Original Article

The Effect of Fetus Stimulation Techniques on Newborn Behavior

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Abstract

Background: Many factors affect fetal behavior, which can also affect the baby's capacity and change interaction with the caregiver. The aim of this study was to investigate the effect of performing fetal sensory systems stimulation techniques by mother during pregnancy on the neonate's habituation behavior. **Materials and Methods:** This semi-experimental study was conducted in 2019 in Isfahan, Iran. Mothers who referred to public comprehensive health centers in the 27th week of gestation and met the inclusion criteria were selected by convenience sampling method and randomly assigned to two groups of intervention and control. Fetal learning programs were held twice a day from the 27th week to the end of the pregnancy. The habituation domain of the neonate's behavior was assessed by the Brazelton's Neonatal Behavioral Assessment Scale (BNBAS) 3–5 days after the delivery. The mean score of habituation domain of BNBAS among 72 subjects in the intervention and control groups was compared by the Mann–Whitney test. **Results:** The habituation domain of all 72 newborns born approximately at the gestational age of 38 weeks was assessed. The Mann–Whitney test results indicated that the two groups were significantly different in terms of the total mean score of habituation domain 3–5 days after birth ($z = -4.37$, $p < 0.001$) and the score of the intervention group was higher than that of the control group. **Conclusions:** Generally, it can be concluded that the fetal stimulation techniques can positively affect the neonate's behaviors including the domain of habituation.

Keywords: *Fetus, learning, pregnancy, Infant, Newborn, behavior*

Introduction

Is the effect of prenatal exposure to stimuli retained and can the fetus learn? This question is relevant to the controversial issue that whether or not fetal neurodevelopment can be improved positively.[1] Favorable environmental conditions can help individuals to reach their innate ability, and this is justified and valuable.[2] According to Piaget, in the first period of intelligence development, that is, the period of sensory-motor development from birth to the age of two, a child learns to achieve perceptual harmony by performing simple reflective actions.[3] Today it is known that the collection, assessment, and response to sensory inputs begin even before birth.[4]

During the fetal life, synaptic connections are progressively and dramatically established in the brain. The processing capacity of the sensory receptors depends on the evolution of the connections in the cerebral-nervous system.[5] From the eighth month of pregnancy to adulthood, the number of neurons and synapses decreases. The maximum number of neurons remaining in the fetus depends on the neurons or group of neurons that establish the sufficient number of connections.[6] By stimulating different sensory systems of the fetus, one can reduce the removal of neurons and increase the number of connections.[5]

Fetus is able to hear the bass sounds since weeks 19–20.[7] Around weeks 23–25, fetus develops active listening and shows sound preferences. The techniques used to stimulate the fetus auditory system include the mother's speaking to the fetus and using music with simple rhythm and melody.[8] There is evidence suggesting that an environment filled with auditory stimuli may play a key role in modulating plasticity in the perinatal period. Plasticity in the nervous system during the early stages of the development is indicative the human's learning ability before the birth.[9] Besides, from the 27th week of pregnancy, the touch receptors at the terminals of the sensory neurons are able to convert mechanical pressure into electrical waves,

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and the fetus begins to understand the sense of touch. Thus, the best time for the first tactile stimulation is from the 27th week of pregnancy.[7] Touching and tapping the womb together with the kicking game of the fetus are among these techniques.[8] Because of these stimulation programs, children become habituated to their environment faster and grow more effectively.[4] Habituation means that neonates gradually reduce their response to a repetitive stimulus and allow that stimulus to be ignored and, doing so, their energy is stored for physiological needs.[9] Habituation is a useful criterion for evaluating the neurobehavioral health of the neonate.[10] Brazelton's Neonatal Behavioral Assessment Scale (BNBAS) was utilized to evaluate the cognitive development of the neonate as well as the habituation domain of the neonate after birth.[11] There is a correlation between the speed of habituation and the score of development in infancy.[1]

Numerous programs have been developed for fetal learning during the perinatal period. These techniques can enhance brain development and fetus's learning, thereby promoting the mother-fetus relationship in both perinatal and postnatal periods.[4] Paradoxically, although it has been argued that the natural sensory environment of the uterus is suitable for the fetus development, the intrauterine sensory stimulation programs have not been extensively studied and cannot be proven to be beneficial.[12] Thus, the researcher decided to use a program to stimulate fetal sensory systems based on a review of the available literature in order to examine the effectiveness of these stimulus programs on newborn behavior.

