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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 influenced by genetic, environmental, and responsibility factors (1,2). Among the factors affecting development, the mother's lifestyle and activities are crucial (2-5).

The American College of Obstetrics and Gynecology (ACOG) and some studies in this field have 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

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(12,13), walking at moderate intensity with a heart rate less than 140 beats per minute (6,12,14), active lifestyle before pregnancy and usual daily activities (15). The type, intensity, and duration of training16 sessions and maternal light to moderate intensity exercise are recommended for all pregnant women (17,18).

A 30-minute activity by increasing the core temperature to less than 1.5 ° Cis defined as the safe limit (8,19,20). According to the Guide to Sports Medicine Australia (SMA), activities with an average of 43 minutes, and the Tomic et al. research recommended 50 minutes of activity. Some studies have been done on exercise frequency, complaining that eight weeks three days a week, is considered the optimum time for an exercise protocol (12,17,19). However, researches in this area are limited and require further study. Animal studies in pregnancy showed that physical activity in pregnant mice is followed by neurogenesis in the hippocampus of children (21). Furthermore, other studies observed that active mothers have better nerve growth in children between 12 and 24 months.

Similarly, on the motion organ, modes of behavior, general intelligence, and learning language, the practiced groups are superior, and this difference will be maintained in the following years (3,6). In the study of Clapp et al., the scores of mental skills of children with active mothers during pregnancy were high, but there was no statistically significant difference between groups. While children of the experimental group at the age of five had significant differences in verbal skills (22). On the contrary, Jukic et al. showed that leisure activities impact children's verbal intelligence and general physical activity because stress and other negative factors can negatively affect verbal intelligence (21). This study sought to find an answer to the question of whether physical activity during pregnancy affects problem-solving skills as a cognitive variable of three-month infants.

Materials and Methods

This was applied research and experimental research methods, and the study design of randomized groups was used. Participants in this study were pregnant women who attended health care centers in Bojnurd. The sample size was determined using the G * Power software. To study the effect size of 0.33, a significance level of 0.05 was considered a 0.8 test, and the results showed 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 women1, 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 wanting to participate in the interventions, and not participating 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. After receiving their consent, the experimental group participated from the end of the twenty-third week of pregnancy in an intervention period of about eight weeks with 16 sessions of activity. The activity time was 50 minutes, and it 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, they were taught 10 minutes of teaching breathing skills and correct position (11,19). The selected movements were carried out with the approval of a gynecologist and obstetrician. 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 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 levels (28). Ages and stages Questionnaire (ASQ) was used to evaluate the development rate of the problem-solving component. The ASQ Questionnaire is the screening questionnaire for development, in the new version states that a detailed investigation of unparalleled samples from 15,138 children with a wide variety shows that ASQ-3 is reliable and valid. ASQ-3 has excellent sensitivity (0.86) and specificity (0.85), and adequate screening accuracy. 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 the 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, which is significant (29). In this study, the Shapiro-Wilk test was used for normality of data distribution, and the independent t-test was used to examine the hypothesis of repeated measure analysis of variance (2 × 2) and to study the differences between the two groups. 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 shown, which the age of 2 months from the first measurement to the second measurement, increase the children's groups.

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

Factor	Square sum	DF	Mean square	F	P	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

*P< 0.05

As the results can be seen in the table, the main effects of time and group are significant, but the effect of group × time interaction is not significant. It means there is a difference between the two groups during one month and three months, but this difference was not so significant that it would be reported as a 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, which will be explained.

Discussion

The prenatal period is a unique physiological valve in which the compatibility between mother and fetus is acquired and has major consequences on infants' health (3,30). Therefore, this study also aimed to assess the effect of maternal physical activity during pregnancy on developing problem-solving skills in infants.

