



news smartnest

# Premature ChillZone – a smart hammock



EUROPÄISCHE UNION  
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Europäischer Fonds  
für regionale Entwicklung



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## Background

Premature infants experience a variety of nonphysiological stimuli from light, noise, touch, and pain in the neonatal intensive care unit compared with fetuses in the uterus of the same developmental stage. At the same time, they experience deprivation of physiological stimuli such as intrauterine acoustics or movement. There are numerous studies that examine how the development and outcome of preterm infants can be improved when they are provided with a developmentally supportive environment.<sup>1</sup>

The present project analysed the needs of prematures, parents and medical staff and developed a prototype with an holistic approach for the clinical daily routine.

Premature infants possess all the anatomical basics for movement. However, they have not been able to further develop these skills under intrauterine conditions through self-motion as well as movement by the maternal body. In addition to a developmental deficit, premature infants exhibit generalized muscular hypotonia based on immaturity. This, along with gravity counteracting many movements, makes it difficult for premature babies to move on their own.

A lot of studies have shown that vestibular stimulation through positioning on hammock or waterbed promotes the development and outcome of premature infants.

Dr. Neal et al had premature infants rocked three times a day for 30 minutes and found improved and faster development of muscle tone, head movements, grasping, pulling, auditory and visual responses, and weight gain.<sup>2</sup>

Dr. Jesus et al found improved sleep and a reduction of heart- and respiratory rate with one hour of hammock positioning in the incubator.<sup>3</sup>

Dr. Ribas et al documented significant differences in 2-hour hammock positioning over 5 days of less pain, better sleep-wakefulness state, and improved oxygen saturation, heart rate, and respiratory rate.<sup>4</sup>

Dr. Keller et al found a higher score of neuromuscular maturity and also a reduction in heart rate and respiratory rate over a 10-day study interval with 3-hour hammock positioning.<sup>5</sup>

The skin-to-skin contact between infant and parent called kangaroo care (KC) has been shown to reduce mortality, severe illness, infection and length of hospital stay in developing countries for low-birthweight infants. „KC is also beneficial for preterm infants in high-income countries. Cardiorespiratory and temperature stability, sleep organization and duration of quiet sleep, neurodevelopmental outcomes, breastfeeding and modulation of pain responses appear to be improved for preterm infants who have received KC during their hospital stay“.<sup>6</sup>

In order to achieve these positive effects, but also to strengthen parent-child bonding, it is important to enable an easy removal from the incubator.

In contrast to this calming care, it is shown that preterm infants in the NICU underwent an excessive number of manipulations over an 24-hour period.<sup>7</sup>

Positioning change is associated with stress and painful expression of the prematures.<sup>8</sup>

Due to this positioning stress sick infants who suffer from pneumonia are often not placed on an X-ray plate directly, but are x-rayed through the incubators walls, mattress and floor plate which results in a lower signal to noise-ratio, a bigger shadow of the organs and particularly more dose.<sup>9,10</sup>

In this context interventions to facilitate a calm behavioral state and motor organization in the infant, addressing positioning and handling of the infant, as well as movement therapy are needed.

Currently used hammocks in intensive care units have to be tied to holes in the incubator with twine and are just as difficult to untie. At the same time medical staff is so confident about the hammock positioning method for the prematures that it often sews hammock textiles as self made installations. Due to the complex installation and no market availability of premature hammocks validated for incubator use, hammocks are used less frequently despite their positive effects.

Additionally, prematures need a lot of sensors for the monitoring of their vital parameters. Due to the used adhesiva on their fragile skin and their hard elements such as cables, they cause a lot of skin injuries. These injuries are followed by pain, scarfs and in worst cases infections with higher mortality.<sup>11</sup>

The quantity of cables are difficult to handle for the medical staff and influence the bonding between parents and their children.

The parents describe the NICU and the incubators as a very technical place without a chance for giving their individual child an individual and lovely environment.