Materials and Methods

This semi-experimental study was conducted on two groups of intervention and control from June to October 2019 in Isfahan, Iran. The study environment was the midwifery unit of the selected public comprehensive health centers. The sample size for each group was 36 subjects. According to the studies on fetus and newborn behavior, the sample size of at least twenty fetus in each group can show behavioral differences in fetus and neonates.[1] A value of $p < 0.05$ was considered to be the significance level.

Inclusion criteria for both the control and intervention groups consisted of 18–35-year-old mothers, first pregnancy, gestational age of 27 weeks based on the ultrasound before week 20, no history of medical disease, no use of psychedelics, no smoking, no alcohol consumption during pregnancy, no depression, accepted pregnancy, and an ultrasound in the week 20 showing the normal development of the fetus. Exclusion criteria were unwillingness to continue participation in the study, failure to perform the technique for two weeks or more, the presence of disorders that make pregnancy high risk including preeclampsia, placenta previa, multiple pregnancy, abnormal volume of amniotic fluid, medical disorder induced in pregnancy, emergency caesarean section caused by meconium excretion, placental abruption, labor dystocia and fetal distress, instrumental delivery, first and fifth minute Apgar scores of less than 7 and 8, lower than 2500 or more than 4000 g birth weight, gestational age of lower than 37 weeks or more than 42 weeks during the birth, stressful events during the study, lack of physical health of the newborn, medically unstable newborns, and diseases leading to the newborn hospitalization.

The sampling was performed by the quota method from the selected public comprehensive health centers of Isfahan (Dastgerd, Kojan, Navab). In these centers, childbirth preparation classes were held and more mothers came to this centers. At first, the mothers who met the inclusion criteria and were willing to participate in the study were selected using the convenience sampling method. The subjects were assigned to the intervention and control groups randomly. Totally, 36 pregnant mothers were in the intervention group and 36 ones in the control group. The fetus stimulation techniques were taught only by the researcher in the intervention group in one session. The prenatal stimulation techniques including the stimulation of the auditory system through talking to the fetus and playing music and the stimulation of the tactile system through kicking and abdominal touch were performed from the third trimester of the pregnancy.

The stimulations were performed twice a day for 10 min, in the morning and at night. In the morning, the fetal auditory and tactile systems were stimulated. Mozart's music was used to stimulate the auditory system. The mothers were asked to adjust the speaker volume to the midrange and place the music player within 20 cm of their womb. In this situation, a sound with an intensity of 65 dB was generated inside the uterus that did not damage the fetus and has also been used in previous studies.[13] The mothers were asked to turn on the music player and place their hands on their womb in a relax position. They were also asked to move their hands gently over their womb and touch the area of the womb where the fetus began to kick or move. At night, the mothers were asked to sit comfortably, in the Fowler's position or lateral position, and stimulate the tactile and auditory systems of the fetus, talk to their fetus loudly and calmly for 10 min and place their hand on their womb while reading the conversation text, touch their womb and their child's body, and whenever their child began to move, hit their womb slowly. Conversation text was about the good human morals and good wishes of the mother for her baby. The mothers were asked to perform the techniques on a daily basis. During the study, the samples of the intervention group were contacted once a week to ensure that the techniques are performed correctly. The implementation of the techniques began at week 27 (the first time the fetus sensory systems became functional) and continued until the end of the pregnancy (at least about 10 weeks).

The materials related to the delivery preparation classes were instructed to the control group in accordance with

the book compiled by the Department of Treatment and Nutrition Education of the Ministry of Health during the pregnancy by the staff of each unit, and the monthly telephone follow-up was conducted for pregnancy trend and lack of the exclusion criteria until the delivery.

Questionnaire was used to collect data by examining the variables including the mother's age, economic status, mother's education, gestational age at birth, type of delivery, neonate sex, and birth weight in various stages. In addition, the BNBAS Likert scale was used to assess the neonate's habituation domain. For this purpose, 3-5 days after the delivery, the samples were asked to refer to the selected midwifery units or the researcher visited them in their homes. The BNBAS is a means of scoring interactive behavior for term and stable infants. The scale consists of seven domains of newborn behavior each of which is scored based on a 9-point scale and 20 elicited responses. As a valid and approved scale, BNBAS has been used in more than 700 studies around the world.[14] In the habituation domain, the decrement of response to the visual, auditory, and tactile stimuli was examined using flashlights, rattles, and tactile stimulation of the sole in a warm, quiet, and dark environment in the medically stable neonates and between meals only by the researcher as the master student of midwifery. Behavioral responses are scored from 1 to 9, where score 9 is given to the best behavioral performance.[15] The evaluation took 30 min to 1 h. The SPSS software (version 16, SPSS Inc, Chicago, IL, USA) was used for statistical analysis [Figure 1].

