

# Effects of infant positioning on acoustic features of cries

Alexander Goberman<sup>#</sup>, Susan Johnson<sup>+</sup>, Michael Cannizzaro<sup>%</sup>, Michael Robb<sup>\*</sup>

<sup>#</sup>Dept. of Communication Disorders, Bowling Green State University, Bowling Green, OH; <sup>+</sup>Obstetrics and Women's Care, Wood County Hospital, Bowling Green, OH;

<sup>%</sup>Dept. of Communication Disorders, University of Vermont, Burlington, VT; <sup>\*</sup>Dept. of Communication Disorders, University of Canterbury, Christchurch, NZ



**Abstract**

A definitive cause for Sudden Infant Death Syndrome (SIDS) has not yet been identified, but some theories point to laryngeal or respiratory causes, in addition to theories of reduced arousal or reduced autonomic response. The occurrence of SIDS has dropped since the movement to place newborns to sleep in the supine (back) position; however some research has found a respiratory disadvantage for infants in this position. This paper studies acoustic characteristics of infant pain cries to determine differences related to prone versus supine positioning. Sixty-two infant cries were recorded during and following a blood draw screening procedure, with infants were placed either in the supine or prone position. Results were based on LTAS analysis across each crying episode. Mean Spectral Energy was found to be higher for infants in the supine position, possibly reflecting increased intensity of pain response in these infants. In addition, Spectral Tilt was lower in the supine position indicating possible vocal fold hyperadduction in this position. Overall, acoustic analysis points to the possibility that there is a difference in pain response or arousal for healthy infants based on position.

**Sudden Infant Death Syndrome (SIDS)**

**Definition**

- Sudden death of an infant under 1 year of age, which remains unexplained after a thorough case investigation, including performance of a complete autopsy, examination of the death scene, and review of the clinical history (Willinger et al., 1991). The incidence of SIDS peaks at 2-3 months of age (AAP Task force on SIDS, 2005).

**Back to Sleep Campaign**

- Recommended non-prone (back) sleeping position in 1992.
- SIDS incidence has decreased over 50% since then.
  - 1.20 deaths / 1000 live births in 1992; 0.56 deaths / 1000 live births in 2000.

**Risk Factors**

- Prone or side sleep position
- Soft bedding / pillows
- Smoking during pregnancy
- Overheating
- Late or no pre-natal care
- Young maternal age
- Pre-term birth or low birth weight
- Male gender

**Causal Theories**

- Laryngeal / Respiratory Problems
- Re-breathing asphyxia
- Decreased arousal in response to life-threatening events during sleep (AAP Task force on SIDS, 2005).

**Methods and Measures**

Infant cries were recorded following a mandatory PKU screening test. In the state of Ohio this test must occur after 24 hours of age but before discharge from the hospital. The blood draw completed with this test involves a painful heel stick procedure.

Long-Time Average Spectrum (LTAS) analysis was used in this study. The LTAS is a frequency by amplitude display based on Fourier analysis of the entire crying episode after pause removal (512 points across 0-8000 Hz). The following acoustic measures were taken from the LTAS:

- Mean Spectral Energy (MSE):** This is a measure of the average energy relative to the peak energy (expressed in -dB). In infants, this has been shown to relate to laryngeal tension (Fuller & Horii, 1988) and severity of cry-eliciting stimulus (Fuller & Conner, 1995).
- Spectral Tilt (ST):** This is a ratio of the sum of amplitudes from 0-1000 Hz by the sum of amplitudes from 1000 – 5000 Hz. In adults, a low ST has been shown to relate to vocal fold hyperadduction (Loqvist & Mandersson, 1987). In infants, Zeskind (1983) noted a correlation between vocal fold hyperadduction and greater arousal from a painful stimulus, and this has been found in pre-term infants (Goberman & Robb, 1999).
- First Spectral Peak (FSP):** This measure corresponds to the average fundamental frequency across the entire crying episode. In infants, FSP has been shown to correlate with vocal fold stiffness / tension (Fuller & Horii, 1988).

