," in his 1974 article, Dr. Caffey described the collection of infantile subdural and subarachnoid hemorrhage, traction-type metaphyseal fractures, and retinal hemorrhage within this syndrome. Shaken baby syndrome is accepted as a subset of Abusive Head Trauma (AHT) diagnosis.[4] A range of traumatic forces, such as blunt force trauma, acceleration/deceleration (inertial) forces, penetrating trauma, and asphyxiation, lead to neural damage in SBS.[2]

This syndrome is mainly encountered in children between 0 and 2 years but may affect children up to 5 years.[1] The incidence of AHT in children under 1 year old between 2000 and 2009 was 33.4-38.8 per 100,000 annually in the USA.[5] Approximately one-fourth of children with AHT under 2 years die.[5] Abusive head trauma is often associated with significant rotational acceleration-deceleration force through violent shaking.[6] Subdural and/or subarachnoid hemorrhages, various neurologic signs and symptoms, retinal hemorrhages, upper cervical spine injuries, and skeletal injuries are the results of SBS.[2] Prolonged unsoothable crying may evoke frustration and anger in the caregiver and lead

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to shaking behavior and abuse toward the infant.[7] Mortality rates due to SBS were between 13% and 26%[8-10] and rates for neurological abnormality were 74% in a literature review by Barlow et al[11] (2004) which included 489 cases; moderate-to-significant disability was 2-100%.[8,9,12]

Early detection of AHT is essential to prevent severe disability and death.[13] The signs and symptoms of SBS include irritability, changes in sleep or feeding patterns, vomiting, paleness, pain, poor contact, decrease in the child's capabilities, inability to suck or swallow, interrupted breathing, symptoms of a viral illness, severe malaise, scalp swelling, bruising, impaired vigilance (extending to coma), severe apnoea, bradycardia, cardiac arrest, convulsions, fixed upward gaze, signs suggesting acute intracranial hypertension and tentorial herniation, and death.[14-17] Long-term consequences of SBS are developmental delay, learning disabilities, physical disabilities, seizures, paralysis, communication deficits, visual deficits, blindness, hearing impairment, behavioral disorders, cognitive impairment, and death.[14,15,18] As cited by Miehl,[3] according to Becker et al (2002), long-term impairment of SBS can also manifest itself as Alzheimer's disease, Parkinson's disease, dementia pugilistica, and post-traumatic dementia.

Risk factors related to the child for AHT include infantile colic and inconsolable crying, being under the age of one, being one of multiple births, prematurity, and disability of the child. Risk factors related to the parent/caregiver include being a single parent, young parental age, lack of support, frustration intolerance, lack of experience with childcare, low education level, domestic violence, caregiver's criminal history, prior child protective services involvement, untreated mental disorder, substance use disorder, unrealistic expectations, attachment problems, and having been abused or neglected in childhood. Risks at the community level are isolation, poverty, and insufficient recreational facilities.[3,6,17,19-21] These factors increase the risk of child physical abuse.

As aforementioned, acceleration/deceleration forces are 2 factors related to neural damage in SBS.[2] Accelerometers are used to provide an objective evaluation of movement. Accelerometers assess the accelerations of an object's motion throughout specified reference axes.[22] Free fall

from 3 feet (approximately 1 m) produces a velocity of 4.09 m/s and normalized impact energy of 0.85 Nm/N; shaking at 11-15.5 km/h produces a velocity of 4.31 m/s and normalized impact energy of 0.95 Nm/N[23] (impact energy corresponds to the kinetic energy of a striking object at the moment of impact).[24] Since these acceleration and velocity levels/numbers are very close to a free fall from 1 m, it is obvious that an infant's neck cannot withstand these acceleration and velocity levels without injury.[23] Adding an objective measurement tool, such as an accelerometer, to research related to simulated baby shaking is essential in attracting the attention of multidisciplinary fields, which may contribute in various ways to the subject.

In this study, we aimed to investigate the factors related to mothers' shaking behavior of their babies. We hypothesized that mothers who stated that they shake their babies would be more likely to have babies with a poor sleeping pattern and/or frequent crying episodes, would have difficulty in soothing their babies while they are crying, would be more likely to be exposed to physical violence in their childhood, would be more likely to have low self-esteem, an insecure attachment profile, low empathic tendency, more psychiatric symptoms, would perceive their social support as inadequate when compared with mothers who stated that they do not shake their babies. For the mothers who stated that they shake their babies, the accelerometer peak resultant values would be correlated with the scores of the Illustrated Numeric Rating Scale (INRS) and Numerical Rating Scale (NRS).

