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Original Article

Exercising during pregnancy: An experimental study of its effects on cognitive development in early infancy

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Abstract

Introduction: Active lifestyle during pregnancy will have a constant impact on mother and Infant. The research aimed to investigate the effects of maternal activity during pregnancy on the child's cognitive development during the three months after birth.

Materials and Methods: In this experimental study, 40 mother-child pairs were selected and randomly divided into two experimental group and control group. The experimental group benefited from 16 sessions of 50 minutes of physical intervention and control group did not have regular physical activity. Finally, the infants of two groups were evaluated by Ages-Stage questionnaire (ASQ 3) in two periods of one and three months. In order to examine the hypothesis, they were used repeated measure analysis of variance and independent t test for the investigation of differences between the two groups. All statistical analysis was conducted with SPSS-22 software.

Results: The results showed that maternal physical exercise in the experimental group improved the problem solving skills and the main effect of time (F=27.55, *P*=0.001) and group (F=78.13, *P*=0.001) was significant.

Conclusion: The obtained results confirmed that physical activity during pregnancy can increase the infant's cognitive development.

Keywords: Cognitive development, Exercise, Infancy, Pregnancy

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Introduction

Human development is a varied and complex field of study that is influenced by genetic, environmental and responsibility factors (1,2). Among the factors affecting the development, mother lifestyle and their activities is crucial (2,3,4,5).

The American College of Obstetrics and Gynecology (ACOG) and some studies in this field, has published guidelines for exercise during pregnancy and offer cardio activities such as walking, jogging, dancing, swimming, cycling (6,7), running on a treadmill (8,9), participate in water and recreational activities (7), balance and coordination training programs, strength training program, muscle strengthening exercises (6), stretching and relaxation exercises (10,11), yoga (12,13), walking at moderate intensity with a heart rate less than 140 beats per minute (6,12,14), active lifestyle before pregnancy and daily usual activities (15). The type, intensity, and duration of training[16] sessions and preparation maternal of light to moderate intensity exercise are recommended for all pregnant women (17,18).

A 30-minute activity by increasing the core temperature less than 1.5 ° Cis defined as the safe limit (8,19,20). According to the Guide to Sports Medicine Australia (SMA) (2002) activities with an average of 43 minutes and in the Tomic et al. (2013) research recommended 50 minutes of activity. Some studies have been done on exercise frequency, complained that an 8-week period three days a week is considered as the optimum time for an exercise protocol (12,17,19). Researches in this area are limited and require further study. Animal studies in the field of pregnancy showed that physical activity in pregnant mice is followed by the neurogenesis in the hippocampus of children (21). Furthermore, in other studies, it was observed that active mothers have a better nerve growth in children between the ages of 12 and 24 months. Similarly, on motion organ, modes of behavior, general intelligence and learning language the practiced groups are superior and this difference will be maintained in following years (3,6). In the study of Clapp et al. (1998) the scores of mental skills of children with active mothers during pregnancy was high but there was no statistically significant difference between groups. While in children of the experimental group at the age of five had significant differences in verbal skills (22). On the contrary, Jukic et al. (2013) showed that leisure activities have an impact on children's verbal intelligence and general physical activity because of stress and other negative factors can have a negative effect on verbal intelligence (21).

Conducting this research is necessary given the importance of development in the first years of life and to raise awareness of sustainable effects in pregnancy on cognitive development of children. This study sought to find an answer to the question whether physical activity during pregnancy has effect on problem-solving skills as a cognitive variable of one and three month's infants?

Materials and Methods

This was an applied research and experimental research methods and the study design of randomized groups was used. Participants in this study were pregnant women who attended to health care centers of Bojnurd. The sample size was determined using the G * Power software. To study the effect size of 0.33, significance level of 0.05 was considered to be 0.8 test and the results showed that the optimal value for each group of 20 participants. They were selected through purposive sampling and were randomly assigned to two groups (n=40).

The inclusion criteria for the study were all nulliparous pregnant women[1], non-athletes and housewives (20,23) admitted to city hospitals and prenatal care centers of Bojnurd.

They had a gestational age of 23 to 34, and according to their health records, body mass index (BMI) before pregnancy (20 to 24.9 kilograms per square meter) was normal (23,24). Similarly they had a normal singleton pregnancy at term (37-41 weeks) with the birth of a healthy baby (without any apparent anomalies) (25,26).

The subjects had no previous history of any underlying disease and were controlled based on their medical records (20,23,24). If there was any contraindication to participate in the exercise by the individual practitioner like bleeding during pregnancy, not want to participate in the interventions and not participate in 80% of training sessions, they were excluded from the study (26,27). Similarly, premature birth and infant in NICU hospitalization led to their withdrawal from the study (25). Thus the final number of mother-child pairs was 36.