## Concept

It is an object of the PrematureChillZone to address as many of the above described needs of the prematures, parents and medical staff as possible.

**1st need:** Promotion of motor development and stress reduction

**Solution:** A hammock positioning device with motor induced movement and a swaddling textile for calming and warming effects of containment

**2nd need:** Reduction of barriers for installation

**Solution:** Easy installation by a rack which is compatible with a majority of incubators and medical product validation

**3rd need:** Improvement of handling with less manipulation of the infant

**Solution:** Handles in which the hammock textile is fixed and can be attached to and detached from the rack, handles and textile functioning as a textile tray for the infant, x-ray translucent textile for a translocation directly on an x-ray plate

**4th need:** Monitoring of vital parameters with less skin lesions

**Solution:** Integration of smart textiles, especially ECG electrodes, into the hammock textile with the contacting to the power supply and data transfer in the handle

**5th need:** Promotion of bonding between child and parents

**Solution:** More bare skin of the prematures chests without electrodes and cables for less impact on kangaroo care; easy translocation with a “textile tray” to the parents’ arms; sloth design for positive associations and design transfer opportunity to the child’s room at home; individual drawings and name letters by textile painting on the hammock textile.

## Developmental Process



### 1) Construction

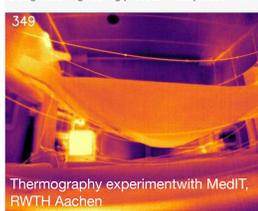
The literature research about developmental care such as NID-CAP (Newborn Individualized Developmental Care and Assessment Program) and published studies about different approaches was complemented with interviews with clinical staff and premature parents in our associated clinical partner hospitals. On this basis first design drafts were made and the pros and cons of each draft were discussed. The most promising draft was further developed as a functional model based on 3D printing. This model was utilised for feedback from the medical staff.

This clinical feedback was integrated in the further development of the engineering process with detailed construction plans, material plans, motor tests and safety mechanisms.

The result is a collapsable rack in which the hammock textile is spread by two removable and height adjustable handles. These handles are moved by a motor to get the hammock into an active swaying. The handles can be attached to and detached from the rack. This connection method enables the medical staff to translocate the infant with this “textile tray” in a two-handed one-person only operation. Thereby the infant can be translocated to other places for medical care or, in particular to a reference person (e.g mother or father). At these places, the infant can even remain in the hammock and has no multiple changes in skin contacting materials being typical during a standard positioning change. Accordingly, the function as a textile tray reduces the need for manipulation, and thus stress, for the infant in addition to the above mentioned other calming effects of a hammock positioning.



Design and engineering process in cooperation with Milan Wild Design and BatchOne

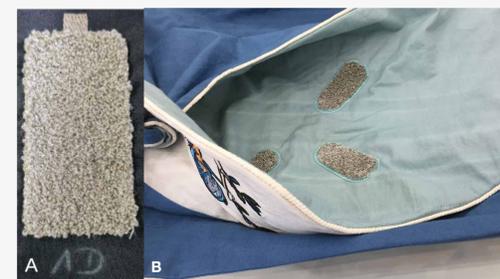


Thermography experiment with MedIT, RWTH Aachen

The functional model was used to investigate the difference of thermal effect of a 37° C corpus lying on an incubator mattress or in the hammock textile of the functional model by thermography. No heat stress or cooling stress for the corpus was found, showing a stable temperature over the experiments time.

### 2) Smart Textile ECG

Parallel to the construction, the textile with its wrinkle-free suiting to to childrens back was identified for good conditions for the integration of smart textiles as sensory elements for the vital parameters monitoring. The development started with textile ECG electrodes, so called “textrodes”, configured with thin silver and different percentages of hydrophilic yarn (Tencel and Lyocell) for a smooth haptic. The best configuration was evaluated by experiments in an incubator.