MATERIAL AND METHODS

Participants

The literate mothers with babies aged between 0 months and 30 months, who applied to or were followed up by the pediatric outpatient clinics of Marmara University Pendik Training and Research Hospital, stated that they shook their babies to soothe them when they cried and volunteered to participate in the present study were included. The age-matched mothers who stated that they did not shake their babies constituted the control group. Both groups of mothers were recruited as consecutive referrals from our University Hospital's pediatric outpatient clinics. Mothers who were illiterate and had difficulties with comprehension were excluded from this study. This study was conducted after the approval of Marmara University Research Ethics Review Committee (date: December 06, 2013; protocol code: 09.2013.0347). Written informed consent was provided by the mothers.

The participants were divided into 2 groups. Group A included mothers who stated that they did not shake their babies; mothers who stated that they shook their babies were in group B.

MAIN POINTS

- In the group of mothers who reported that they shook their babies, the babies had poorer sleep patterns; babies' crying frequency was higher; soothing the babies when they cried was more difficult and the mothers reported being exposed to physical violence more often in their childhood.
- Brief Symptom Inventory—hostility and anxiety scores of mothers who shook their babies were higher.
- The mothers' difficulty in soothing their babies and the mothers' experience of physical violence in childhood were found to be the most important factors affecting the shaking behavior of the mothers.

Research Design

This research was conducted in the Pediatric Outpatient Clinics of Marmara University Pendik Training and Research Hospital. Mothers who volunteered to participate were included in this study. The mothers completed the psychiatric rating scales. Afterwards, the mother and the researcher completed related parts of the sociodemographic questionnaire, respectively.

As the mother was being inquired about the crying frequency of the baby and difficulties regarding soothing the baby, she was asked whether she had ever shaken her baby, as shown by the researcher. Mothers who admitted shaking their babies were further requested to demonstrate the intensity of a maximum shake using the infant manikin. The accelerometer recorded the acceleration generated by this movement. Meanwhile, the observed shaking intensity of the mother was noted on the researchers' Numerical Rating Scale (NRS) by the researchers. Finally, the mothers were asked to score their shaking intensity on the mothers' Illustrated Numeric Rating Scale (INRS). Afterwards, each mother was informed about the health risks of shaking a baby. None of the mothers reported any history of head trauma.

We encountered a similar experimental approach that employed simulated shaking as a method by Yamazaki et al[25] (2014) which investigated several modes of violent shaking by volunteers who imitate perpetrators using a dummy doll with an eyeball model that can lead to retinal hemorrhages observed in SBS.

Data Collection Tools

Sociodemographic questionnaire (SQ): The researchers composed the SQ for this study. The relevant parts of the SQ were filled in separately by the mother and the researcher.

Adult Attachment Style Questionnaire (AASQ): AASQ consists of 2 parts. The first part, developed by Hazan and Shaver[26] (1987), has 3 statements that are used to classify the attachment style of the participant as secure, anxious/ambivalent, or avoidant. These statements contain definitions of the characteristics of the relationship with the parents in childhood and the general behavioral characteristics of the participant. The second part of the scale, developed by Mikulincer et al[27] (1990), consists of 15 items, each of which is scored between 1 and 7. Each attachment style is represented by 5 items, and the highest score determines the attachment style of the individual who completed the scale. In Mikulincer et al's[27] (1990) study, Cronbach' alpha coefficients for each factor, on which secure, avoidant, and ambivalent items were loaded, ranged from 0.79 to 0.83. In Sabuncuoğlu and Berkem's[28] study (2006), in which AASQ was used, the internal consistency of the second part of the scale was found to be acceptable for avoidant and anxious/ambivalent attachment (Cronbach's α = 0.61 and 0.66, respectively), while it was found to be poor for secure attachment (Cronbach's α = 0.42). The validity and reliability study of the Turkish version of the scale was performed by Kesebir et al[29] (2012), during which the authors made some changes to increase the reliability of the Turkish version of the scale. For the second part of the scale, the items that were thought to be incomprehensible were divided, and the number of items increased from 15 to 18. Participants were asked to answer the items of the second part as "true" or "false." In Kesebir et al's[29] study (2012), Cronbach's alpha coefficients for secure, avoidant, and anxious/ambivalent attachment were 0.72, 0.82, and 0.85, respectively. In our study, Cronbach's alpha coefficients for secure, avoidant, and anxious/ambivalent attachment were 0.55, 0.51, and 0.53, respectively.

Empathic Tendency Scale (ETS): ETS was developed by Dökmen[30] (1988) to measure the empathic tendency of the participants. It is a 20-item 5-point Likert type scale. Reported test-retest reliability was 0.82.[30] High scores indicate high levels of empathic tendency. ETS was used to measure the empathic tendency of the mothers. In Dökmen's[30] study (1988) study, ETS was administered to a group of 70 students twice with a 3-week interval, and a correlation of $r = 0.82$ was found between the scores obtained from these 2 applications. In our study, Cronbach's alpha coefficient was found to be 0.58.