Ethical considerations

With the ethics code of IR.MUI.RESERCH.REC.1397.313, this study was approved by the Isfahan University of Medical Sciences, Isfahan, Iran. The informed consent was obtained from all mothers before entering the study.

Results

As Table 1 shows, the demographic variables, fertility characteristics of mothers, and characteristics of neonates are compared between the two groups and analyzed by the independent *t* test, Mann–Whitney test, and Chi-square test. None of the tests were significant and, thus, the two groups were homogeneous in terms of the individual and demographic variables, fertility characteristics of mothers, and characteristics of neonates.

The Mann–Whitney test results indicated that the mean total score of habitation domain of BNBAS was 6.38 (1.10) and 5.32 (0.08) in the intervention and control groups, respectively, and there was a statistically significant difference between the two groups ($z = 4.37$, $p < 0.001$). Moreover, the scores of the three constructs of habituation including the light response decrement score ($z = 3.20$, $p = 0.001$), the rattle response decrement score ($z = 4.50$, $p < 0.001$), and the foot touch response decrement score ($z = 3.16$, $p = 0.002$) had a statistically significant difference between the two groups three days after birth, and a higher score was reported in the intervention group [Table 2].

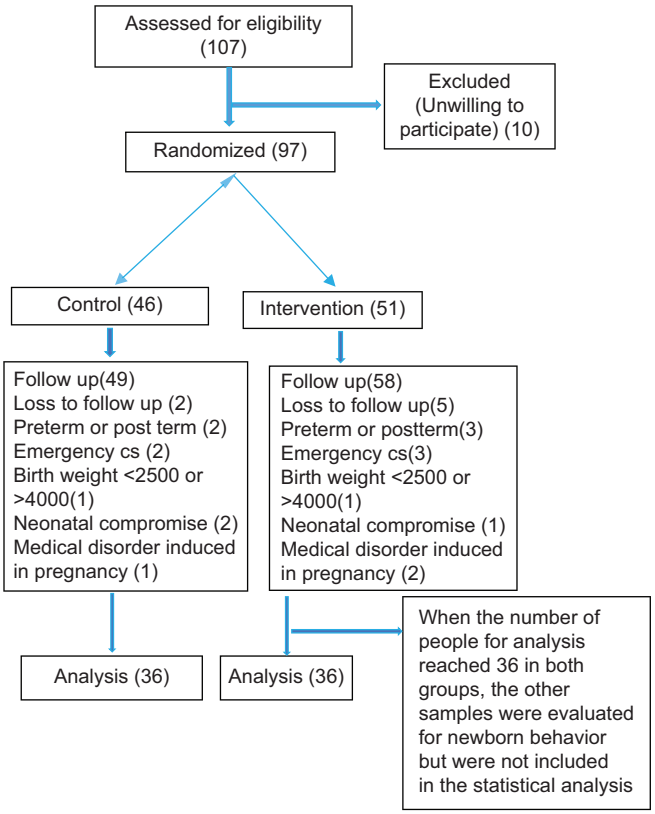

Figure 1: Consort flow diagram of intervention and control groups in the study. CS: Cesarean Section

Discussion

The aim of this study was to examine the effect of fetal sensory systems stimulation techniques on the neonate's habituation behavior. According to the findings, there was a statistically significant difference in the total score of habitation domain of BNBAS between the two groups 3–5 days after the birth. In the three sub-branches of habituation domain in the intervention group, the mean score was higher, indicating that fetal stimulation techniques were effective on neonatal habituation behavior and the habituation of the neonates of the intervention group was faster than that of the control group. With regard to the light response decrement item, the body movements, respiratory changes, and blinking stopped after 5–6 and 9–10 times of presentation of the stimuli in the intervention and control group, respectively. In the rattle response decrement case, the body movements, respiratory changes and blinking stopped after 7–8 times of presentation of the stimuli in the intervention group and 9–10 times in the control group. In the foot stimulation response decrement, the response to the foot stimulation was limited to the stimulated foot and the neonate did not respond after 1–2 and 3–4 times of stimulation in the intervention and control groups, respectively.