After getting permission from North Khorasan University of Medical Sciences, we referred to health care centers and after receiving their consent, the experimental group participated from the end of twenty-third week of pregnancy in an intervention period of about 8 weeks with 16 sessions of activity. The activity time was 50 minutes and it was consisted of two parts. The first part includes a 5 minute warm-up, specialized training, such as walking at moderate intensity (60-75 percent of maximum heart rate), massage, relaxation, and 5 minutes of cooling down. In the first part of training time from 25 minutes rose to 40 minutes in the last week. In the second part 10 minutes of teaching breathing skills and correctly position were taught to them (11,19). The selected movements were carried out with the approval of a gynecologist and obstetrician monitoring. After intervention and mothers labor, infants were evaluated between the ages of 1 and 3 months for cognitive development.

A demographic questionnaire assessed the general information and physical activity status of mothers. According to the Kuppuswamy's Socioeconomic Status Scale which is based on the combined scores of education, occupation and monthly income of households (score range 3-29), the participants in this study had moderate to high socio-economic level (28). Ages and stages Questionnaire (ASQ) was used to evaluate the development rate of problem-solving component. The ASQ Questionnaire is the screening questionnaire of development and in the new version states that a detailed investigation of unparalleled samples from 15,138 children with high variety show that ASQ-3 is reliable and valid. ASQ-3 has excellent sensitivity (0.86) and specificity (0.85) that has adequate accuracy for screening. Strong test-retest reliability of 0.75 to 0.82, inter-rater reliability by comparing the filled-in forms to parents and professional examiners was 0.93. The internal consistency of the questionnaire was represented by correlation between scores and the total score for each area. The Pearson correlation coefficient for scores and total score of 0.60 to 0.85 areas of development were achieved at the level of $p < 0.01$ that is significant[29]. In this study, the Shapiro-Wilk test was used for normality of data distribution and the independent t-test was used in order to examine the hypothesis of repeated measure analysis of variance (2×2) and to study the differences between the two groups. The significance level for all inferential statistics, $p \geq 0.05$ was considered. Also all statistical analysis was conducted using SPSS-22 software.

Results

After collecting the mean (SD) age, weight, height and body mass index of participants in both control and experimental groups, the mean and standard deviation of problem solving skills variable of participants in both groups at one month and three months were

showed which the age of 2 months from the first measurement to the second measurement, increase the children's groups.

In order to test this hypothesis scores Ages and Stages Questionnaires were used which the results of repeated measure analysis of variance (2 × 2) can be seen in the table below.

Table 1. Analysis of variance to compare two sizes of repetitive measurements in children

Factor	Square sum	D.F	Mean square	F	Sig	Partial eta squared
Time	975.3	1	975.3	27.55	* 0.001	0.448
Error	1203.4	34	35.39			
Group	4125.3	1	4125.3	78.13	*0.001	0.697
Error	1795.1	34	52.79			
Time interaction × Group	58.48	1	58.68	1.65	0.207	0.046

* The significant level of $p<0.05$

As the results can be seen in the table, the main effects of time and group is significant but the effect of group × time interaction is not a significant. It means that there is a difference between the two groups during one month and three months but this difference was not so significant that would be reported as significant interaction effect. Thus, we can say that exercise during pregnancy on children's problem-solving skills improvement was statistically ineffective. The partial eta squared was used to estimate the effect size that shows the effect of physical exercise on cognitive development. In other words, about 5 percent of the total variance is due to the independent variable on the dependent variable and other factors affect the results of which will be explained.

Discussion

Prenatal period is known as unique physiological valve which the compatibility between mother and fetus during is acquired and it has major consequences on infants health (3,30). This study also aimed to assess the effect of maternal physical activity during pregnancy on the development of problem solving skills in infants.

Barakat et al. had consistent findings with this study and they stated that physical activity during pregnancy has no significant effects on features of physical and cognitive development (31). Clapp et al. also said that the scores of mental skill of one year children with active mothers during pregnancy are higher, although there was no statistically significant difference between groups, while the children of experimental group at the age of five had significant differences in verbal skills. The available environmental stimuli for children are among affecting reasons in addition to mother exercise during pregnancy (22). Jukic et al. study showed that recreational activities have no an impact on children's verbal intelligence and general physical activity can have a negative effect on verbal intelligence because of stress and other negative factors. They claim that physical activity may specifically improve memory and cognition associated with related word and it is not associated with improved verbal intelligence (21).