Brief Symptom Inventory (BSI): The BSI was developed by Derogatis[31] (1992). It is a 53-item self-report scale used to evaluate psychopathological and psychological symptoms. The BSI is a 5-point Likert scale with 9 subscales (somatization, obsession-compulsion, interpersonal sensitivity, depression, anxiety, hostility, phobic anxiety, paranoid ideation, and psychoticism) and 3 global indices as it is the short form of SCL-90.[31] These indices are the Global Severity Index (GSI), the Positive Symptom Distress Index, and the Positive Symptom Total. Higher scores indicate greater psychological distress. Derogatis[31] (1992) reported that the internal consistency coefficients for the 9 subscales of the BSI ranged between 0.71 and 0.85. The validity and reliability study of the Turkish version of the scale was performed by Şahin and Durak.[31] In Şahin and Durak's[32] study (1994), the Cronbach's alpha coefficient obtained from the entire BSI was found to be 0.95. The reliability coefficients obtained from the original 9 subscales of the scale were as follows: Obsessive-Compulsive, α = 0.69; Paranoid Thoughts, α = 0.72; Hostility, α = 0.74; Phobic Anxiety, α = 0.63; Psychoticism, α = 0.55; Somatization, α = 0.82; Interpersonal Sensitivity, α = 0.69; Depression, α = 0.82; Anxiety, α = 0.82; Additional Items, α = 0.63.[31] In our study, the Cronbach's alpha coefficient retrieved from the entire BSI was 0.95. The Cronbach's alpha coefficients retrieved from the original 9 subscales were: Obsessive-Compulsive, α = 0.72; Paranoid

Thoughts, α = 0.70; Hostility, $\alpha=0.66$; Phobic Anxiety, $\alpha=0.62$; Psychoticism, $\alpha=0.59$; Somatization, $\alpha=0.79$; Interpersonal Sensitivity, $\alpha=0.64$; Depression, $\alpha=0.78$; Anxiety, $\alpha=0.82$; Additional Items, $\alpha=0.50$.

The Multidimensional Scale of Perceived Social Support (MSPSS) is a 12-item self-report scale used to evaluate social support given by a significant other, family, and friends. It was developed by Zimet et al[33] (1988) and is a 7-point Likert-type scale. Higher scores reflect higher perceived social support. In Zimet et al's[33] study (1988), the Cronbach's alpha coefficients for the significant other, family, and friends subscales, and the entire scale were 0.91, 0.87, 0.85, and 0.88, respectively. A validity and reliability study of the Turkish version of the scale was conducted by Eker and Arkar.[33] In Eker and Arkar's[34] study (1995), the Cronbach's alpha coefficients of the whole scale for the normal group (randomly selected patient visitors) and the psychiatry clinic patient group (half inpatient and half outpatient) were 0.87 and 0.88, respectively. The alpha coefficients for the significant other subscale were 0.89 for both groups, while the alpha coefficients for the family subscale were 0.83 for both groups. The alpha coefficients for the friends subscale were 0.90 and 0.86, respectively. In our study, Cronbach's alpha coefficients for the entire scale and the significant other, family, and friends subscales were found to be 0.89, 0.86, 0.85, and 0.87, respectively.

Rosenberg Self-Esteem Scale (RSES): RSES was developed by Rosenberg[35] (1965). It is a self-report scale used to measure self-esteem. It has 10 items and is scored on a 4-point Likert scale. Higher scores indicate low self-esteem. The RSES's reproducibility was found to be 0.92 and scalability was found to be 0.72 by Rosenberg.[35] A validity and reliability study of the Turkish version of the scale was carried out by Çuhadaroğlu.[36] In Çuhadaroğlu's[36] study (1986), the test-retest reliability method was used, and the reliability coefficient of RSES was found to be

0.75. In our study, Cronbach's alpha coefficient of RSES was found to be 0.66.

Numerical Rating Scale (NRS) and Illustrated Numeric Rating Scale (INRS): The NRS is a 0-10 scale completed by the researcher after the mother made a shaking simulation with the infant CPR manikin. The NRS was located in the researcher's part of the sociodemographic questionnaire. Higher scores indicate more severe shaking.

The illustrated numeric rating scale (INRS) (Figure 1) was designed by the authors for this study. The baby's head movement pictures were located above a 0-10 NRS at points 0, 2, 4, 6, 8, and 10 on the scale. It has been enriched with pictures describing the baby's back-and-forth head movements with increasing intensity so that mothers can accurately mark the severity of their shaking. Point 0 is "no shaking," 5 is "moderate shaking," and 10 is "most severe shaking." After the shaking simulation with the infant CPR manikin, the INRS completed by the mother to rate her own shaking intensity.

Accelerometer: Accelerometer measures the instantaneous acceleration applied to an object. In our study, Node modular wireless sensor (Variable Inc.), a 3-axis accelerometer fixed to the chest of the infant CPR manikin, was used to measure the mothers' shaking intensity of their babies. Since the neck of the infant CPR manikin was not flexible enough, we placed the accelerometer on the chest instead of the head. The data obtained during the shaking movement was saved via Bluetooth to the Node-specific application on the iOS operating system. The peak (maximum) resultant acceleration vector value is calculated by the formula $R = \sqrt{x^2 + y^2 + z^2}$. The accelerometer peak resultant value for each mother was used as a variable in the analysis.

