Unlike Kangaroo care, mechanically simulated Kangaroo care does not change heart rate variability in preterm neonates☆

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ARTICLE INFO

ABSTRACT

Background: While numerous positive effects of Kangaroo care (KC) have been reported, the duration that parents can spend kangarooing is often limited.
Aim: To investigate whether a mattress that aims to mimic breathing motion and the sounds of heartbeats (BabyBe GMBH, Stuttgart, Germany) can simulate aspects of KC in preterm infants as measured by features of heart rate variability (HRV).
Methods: A within-subject study design was employed in which every routine KC session was followed by a BabyBe (BB) session, with a washout period of at least 2 h in between. Nurses annotated the start and end times of KC and BB sessions. Data from the pre-KC, KC, post-KC, pre-BB, BB and post-BB were retrieved from the patient monitor via a data warehouse. Five time-domain features of HRV were used to compare both types of intervention. Two of these features, the percentage of decelerations (pDec) and the standard deviation of decelerations (SDDec), were developed in a previous study to capture the contribution of transient heart rate decelerations to HRV, a measure of regulatory instability.
Results: A total of 182 KC and 180 BabyBe sessions were analyzed in 20 preterm infants. Overall, HRV decreased during KC and after KC. Two of the five features showed a decrease during KC, and all features decreased in the post-KC period ($p \leq 0.01$). The BB mattress as employed in this study did not affect HRV.
Conclusion: Unlike KC, a mattress that attempts to mimic breathing motion and heartbeat sounds does not affect HRV of preterm infants.

1. Introduction

Kangaroo care (KC) refers to a period in which a diaper-clad infant is lying prone on a naked caregiver's chest, in direct skin-to-skin contact. It is a frequently used intervention in preterm infants since it reduces morbidity and mortality and is safe, even in infants who are born very prematurely [1]. KC is associated with multiple physiological benefits such as improved regulation of temperature and sleep [2–5].

Previous research demonstrated that features of heart rate variability (HRV) could capture regulatory changes taking place during KC [6]. HRV reflects the dynamic, rapidly occurring changes in autonomic regulation caused by the primary physiological systems controlling the heart rate – the sympathetic nervous system (SNS) and the parasympathetic nervous system (PSNS). These neuronal pathways can

modulate heart rate from one beat to another in response to environmental changes [7,8]. In preterm infants, this beat-to-beat variability decreases during KC, owing to a decrease in the magnitude of transient heart rate decelerations, a feature reflective of regulatory instability [6]. In other words, in preterm infants, KC improves regulation despite their physiologically immature autonomic nervous system.

To enhance KC, hospitals strive to increase kangarooing by coaching parents about its importance [9]. Also, the industry aims to develop devices intended for facilitating, augmenting and simulating aspects of KC. Examples of these potentially include KC chairs, KC vests, and products using parental or familiar scents and those that generate biological sounds, as well as mattresses that can generate breathing-like motion [10]. In theory, such devices, aiming to simulate aspects of KC can play a role in improving regulation in preterm infants. Such devices might be especially important when parents are unable to spend sufficient time kangarooing, for various reasons, for instance, due to long distances from home to hospital and limited parental leave after birth, or back-to-work obligations [11]. While it is well accepted that decreasing exposure of neonates to noxious stimuli such as handling, light, and noise improves outcomes [12], at present, there is insufficient evidence to suggest that stimuli reminiscent of parental presence or the fetal environment are beneficial and should be incorporated into routine clinical practice [10]. However, as devices using such stimuli become more commonly available, formal quantitative and qualitative analyses will be required to ascertain their usefulness in improving neonatal care.

One such CE-certified device is the BabyBe (BabyBe GMBH, Stuttgart, Germany), a mattress that aims to mimic the sounds of heartbeats and the motion of a breathing chest [13]. Since HRV predictably responds to KC, we conducted a study to investigate whether the BabyBe can simulate KC as measured by features of HRV.

2. Method

Clinically stable preterm infants, born between 26 and 34 weeks gestational age and admitted to the neonatal intensive care unit (NICU) of Máxima Medical Centre from October 2016–March 2017 were incorporated into the study at the earliest suitable occasion after admission. Exclusion criteria were any serious clinical conditions at the time of inclusion (e.g., sepsis, necrotizing enterocolitis), conditions that interfered with breathing (mechanical ventilation), and severe brain pathology (intraventricular haemorrhage grade III/IV or cystic periventricular leukomalacia). Since, aside from providing an alternative (CE-certified) mattress, the study was of an observational nature, the medical ethical committee provided a waiver in accordance with the Dutch law on medical research with humans (WMO). Written informed consent was obtained from parents for allowing their baby to be cared for on a BabyBe mattress. Table 1 characterizes the study participants.

For infants who were included in the study, the routine mattress was

Table 1
Patient characteristics at birth and on the days corresponding to intervention (KC and BabyBe).

Characteristics	Median	25th percentile	75th percentile
Gestational age (weeks)	29.0	27.6	30.6
Birth weight (g)	1267	1030	1437
No. of KC sessions in each infant	9	5.5	11
Duration of KC sessions (min)	100	81	124
PMA during first KC session (weeks)	30.6	29.8	31.4
PMA for all KC sessions (weeks)	31.3	30.6	32.0
Postnatal age during KC (days)	11	5.5	26
Duration of data collection period (days)[a]	6	4.5	10.5

Legend: Abbreviations: KC, Kangaroo care; PMA, Post menstrual age.
 [a] Defined as the number of days between the first and the last days of the intervention.

Fig. 1. The BabyBe mattress.
The BabyBe mattress has two incorporated lung-like air bladders for mimicking chest motion and one smaller, round air bladder in the middle for mimicking heartbeat sounds. The air bladders are attached to two tubes (one for the two lung-shaped air bladders (blue) and one for the round air bladder (white)) that exit the mattress to be connected to the control module which is responsible for inflating and deflating the bladders at the right pace. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

replaced by the BB mattress (shown in Fig. 1) for the entire duration of the study. The BB mattress is a medical device (class 1) that attempts to simulate breathing motion and the sounds of heartbeats passively by periodically inflating air bladders that are incorporated within the mattress [13]. For simulating breathing, two lung-shaped air bladders are sinusoidally inflated at a rate of 13 cycles per minute, corresponding to the typical breathing rate of an adult at rest. For the heartbeats, an air bladder (in between the lung-shaped air bladders) is biphasically inflated and deflated at a frequency of 68 cycles per minute to mimic the lub-dubb sounds of a heartbeat (57 dB). Notably, the inflation of this air bladder is audible but not palpable. When the mattress is switched off, it does not move nor sound. The mattress was only switched on during the periods of intended use after KC.

Since KC visibly changes HRV, we designed a study to explore whether the simulation of parental presence by the BB mattress exerts a similar effect. Nurses were asked to switch on the BB mattress 2 after every KC session. This washout period of 2 h allows for any lasting effect of KC to wear off. Since, on average, KC sessions in our unit are approximately 90 min long, nurses were asked to leave the BB mattress on for 90 min as well. For every KC and BB-session, nurses annotated the start and end-times. This within-subject design controlled for inter-individual differences in HRV due to for instance gender, gestational age and postmenstrual age. Each infant was included in the study until approximately 10 KC and BabyBe sessions were obtained, which on average took a week.

As is also described in a previous publication, all KC sessions that were shorter than 60 min were excluded from the analysis since a 30-minute stable period was required during KC for statistical comparisons and to reduce effects of transfers from and to the incubator [6]. Similarly, BB sessions that were shorter than 60 min or which started within 2 h of the last KC-session were excluded. All patient monitor data,