A) Hydrophilic electrode B) Textrodes embroidered on the hammock textile

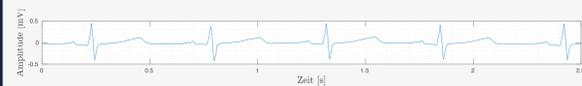
The textrodes connection to a commercially available ECG monitor is realized by metal pushbuttons and commercially available ECG cables.

The textile design was planned with Cradle to Cradle material because of the sensitive skin of prematures with relatively high absorption of harmful substances. The Cradle to Cradle material has the smallest chemical processing without harmful substances which is possible.

As one of the most expressed wishes of parents and medical staff for the prematures was “stress reduction” a sleeping sloth baby was identified as the most positive association for a “swaying relaxing time”. With the opportunity of individual textile painting the parents are involved into the design of the premature’s first child room (incubator chamber). With an adapted birth card, they are motivated to take the most peaceful images and experiences of the sorrowful time home.

## Results

The result of the research and developmental process is a submitted patent and a version 3 prototype enabling clinical trials. The separate hydrophilic ECG textrodes and the hammock textile with integrated ECG textrodes have already been tested with a newborn and showed very well recognisable QRS complexes.



## Discussion

Further clinical trials are needed to validate the intended positive effects of the single solutions for each need.

## Contact

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## Literature

- Liu WF, Lauden S, Perkins B, Mac-Millan-York E, Martin S, Graven S. The development of potentially better practices to support the neurodevelopment of infants in the NICU. *J Perinatol* 27, S48-S74 (2007). <https://doi.org/10.1038/sj.jp.7211844>
- Neal M (1968) Vestibular stimulation and developmental behavior of the small premature infant. *Nursing Research Report* 3:1-5
- Jesus VR, Oliveira PMN, Azevedo VMGO. Effects of hammock positioning in behavioral status, vital signs, and pain in preterms: a case series study. *Braz J Phys Ther* 2018 Jul-Aug;22(4):304-309
- Ribas CG, Andreazza MG, Neves VC, Valderramas S. Effectiveness of Hammock Positioning in Reducing Pain and Improving Sleep-Wakefulness State in Preterm Infants. *Respir Care* 2019;64(4):384-389
- Keller A, Arbel N, Merlob P, Davidson S. Neurobehavioral and autonomic effects of hammock positioning in infants with very low birth weight. *Pediatr Phys Ther* 2003;15(1):3-7
- Jefferies AL: Canadian Paediatric Society, Fetus and Newborn Committee. Kangaroo care for the preterm infant and family. *Paediatr Child Health*. 2012 Mar;17(3):141-6. doi: 10.1093/pch/17.3.141. PMID: 23449885; PMCID: PMC3287094
- Pereira FL, Nogueira de Góes Fdos S, Fonseca LM, Scocchi CG, Castral TC, Leite AM. A manipulação de prematuros em uma Unidade de Terapia Intensiva Neonatal [Handling of preterm infants in a neonatal intensive care unit]. *Rev Esc Enferm USP* 2013 Dec;47(6):1272-8. Portuguese. doi: 10.1590/S0080-62342013000600003. PMID: 24626374
- Ganguly A, Bhadesia PJ, Phatak AG, Nimbalkar AS, Nimbalkar SM. Pain profile of premature infants during routine procedures in neonatal intensive care: An observational study. *J Family Med Prim Care*. 2020;9(3):1517-1521. Published 2020 Mar 26. doi:10.4103/jfmpc.jfmpc.1033.19
- Tugwell-Allsup J, England A. A systematic review of incubator-based neonatal radiography – what does the evidence say? *Br J Radiol*. 2007 Nov;80(959):902-10. Epub 2007 Sep 17
- Gerhards T. Röntgenuntersuchungen von Frühgeborenen in modernen Inkubatoren – Eine dosimetrische und qualitative Evaluation. *Medicine, Dissertation on the Philipps-Universität Marburg*, 2016
- Schlüter AB. Pressure ulcers in maturing skin – A clinical perspective. *Journal of Tissue Viability* 2017 Feb; 28(1): 2-5