Infant CPR manikin: The infant (6-month-old) CPR manikin provided by the Clinical Skills Laboratory of our Faculty was used in the shaking simulation. As previously
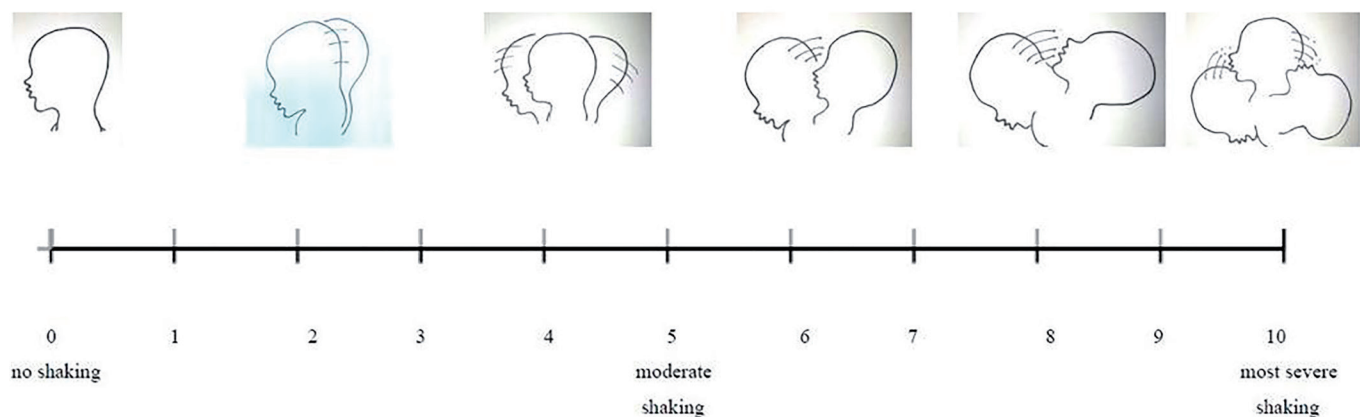

ILLUSTRATED NUMERIC RATING SCALE

Figure 1. Illustrated numeric rating scale.

explained, a 3-axis wireless accelerometer was preferred to be placed on the chest of the infant CPR manikin.

Statistical Analysis

IBM SPSS Statistics 27 (IBM SPSS Statistics for Windows, Version 27.0. Armonk, NY: IBM Corp) software was used for statistical analysis; PASS 2011 (NCSS Corp. Released 2011. Power Analysis and Sample Size for Windows, Version 11.0. (Utah, USA) software was used for power analysis. Reliability analyses of psychiatric rating scales were evaluated with Cronbach's alpha coefficient. The Kolmogorov-Smirnov test was used to determine the normality of the data distribution. Descriptive analyses were performed to reveal the characteristics of the study sample. Continuous variables are expressed as mean ± SD or median (IQR) according to the normality of the distribution, and categorical data are expressed as n (%). Independent samples t-test was used to compare normally distributed continuous variables; Mann–Whitney U-test was used to compare non-normally distributed continuous variables. Pearson's chi-square test and Fisher's exact test were used to compare the categorical variables between the groups of mothers who stated that they shook their babies and those who did not. Pearson's correlation coefficient or Spearman's rank-order correlation coefficient depending on the normality of the variables was used to examine the relationships between accelerometer peak resultant values, researchers' NRS, and mothers' INRS and psychiatric rating scale scores of mothers who stated that they shook their babies. We conducted a multivariable logistic regression analysis to investigate the risk factors related to mothers' shaking behavior of their babies, including only those identified in the univariate analyses with a P-value of .05 or less. All predictor variables were simultaneously entered into the logistic regression model using the enter method. The appropriateness of the model was analyzed using the Hosmer-Lemeshow test. The significance level was accepted as $P < .05$.

Outliers: Mothers who performed more than 3 SDs above group means for the psychiatric rating scale total scores were accepted as outliers and excluded from the analysis. One of the mothers from the group B, BSI-psychoticism subscale score was a major outlier. Even though this was a subscale, to be on the safer side regarding the accurate completion of the psychiatric rating scales, her data were removed from the analysis.

RESULTS

Sixty-three (40.9%) mothers who stated that they shook their babies to soothe them when they cried and 91 (59.1%) mothers who stated they did not were included in this study. When the variable "mothers' exposure to physical violence in childhood" was taken into account, the power of the study was found to be 84.8%.

Some of the significant findings we would like to emphasize were (Table 1): In group B, babies had poorer sleep patterns; babies' crying frequency was higher; soothing the babies when they cried was more difficult, and the mothers reported being exposed to physical violence more often in their childhood when compared with group A. The mean ages of the babies were higher in group B.