**Participants**

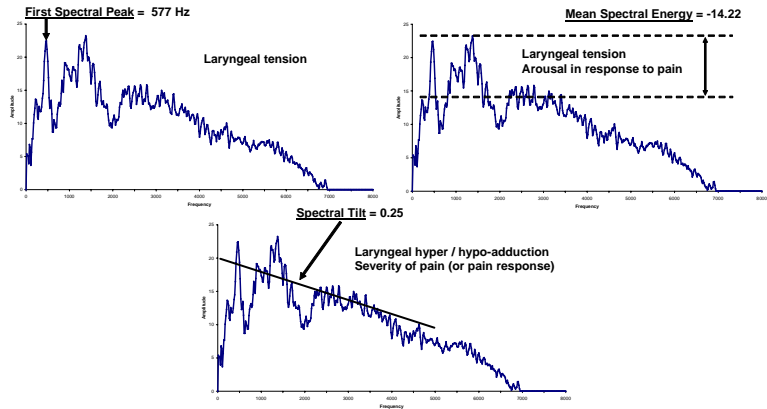
A total of 75 infants were recorded, and of these 62 usable samples were collected. A total of 11 samples were unusable because of no/minimal crying, and 2 were unusable because of background noise. All identifying data were removed prior to any analysis being completed.

The following is a description of the participants:

- 56 full-term infants (37+ weeks gestational age); 6 mild pre-term (35-36 weeks GA)
- 25 males; 37 females
- 35 prone during recording; 27 supine
- Normal distribution of weight / length / head circumference
- All Appgar scores normal (5-9 at 1 minute, 8-9 at 5 minutes)
- 6 mothers reported smoking during pregnancy

**Participant Characteristics**

Measure	Mean	SD	Range
Gestational Age (weeks)	38.6	1.5	35 – 41
Age at recording (hours)	37.9	12.7	24 – 89
Weight (grams)	3349.0	459.3	1849 – 4263
Length (inches)	19.4	0.8	17.0 – 21.5
Head Circumference (inches)	13.4	0.5	12.0 – 14.5



**Acoustic results for supine (back) vs. prone (belly) position**

Measure	Supine Position	Prone Position	Difference
	Mean (SD)	Mean (SD)	
Mean Spectral Energy (relative dB)	-16.3 (3.2)	-20.3 (4.0)	$p < 0.05$
Spectral Tilt	0.35 (0.14)	0.41 (0.12)	$p < 0.05$
First Spectral Peak (Hz)	449.1 (80.4)	454.5 (52.0)	
Unedited duration (sec)	137.2 (98.3)	180.6 (110.9)	
Percent pause (%)	30.0 (8.9)	31.7 (13.3)	
Expirations / second	0.78 (0.20)	0.84 (0.23)	
Inspiratory percentage (%)	34.9 (13.0)	31.8 (14.0)	

**Results and Discussion**

**Gender Results**

One risk factor for SIDS is male gender. A comparison was completed on all measures to examine possible gender differences in acoustic characteristics of cries.

- Results indicated that there were no overall significant differences in any measures between males and females. However, there was a non-significant trend toward a lower (more negative) MSE in boys compared to girls. This could be interpreted as boys tending to have decreased response to the pain stimulus compared to girls.

**Position Results**

As a prone sleeping position is a major risk factor for SIDS, a comparison was completed of all measures based on infant position.

- Results indicated an overall significant effect of position on acoustic features of cry.
- In the prone position, infants had significantly more negative MSE. This can be interpreted as exhibiting decreased laryngeal tension, experiencing less pain, or as having decreased arousal in response to the pain stimulus.
- In the prone position, infants had significantly higher ST values. This can be interpreted as producing less vocal fold hyperadduction or a less intense response to the pain stimulus.
- There were no respiratory or other differences between infants in the supine vs. prone positions.

**Changes across the cry sample**

Cries analysis was completed on the first, middle, and third 1/3 of each cry episode to examine self-soothing behavior.

- There was an overall significant effect of time, and this effect was further seen for MSE and ST. MSE decreased and ST increased across the crying episode (for both supine and prone positions). This can be interpreted as all infants calming as the time since stimulus increases.

**Conclusions**

Overall, acoustic differences (in ST and MSE) are indicative of infants reacting more intensely to a pain stimulus on their backs (supine), and less intensely while prone. These results support the decreased arousal in response to life-threatening events during sleep theory of SIDS. It is self-protective for an infant to react intensely to a painful stimulus (or any potential life-threatening event). When infants are placed on their stomachs, they are not reacting as intensely to a painful stimulus.

**References**

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