The size of obtained effect did not approve the significant differences between the groups in two times which can be due to other factors such as gender, motivation, learning capacity, motor abilities, maturity, physical size, body composition, training opportunities, and so on. Many of these factors are correlated (i.e. chronological age and biological age, cultural support and training opportunities) however, their exact relationship is unclear (32). Other factors affecting the study were: smoking, nutrition, children weight (3,34,35), parent-child interaction (33), parenting method (36) and medical history (37).

Kjøbli et al. in their study stated that children IQ in their early life is a sign of cognitive development that is significantly associated with genetics (33). The BMI of mothers and fathers is also associated with children development (34,38,39). Similarly, Casas et al. stated that obesity is associated with intellectual disabilities (IQ 50-70) at age 11. Obesity and overweight is related with an increased neurotoxin (such as poly-chloride, and mercury) and that limits brain growth (39). In this study, weight changes during the intervention, the type and amount of mothers' food compared to their activity was not measured that could be one of the reasons affecting cognitive development of children. In addition, information about father's weight as a parent was not available.

As it was mentioned at the beginning, one of the most effective environmental factors affecting development is nutrition during pregnancy (15,19,33). Calcium, phosphorus and potassium is very effective on fetal growth, which should be provided by mother's feeding (31). Angulo-Barroso et al. study confirms that supplements such as iron help myelination, neurotransmitter function of metabolic activity (40). In addition to supplements, as well as at birth, breastfeeding is effective on children's development (33,36). The breastfeeding leads to improved skills and language development (33,36). Children who were breastfed showed a higher Electroencephalography (EEG) activity and better cognitive and motor development. Feeding is an essential part in the development and is associated with mature structure and brain activity. At least six months of breastfeeding helps to prevent developmental delay (36).

From the perspective of dynamic systems, motor proficiency affects children, movement and the environment task (34,41,42). The effect of providers, the home environment by creating space and providing toys to children helps improve motor development (43). Various and appropriate toys improve problem solving skills, hand eye coordination and development of manipulative skills. Toys are the available predictor of cognitive and motor skills (36). Although in this study, the parents' reports, environmental conditions appear to be identical, however the optimal use of available tools were not available.

Diversity training, time and the intensity are effective in obtaining results (22,26,31,44). ACOG guidelines emphasize the severity of the specific programs should be designed on the basis of primary capacity (44). In this study, the training protocol approved by the Ministry of Health was used but the likely duration and intensity of exercise is not enough. The mechanism by which maternal exercise on fetal growth and development is not clear and many controversies can be seen. Some studies have stated that by doing aerobic exercise more than 30 minutes late in the pregnancy, the mother's blood glucose concentrations are decreased (23,31,45) and the reduced sugar available to the fetus can limit the growth which has negative impact on children's cognitive and psychomotor development (3). On the other hand expressed, by doing, improve oxygen supply to the fetus, high plasma volume, cardiac output and better blood flow happened in the placenta and fetus and it is followed by better development (46). Although the results of this study are consistent with previous results expressed by positive effect of physical activity on children's development is coordinated, but despite the differences, more research needs to be done.

Another point of consideration that has effect on results is the number of analyzed samples and their diversity (45,46). More samples provide more accurate results which one of the limitations of the study. Limitations of the tools were also remarkable. Velikonja et al. stated that there is an average value for the reliability and validity, sensitivity and specificity of the ASQ3 questionnaire.

Cronbach's alpha value down to scales of problem-solving skills at the age of 24 months was 0.53 (47). Veldhuizen et al. suggest that the sample size, age range of children, country, and responsiveness to questions, language and reference for measuring are effective for test results. One of the concerns in the use of ASQ3, is the high false-positive data that seen among children: half the people who their two months questionnaire ASQ (between 1 and 3 months) was used had low scores in one or more subscales (48).

The study design used in this study had limitations. The first is that the effect of the independent variable to control samples were selected by a large number of criteria that are representative of a large community and the obtained results for the same sample was used and cannot be generalized. Second, the current data set cannot generally control all confounding factors like test sensitivity and specificity. Studying the children in the early days of life and the relationship of its primary developmental outcomes and their implications for the future was the salient features of this study. However, the need for further studies to identify the effect is lasting.

Conclusion

Exercising and physical activity for healthy mothers can have great potential benefits. The results showed that maternal physical activity during pregnancy can lead to improved problem solving skills although no significant difference was seen. However, due to conflicting results that was mentioned and given the importance of cognitive development in infancy and its relation to the future consequences such as academic achievements and functions of the brain, more research should be conducted in this regard.

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