Psychiatric rating scale comparisons of group A and group B, and accelerometer peak resultant values, researchers' NRS, and mothers' INRS scores for group B are presented in Table 2.

A significantly positive correlation was found between accelerometer peak resultant values and researchers' NRS scores, and between researchers' NRS, and mothers' INRS scores (Table 3).

Correlations between psychiatric rating scale scores and accelerometer peak resultant values, researchers' NRS, and mothers' INRS scores are presented in Tables 4 and 5.

Significant positive correlations were found between mothers' INRS and BSI-depression scores, researchers' NRS and BSI-depression scores, mothers' INRS and BSI-hostility scores, mothers' INRS scores and BSI-Positive Symptom Distress Index, and mothers' INRS and BSI-interpersonal sensitivity scores (Table 5).

Risk factors we found related to mothers' shaking behavior of their babies with a P-value of .05 or less in the univariate analyses were included in the multivariable logistic regression analysis (Table 6). The goodness-of-fit of the logistic regression model was evaluated using the Hosmer-Lemeshow test, which yielded a significance value of 0.917, indicating that the model adequately fits the data. Significant factors associated with mothers' shaking behavior were as follows: each monthly increase in the age of the babies increased the mothers' shaking tendency 1.096 times. In mothers who stated that the babies' crying frequency was moderate, the tendency to shake increased 2.900 times compared to the mothers who stated that the babies' crying frequency was low or very low. Compared to mothers who stated that they never had difficulty in soothing their babies, the tendency to shake increased 3.705 times in mothers who said that they sometimes had difficulty in soothing their babies; the tendency to shake increased 7.777 times in mothers who said that they often or always had difficulty in this issue. In mothers who experienced physical violence in their childhood, the tendency to shake their babies increased 5.674 times compared to mothers who did not experience physical violence in their childhood (Table 6).

DISCUSSION

In the group of mothers who stated that they shook their babies, the babies had poorer sleep patterns, babies' crying frequency was higher, and soothing the babies

Table 1. Sociodemographic Characteristics Related to the Mother, the Family, and the Baby

		Group A[#] (n = 91)	Group B[#] (n = 63)	P
Mothers' age		27.70 ± 5.47	27.92 ± 5.34	.807[a]
Age of first motherhood		23.00 (6.00)	23.00 (7.00)	.884[b]
Mothers' education	Primary school	27 (29.7%)	22 (34.9%)	.191[c]
	Secondary school	26 (28.6%)	17 (27.0%)	
	High school	22 (24.2%)	20 (31.7%)	
	Undergraduate and higher education	16 (17.6%)	4 (6.3%)	
Mothers' employment status	Employed	6 (6.6%)	3 (4.8%)	.085[c]
	Unemployed/on leave	12 (13.2%)	2 (3.2%)	
	Homemaker	73 (80.2%)	58 (92.1%)	
Family's total monthly income	Below 1000 ₺	26 (28.6%)	12 (19.0%)	.367[c]
	1000-1999 ₺	36 (39.6%)	33 (52.4%)	
	2000-2999 ₺	20 (22.0%)	11 (17.5%)	
	3000 ₺ and above	9 (9.9%)	7 (11.1%)	
Number of children	1	41 (45.1%)	20 (31.7%)	.129[c]
	2	33 (36.3%)	33 (52.4%)	
	3 and above	17 (18.7%)	10 (15.9%)	
Difficulty in soothing the baby when crying	Never	30 (33.0%)	8 (12.7%)	**.019*,[c]**
	Sometimes	51 (56.0%)	41 (65.1%)	
	Often	8 (8.8%)	10 (15.9%)	
	Always	2 (2.2%)	4 (6.3%)	
Mothers' exposure to physical violence in childhood	Yes	8 (8.8%)	17 (27.0%)	**.003**,[c]**
	No	83 (91.2%)	46 (73.0%)	
Gender of the baby	Girl	44 (48.4%)	30 (47.6%)	.929[c]
	Boy	47 (51.6%)	33 (52.4%)	
Age of the baby (month)		7.00 (9.00)	11.00 (14.00)	**.015*,[b]**
The person who takes care of the baby the most	Mother	84 (92.3%)	62 (98.4%)	.091[d]
	Relative	7 (7.7%)	1 (1.6%)	
Baby's sleep pattern	Good	30 (33.0%)	21 (33.3%)	**.029*,[c]**
	Moderate	46 (50.5%)	21 (33.3%)	
	Poor	15 (16.5%)	21 (33.3%)	
Baby's crying frequency	Very little	13 (14.3%)	1 (1.6%)	**.008**,[c]**
	Little	21 (23.1%)	9 (14.3%)	
	Moderate	41 (45.1%)	35 (55.6%)	
	Much	10 (11.0%)	6 (9.5%)	
	Very much	6 (6.6%)	12 (19.0%)	