Table 1: Comparison of relevant maternal and neonatal variables between intervention and control groups

Variables		Intervention (36) *n* (%)	Control (36) *n* (%)	Statistical test	*p*
Economic status	weak	3 (8.30)	6 (16.70)	0.59**	0.551**
	moderate	26 (72.20)	23 (63.90)		
	good	7 (19.40)	7 (19.40)		
Delivery	NVD****	19 (52.80)	22 (61.10)	0.51*	0.475*
	CS*****	17 (47.20)	14 (38.90)		
Neonate sex	male	17 (47.20)	19 (52.80)	0.22*	0.637*
	female	19 (52.80)	17 (47.20)		
Mother's education	Highschool	0 (0.0)	1 (2.80)	0.44**	0.659**
	Diploma	11 (30.60)	8 (22.20)		
	College	25 (69.40)	27 (75.00)		
Variables		**Intervention (36) Mean (SD)**	**Control (36) Mean (SD)**		
Mother's age		28.88 (3.95)	27.66 (4.30)	-1.25***	0.214***
Gestational age at birth (week)		38.58 (0.09)	38.64 (0.88)	-0.52**	0.597**
Birth weight (kg)		3.05 (0.54)	3.19 (0.29)	-0.73**	0.464**

*Chi-square, **Mann-Whitney, *** independent *t*, ****Normal Vaginal Delivery, *****Cesarian Section

Table 2: Comparison of habitation domain score of BNBAS* and its constructs in the intervention and control groups

Variables	Intervention (36) mean (SD)	Control (36) mean (SD)	Mann-Whitney test	
			Z	*p*
Response decrement to light (1-9)	6.16 (1.32)	5.08 (1.38)	-3.20	0.001
Response decrement to rattle (1-9)	6.33 (1.19)	5.22 (1.28)	-4.50	<0.001
Response decrement to foot probe (1-9)	6.63 (1.09)	5.66 (1.28)	-3.16	0.002
The total average of habituation domain	6.38 (1.11)	5.32 (0.83)	-4.37	<0.001

*Brazelton's Neonatal Behavioral Assessment Scale

Habituation is a basic form of learning.[9] The retention of a change in learning is called memory.[16] Possible functions of fetal memory are practice, recognition of and attachment to the mother, and language acquisition.[9]

In this regard, the result of the study conducted by Arya *et al*.[15] showed that the exposure of the mother to music during her pregnancy has a significant effect on the neonate's behavior. Moreover, it was revealed that the neonates of the intervention group had a better performance in the five behavioral areas of the BNBAS test including the habituation area. Although results of this study are consistent with our results, music in our study was played directly at a distance of twenty centimeters from the mother's abdomen, while in the Arya's study, the mother listened to the music through headphones. Structured sounds, such as music, can influence the organization and synaptogenesis in the brain. Listening to music induces neurogenesis in the hippocampus, produces and repairs nerves by modulating the secretion of steroid hormones and, ultimately, enhances the brain plasticity. Being exposed to music before the birth can change the behavioral modes of the fetus and increase the baby's attention after birth.[9]

Similarly, a study was conducted by Persico. G *et al*.[17] in Italy in 2016. Consistent with the results of our study, their study showed that reading lullabies by the mother can enhance the mother-neonate bonding, while it has positive effects on neonate behavior. Habituation to speech sounds is also essential for the development of speech and language of the baby.[18] Frequent prenatal contact is essential to distinguish the maternal postnatal voice.[19] However, in contrast to our study where both auditory and tactile systems were stimulated, in the Persico's study, only the auditory system was stimulated. Quite contrary, a study by Van der Walt showed that performing these techniques had no effect on postnatal bonding of mother and her infant.[14]

Some studies have provided evidence for the importance of tactile stimulation to health, early development and growth. Marx and Nagy in their study showed that fetuses had a tendency to reach out and to touch the uterus wall when the mother touched her abdomen and also touched themselves less during the mother's touch.[20] The premature neonates showed facilitated growth, increased weight gain, better sleep, and higher scores on the BNBAS after massage.[21] Tactile stimulation is beneficial to the mother and reduces stress level in the mother as well.[20]

Each of these techniques alone can contribute to the fetus development and affect the neonate behavior. In the present study, the samples were not divided into two separate groups to investigate the effect of each of the fetus stimulation techniques, and it is not clear whether the positive effect on neonatal habituation was due to the simultaneous use of the techniques or that each technique alone had a significant effect on the neonate's habituation. Therefore, further studies are required to measure and compare

the effects of each technique (tactile and auditory stimulation) on the neonates's habituation separately.

Conclusion

Fetal stimulation techniques can bring about positive effects on the neonate's behaviors including the area of habituation. Therefore, mothers are advised to perform these techniques from week 27 of gestation as the best time for performing these techniques in order to observe the beneficial effects of them on neonate behavior and the mother-neonate bonding.

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Conflicts of interest

Nothing to declare.

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