SMART CLOTHING FOR MONITORING BREASTFEEDING CARE

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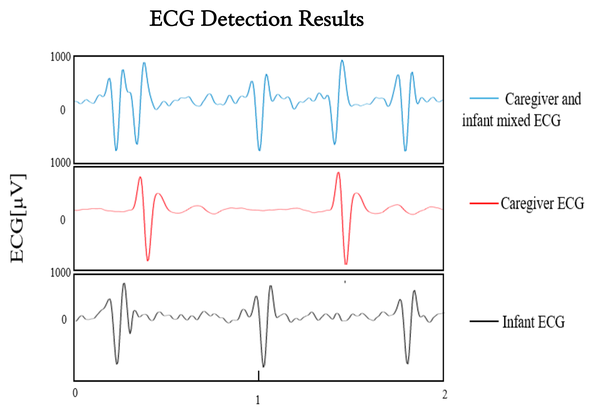
Introduction and Background:

Optimal breastfeeding is the most efficient way to properly nourish an infant. Because of an infant's reliance and repetitive timing of breastfeeding, several health factors can be revealed. This includes issues with an infant's oral structure. Infants with tongue-ties may have difficulty latching onto the breast which can lead to poor sucking patterns or not being able to extract any milk. Breastfeeding duration can be a further gauge to foresee an infant's efficient nutrient intake. It also can signify several issues with an infant's heart; for example, Congenital Heart Defects (CHDs). Nearly 1/110 infants are diagnosed annually. These infants will have a difficult time nursing because they lack the stamina to endure a full feed. The infant's swallowing is also another important indicator of their health, part of the suck-breathe-swallow ratio, showcasing the efficiency of an infant's feed. Based on these characteristics, monitoring an infant's feeding can have a major effect on recognizing potential health issues. However, the available technology for this purpose are limited, particularly due to the challenges of placing wearable devices on an infant's fragile skin.

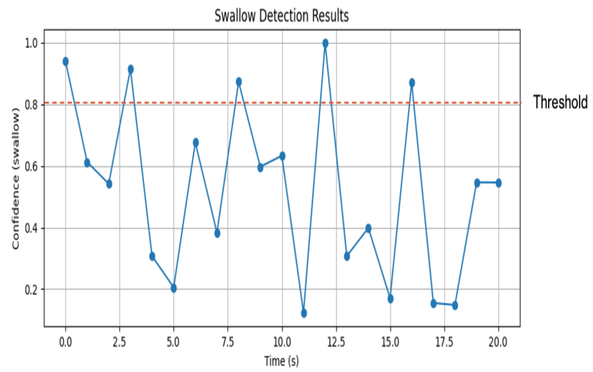
This experiment will focus on creating an intelligent garment for breastfeeding mothers to wear while feeding. It will be able to monitor the mother and infant's heart rate and have a non-contact microphone for measuring suck-breath-swallow ratios.

Methods:

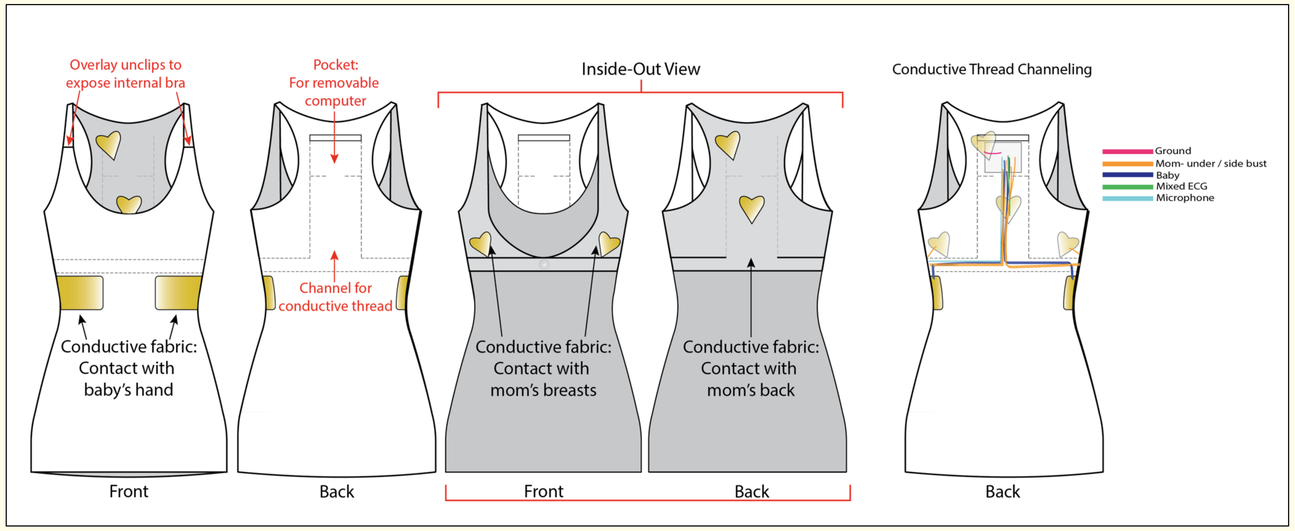
This experiment focuses on the development of a smart garment to be worn by a mother during breastfeeding. This garment will record breastfeeding duration, infant respiration rate, infant heartbeat, and infant swallow rate. To monitor the infant's heartbeat, the experiment reads an electrocardiogram (ECG) which shows the infant and mother's signals. To isolate just the infant's heartbeat, it required ECG separation and contact type recognition using OpenBCI Cyton Board. The infant's ECG signal has been successfully separated at a rate of 98.7% accuracy. Along the same lines, the experiment has measured infant respiration rate with 97% accuracy. To monitor the infant's swallowing activity, the experiment will use a shotgun microphone. All this data and technology will be used in the garment. There will be six sensors throughout the garment to assist with these measurements. Two will be placed along the mother's waist for direct contact with the infant's hand. Two more sensors will be placed along the garment bra's lining for contact with the mother's breasts. One sensor will lay along the mother's spine for her ECG reading. A final sensor will also be placed on the mother's back for the signal's ground reading. The garment will also include a contact microphone to measure the infant's swallowing activity. Once the next portion commences, the experiment will use mother and infant participants to further measure garment functionality and accuracy.