Descriptive data were presented as mean ± SD, median (IQR), n (%). For group A, the sum of all subcategories is 91 and 100 %; for group B, the sum of all subcategories is 63 and 100%.
[a]Independent samples *t*-test.
[b]Mann-Whitney *U*-test.
[c]Pearson's chi-squared test.
[d]Fisher's exact test.
*P < .05.
**P < .01.
[#]Group A: mothers who stated that they did not shake their babies; Group B: Mothers who stated that they shook their babies.

when they cried was more difficult when compared to the group of mothers who stated that they did not shake their babies. Prolonged, unsoothable crying episodes and misperceptions by the caregiver that the reason for crying is pain may lead to frustration and consequently to shaking of the baby.[7,37]

In the group of mothers who stated that they shook their babies, mothers reported being exposed to physical violence more often in their childhood when compared to the group of mothers who stated that they did not. This finding is in accordance with previous studies that highlight the mothers'[38,39] or parents'[40] own abuse history as a risk

Table 2. Psychiatric Rating Scale Comparisons of Group A and Group B, Accelerometer Peak Resultant Values, Researchers' NRS, and Mothers' INRS Scores for Group B

	Group A[#]	Group B[#]	P
AASQ	n = 89	n = 63	
Avoidant attachment	3.00 (3.00)	4.00 (3.00)	.204[b]
Anxious/ambivalent attachment	2.00 (2.00)	1.00 (2.00)	.225[b]
Insecure attachment	2.50 (1.50)	2.50 (1.50)	.998[b]
Secure attachment	3.00 (3.00)	4.00 (2.00)	.449[b]
ETS	n = 91	n = 63	.059[a]
	69.74 ± 8.12	67.22 ± 7.98	
MSPSS	n = 91	n = 63	
Family	27.00 (4.00)	27.00 (8.00)	.505[b]
Significant other	28.00 (6.00)	28.00 (6.00)	.926[b]
Friends	22.00 (12.00)	22.00 (12.00)	.817[b]
Total	72.00 (17.00)	74.00 (19.00)	.971[b]
RSES	n = 91	n = 63	
	1.00 (1.00)	1.00 (1.00)	.289[b]
BSI	n = 91	n = 63	
Somatization	4.00 (9.00)	5.00 (8.00)	.084[b]
Obsession-compulsion	7.00 (8.00)	8.00 (8.00)	.227[b]
Interpersonal sensitivity	4.00 (6.00)	6.00 (6.00)	.193[b]
Depression	4.00 (7.00)	5.00 (8.00)	.142[b]
Anxiety	4.00 (8.00)	7.00 (7.00)	**.034*[b]**
Hostility	4.00 (5.00)	6.00 (6.00)	**.004**[b]**
Phobic anxiety	3.00 (5.00)	3.00 (5.00)	.269[b]
Paranoid ideation	5.00 (7.00)	6.00 (6.00)	.418[b]
Psychoticism	3.00 (5.00)	3.00 (5.00)	.634[b]
Additional items	3.00 (5.00)	4.00 (4.00)	.138[b]
Global Severity Index	0.75 (0.94)	1.11 (0.98)	.066[b]
Positive Symptom Total	25.30 ± 12.00	27.68 ± 10.45	.203[a]
Positive Symptom Distress Index	1.75 (1.27)	2.06 (1.04)	.110[b]
Accelerometer peak resultant value	–	n = 57	
		1.86 ± 0.85	
Researchers' NRS	–	n = 63	
		3.00 (1.00)	
Mothers' INRS	–	n = 63	
		2.00 (2.00)	

Descriptive data were presented as mean ± SD, median (IQR).
AASQ, Adult Attachment Questionnaire; ETS, Empathic Tendency Scale; MSPSS, Multidimensional Scale of Perceived Social Support; RSES, Rosenberg Self Esteem Scale.
BSI: Brief Symptom Inventory, NRS: Numerical Rating Scale, INRS: Illustrated Numeric Rating Scale, Accelerometer peak resultant value:
$R = \sqrt{x^2 + y^2 + z^2}$.
[#]Group A: Mothers who stated that they did not shake their babies; Group B: Mothers who stated that they shook their babies.
[a]Independent samples *t*-test
[b]Mann-Whitney *U*-test.
*P < .05.
**P < .01.

factor for their children to be exposed to abuse. It was reported that parents with an abuse history in childhood are more likely to display hostile parenting towards their children during early childhood.[39]

The BSI hostility subscale scores of the mothers who said that they shook their babies were higher than those of the mothers who stated that they did not. It was suggested that hostile parental feelings may cause an increased risk for abuse toward preterm infants or infants with poor fetal growth.[41] It was also suggested that exposure to high levels of hostility in the home may be related to important mechanisms linking child maltreatment to adverse outcomes.[42] Brief Symptom Inventory anxiety subscale scores of the mothers who stated that they shook their babies were higher than those of the mothers who stated that they did not. Mental health problems can lead to AHT.[19,20] In terms of the BSI's other subscale scores, global severity index, positive symptom total, and positive symptom distress index, we could not find any statistically significant difference between the mothers who stated that they shook their babies and the mothers who stated that they did not. We could not find any significant differences in terms of attachment styles, empathic tendency levels, perceived social support, and self-esteem levels between the mothers who stated that they shook their babies and those who did not. Mental health problems of a parent were found to be associated with an increased risk of child maltreatment[43,44] or AHT.[19,20] Mothers with a high risk of physically abusing their children were found to have a lack of empathy and a higher presence of negative affectivity.[45] Deficits in parental empathy/low levels of parental empathy were found to be related to abuse potential.[46,47] Attachment styles of the parents may contribute to the development of risk factors, which may lead to child maltreatment. Cooke et al[48] (2019) revealed that mothers who had adverse childhood experiences were at increased risk of having children with behavioral and emotional difficulties in early childhood; this effect was thought to be conveyed via mothers' attachment styles and depressive symptoms. Perceived lack of social support or lack of support was shown to be associated with an increased risk of child physical abuse.[43,49,50]

In the group of mothers who stated that they shook their babies, a significant positive correlation was found between accelerometer peak resultant values and researchers' NRS scores, researchers' NRS, and mothers' INRS scores. The results indicated significant positive correlations between mothers' INRS and BSI-depression scores, researchers' NRS and BSI-depression scores, mothers' INRS and BSI-hostility scores, mothers' INRS scores and BSI-Positive Symptom Distress Index, and mothers' INRS and BSI-interpersonal sensitivity scores. Higher depressive scores or higher psychiatric symptoms of mothers may have contributed to the severity of shaking their babies. Depression and other

Table 3. Correlation Between Accelerometer Peak Resultant Value and Researchers' Numerical Rating Scale, and Mothers' Illustrated Numeric Rating Scale in Group B

		Accelerometer Peak Resultant Value	Researchers' NRS	Mothers' INRS
Accelerometer peak resultant value	r	1.000[a]		
	P	<.001		
	n	57		
Researchers' NRS	r	0.475[a]	1.000[a]	
	P	**<.001****	<.001	
	n	57	63	
Mothers' INRS	r	0.204[a]	0.482[a]	1.000[a]
	P	.128	**<.001****	<.001
	n	57	63	63

Group B: Mothers who stated that they shook their babies. [a] Spearman's rank-order correlation coefficient.
NRS, Numerical Rating Scale; INRS, Illustrated Numeric Rating Scale.
*P < .05.
**P < .01.

mental health disorders of the caregivers are among the risk factors for physical abuse or SBS.[3,19,20] We could not encounter a study measuring the mothers' shaking severity with INRS and comparing this parameter with various psychiatric rating scale scores.

The age of the babies, moderate crying frequency of the babies, the mothers' difficulty in soothing their babies, and the mothers' experience of physical violence in their own childhood were found to be significant factors affecting the shaking behavior. SBS is encountered mostly under the age of 2.[1] Moderate crying frequency had an effect on shaking behavior. To our surprise, higher frequencies of crying did not reveal a significant effect. This finding may be explained by the possibility that since kinship relations are strong in our country, mothers may have found a solution to cope with a higher frequency of crying, such as arranging family support (e.g., inviting a relative to live with them).

After this study, our Faculty's Department of Forensic Medicine and Child Protection Unit composed and

Table 4. Correlation Between Accelerometer Peak Resultant Value, Researchers' Numerical Rating Scale, Mothers' Illustrated Numeric Rating Scale, and Adult Attachment Questionnaire, Empathic Tendency Scale, Multidimensional Scale of Perceived Social Support, Rosenberg Self Esteem Scale Scores in Group B

	Accelerometer Peak Resultant Value		Researchers' NRS		Mothers' INRS	
	r	P	r	P	r	P
AASQ						
Avoidant attachment	0.172[a]	.201	0.123[a]	.337	0.131[a]	.307
Anxious/ambivalent attachment	−0.157[a]	.243	0.048[a]	.709	0.138[a]	.282
Insecure attachment	0.059[a]	.661	0.164[a]	.198	0.216[a]	.089
Secure attachment	0.054[a]	.690	−0.022[a]	.863	−0.044[a]	.731
ETS	0.189[b]	.159	0.079[a]	.539	0.057[a]	.655
MSPSS						
Family	0.072[a]	.594	0.005[a]	.967	−0.041[a]	.750
Significant other	0.179[a]	.182	0.039[a]	.761	−0.079[a]	.540
Friends	0.247[a]	.064	−0.003[a]	.980	0.169[a]	.184
Total	0.213[a]	.112	0.038[a]	.770	0.058[a]	.651
RSES	−0.239[a]	.073	0.310[a]	**.013***	0.313[a]	**.013***

Group B, mothers who stated that they shook their babies.
AASQ, Adult Attachment Questionnaire; ETS, Empathic Tendency Scale; INRS, Illustrated Numeric Rating Scale; MSPSS, Multidimensional Scale of Perceived Social Support; NRS, Numerical Rating Scale; RSES, Rosenberg Self Esteem Scale.
[a]Spearman's rank-order correlation coefficient.
[b]Pearson's correlat'on coefficient.
*P < .05.
**P < .01.