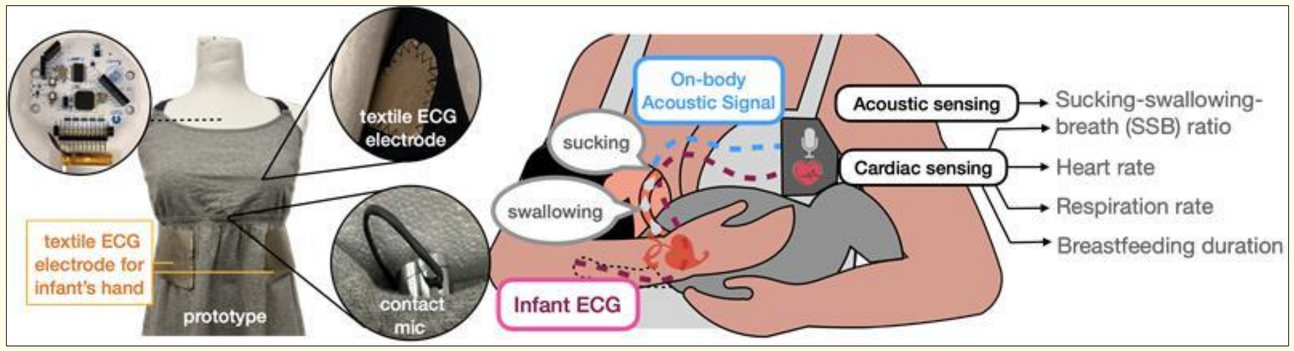


Through using OpenBCI Cyton Board, the mother and infant signals have been isolated at a 98.7% accuracy.



The threshold for swallow detection is 0.8. Only the confidence higher than the threshold will be identified as a swallow.





Conclusions:

This smart garment will be worn by breastfeeding mothers and indicate key vitals during the feed. The garment's ability to successfully isolate mother and infant electrocardiogram signals will greatly assist in this experiment's future studies. With completed wear tests with mothers and infants, there will be increased insight into the garment's functionality. This will expand upon the current scope of infant vitals while feeding as well as the smart garment's importance. Increased insight in this domain can be crucial to early recognition of infant health, including, but not limited to congenital heart defects, issues within oral structure, and lung disease.

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Geraghty, S. R., Riddle, S. W., & Shaikh, U. (2008). The Breastfeeding Mother and the Pediatrician. *Journal of Human Lactation*, 24(3), 335–339. https://doi.org/10.1177/0890334408321091

Goldfield, E. C., Richardson, M. J., Lee, K. G., & Margetts, S. (2006). Coordination of Sucking, Swallowing, and Breathing and Oxygen Saturation During Early Infant Breast-feeding and Bottle-feeding. *Pediatric Research*, 60(4), 450–455. https://doi.org/10.1203/01.pdr.0000238378.24238.9d

Mayerl, C. J., Gould, F. D. H., Bond, L. E., Stricklen, B. M., Buddington, R. K., & German, R. Z. (2019). Preterm birth disrupts the development of feeding and breathing coordination. *Journal of Applied Physiology*, 126(6), 1681–1686. https://doi.org/10.1152/japplphysiol.00101.2019

Mizuno, K. et al. *Pediatrics (Evanston)*, 2007-10, Vol.120 (4), p.e1035-e1042. DOI: 10.1542/peds.2006-3567

Montgomery-Downs, H. E., Crabtree, V. M., Capdevila, O. S., & Gozal, D. (2007). Infant-Feeding Methods and Childhood Sleep-Disordered Breathing. *PEDIATRICS*, 120(5), 1030–1035. https://doi.org/10.1542/peds.2007-0722

Pharm, R.-N. M. (2019, August 15). News-Medical. *News-Medical*. https://www.news-medical.net/health/Infantile-Bradycardia-Causes-Diagnosis-Symptoms-and-Treatment.aspx#2

Sakalidis, V. S., & Geddes, D. T. (2015). Suck-Swallow-Breathe Dynamics in Breastfed Infants. *Journal of Human Lactation*, 32(2), 201–211. https://doi.org/10.1177/0890334415601093

Siegel, S. A. (2016). Aerophagia Induced Reflux in Breastfeeding Infants With Ankyloglossia and Shortened Maxillary Labial Frenula (Tongue and Lip Tie). *International Journal of Clinical Pediatrics*, 5(1), 6–8. https://doi.org/10.14740/ijcp246w

Vijay, A., Radish Kumar Balasubramanium, Krishnamurthy, R., Uzair Chilwan, Kamath, N., & Bhat, K. G. (2023). Profiling non-nutritive sucking skills in full-term and preterm neonates. *The Egyptian Journal of Otolaryngology*, *39*(1) https://doi.org/10.1186/s43163-023-00550-9