Table 5. Correlation Between Accelerometer Peak Resultant Value, Researchers' Numerical Rating Scale, Mothers' Illustrated Numeric Rating Scaleand Brief Symptom Inventory Scores in Group B

	Accelerometer Peak Resultant Value		Researchers' NRS		Mothers' INRS	
	r	P	r	P	r	P
BSI						
Somatization	−0.011ᵃ	0.936	0.119ᵃ	.351	0.195ᵃ	.125
Obsession-compulsion	0.094ᵃ	0.486	0.174ᵃ	.173	0.256ᵃ	**.043***
Interpersonal sensitivity	0.046ᵃ	0.735	0.187ᵃ	.143	0.339ᵃ	**.007****
Depression	−0.049ᵃ	0.715	0.376ᵃ	**.002****	0.401ᵃ	**.001****
Anxiety	0.054ᵃ	0.692	0.279ᵃ	.027	0.284ᵃ	**.024***
Hostility	−0.021ᵃ	0.877	0.180ᵃ	.157	0.353ᵃ	**.005****
Phobic anxiety	−0.086ᵃ	0.524	0.054ᵃ	.675	0.226ᵃ	.075
Paranoid ideation	0.082ᵃ	0.545	0.113ᵃ	.376	0.242ᵃ	**.056**
Psychoticism	0.038ᵃ	0.779	0.017ᵃ	.894	0.180ᵃ	.158
Additional items	−0.047ᵃ	0.727	0.221ᵃ	.081	0.158ᵃ	.217
Global severity index	−0.010ᵃ	0.939	0.209ᵃ	.100	0.327ᵃ	**.009****
Positive symptom total	−0.039ᵇ	0.773	0.237ᵃ	.061	0.205ᵃ	.107
Positive symptom distress index	0.029ᵃ	0.831	0.081ᵃ	.527	0.340ᵃ	**<.006****

Group B: Mothers who stated that they shook their babies.
BSI, Brief Symptom Inventory; INRS, Illustrated Numeric Rating Scale; NRS, Numerical Rating Scale.
ᵃ Spearman's rank-order correlation coefficient.
ᵇ Pearson's correlation coefficient.
*P < .05.
**P < .01.

distributed brochures related to SBS to inform the families who referred to the pediatric outpatient clinics about the risks related to infant shaking.

Our study has several limitations. First of all, if the sample size was larger, it would be easier to reveal the differences between the mothers who stated that they shook their babies and those who stated that they did not. We had to attach the accelerometer to the infant manikin's chest instead of the head; this may have prevented us from measuring the shaking intensity accurately, and the actual

Table 6. Investigation of the Risk Factors Related to Mothers' Shaking Behavior of their Babies

		B	P	OR	95% CI for OR	
					Lower	Upper
Age of the baby (month)		0.092	**.002****	1.096	1.033	1.162
BSI-anxiety subscale		−0.001	.974	0.999	0.915	1.090
BSI-hostility subscale		0.097	.131	1.102	0.971	1.251
Baby's sleep pattern	Good	ref				
	Moderate	−0.758	.106	0.468	0.187	1.176
	Poor	0.385	.480	1.470	0.505	4.279
Baby's crying frequency	Very little or little	ref				
	Moderate	1.065	**.035***	2.900	1.080	7.788
	Much or very much	0.751	.282	2.119	0.540	8.318
Difficulty in soothing the baby when crying	Never	ref				
	Sometimes	1.310	**.018***	3.705	1.246	11.017
	Often or always	2.051	**.014***	7.777	1.519	39.818
Mothers' exposure to physical violence in childhood		1.736	**.002****	5.674	1.887	17.058
Constant		−1.240	**.014***	0.289		

Logistic regression model P < .001.
BSI, Brief Symptom Inventory; OR, odds ratio, logistic regression analyses.
*P < .05.
**P < .01.

shaking intensity may be higher. There was a possibility that some mothers may have withheld information about shaking their babies.

To our knowledge, this is the first study in the literature that examines various parameters, such as attachment style, empathic tendency, psychiatric symptoms, and perceived social support, as well as self-esteem in relation to mothers' shaking behavior of their babies. Our study also includes a shaking simulation with an infant manikin and an accelerometer.

CONCLUSION

The shaking behavior of mothers is related to various factors associated with babies and mothers themselves. Education regarding babies' crying patterns during their development, ways for soothing the babies or calming the mothers/caregivers, and risks of shaking the babies are crucial for preventing the development of SBS. Steps for the prevention of SBS should be undertaken to protect new generations.

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