Barakat et al. had consistent findings with this study, stating 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 skills of one year children with active mothers during pregnancy are higher, although there was no statistically significant difference between groups, while the children of the experimental

group at the age of five had significant differences in verbal skills. The available environmental stimuli for children are among the factors besides mother exercise during pregnancy (22). Jukic et al. study showed that recreational activities have no impact on children's verbal intelligence, and general physical activity can harm verbal intelligence because of stress and other negative factors. They claim that physical activity may improve memory and cognition associated with the related word and is not associated with improved verbal intelligence (21). The size of obtained effect did not approve the significant differences between the groups 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's weight (3,34,35), parent-child interaction (33), parenting method (36), and medical history (37).

Kjøbli et al., in their study, stated that children's 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's 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 are related to an increased neurotoxin (such as poly-chloride and mercury), which limits brain growth (39). In this study, weight changes during the intervention and the type and amount of mothers' food compared to their activity were not measured, which could be one of the reasons affecting children's cognitive development. In addition, information about the father's weight as a parent was unavailable. As 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 are very effective in fetal growth, which should be provided by the mother's feeding (31). Angulo-Barroso et al. study confirms that supplements such as iron help myelination and neurotransmitter function of metabolic activity (40). In addition to supplements and at birth, breastfeeding is effective in children's development (33,36). Breastfeeding leads to improved skills and language development (33,36). Breastfed children showed higher Electroencephalography (EEG) activity and better cognitive and motor development. Feeding is essential 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 the development of manipulative skills. Toys are the available predictor of cognitive and motor skills (36). Although the parents' reports and environmental conditions appear identical in this study, the optimal use of available tools was not available.Diversity training, time, and intensity effectively obtain results (22,26,31,44). ACOG guidelines emphasize that the severity of the specific programs should be designed based on 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 are insufficient. The mechanism of maternal exercise on fetal growth and development is unclear, and many controversies can be seen. Some studies have stated that aerobic exercise more than 30 minutes late in the pregnancy decreases the mother's blood glucose concentrations (23,31,45), and the reduced sugar available to the fetus can limit growth, which harms children's cognitive and psychomotor development (3). On the other hand, by improving oxygen supply to the fetus, high plasma volume, cardiac output, and better blood flow happen in the placenta and fetus, followed by better development (46). Although the results of this study are consistent with previous results expressed by the positive effect of physical activity on children's development is coordinated, despite the differences, more research needs to be done. Another consideration that affects results is the number of analyzed samples and their

diversity (45,46). More samples provide more accurate results, which is one of the limitations of the study. The limitations of the tools were also remarkable. Velikonja et al. stated that there is an average value for the reliability, validity, 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, the age range of children, country, 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 was seen among children: half of the people whose 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 was selected by a large number of criteria representative of a large community, and the obtained results for the same sample were used and cannot be generalized. Second, the current data set cannot generally control all confounding factors like test sensitivity and specificity. Third, studying children in the early days of life and the relationship between their primary developmental outcomes and their implications for the future was the salient feature 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 could improve problem-solving skills, although no significant difference was seen. However, due to conflicting results mentioned and given the importance of cognitive development in infancy and its relation to future consequences such as academic achievements and functions of the brain, more research should be conducted in this regard.

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References

1. Shojaei M, Daneshfar A. [Motor development]. 3rd ed. Tehran: The Imam Hossein University; 2013. (Persian)
2. Polanska K, Muszynski P, Sobala W, Dziewirska E, Merecz-Kot D, Hanke W. Maternal life style during pregnancy and child psychomotor development- Polish mother and child cohort study. Early Hum Dev 2015; 91: 317-25.
3. Domingues M, Matijasevich A, Barros A, Santos I, Horta B, Hallal P. Physical activity during pregnancy and offspring neurodevelopment and IQ in the first 4 years of life. Plos One 2014; 9(10): e110050.
4. Oliveria Melo A, Silva J, Tavares J. Effect of a physical exercise program during pregnancy on uteroplacental and fetal blood flow and fetal growth. Obstet Gynecol 2012; 120: 302-10.
5. Ferraro Z, Gaudet L, Adamo K. The potential impact of physical activity during pregnancy on maternal and neonatal outcomes. Obstet Gynecol Survey 2012; 67: 2.
6. Kalisiak B, Spitznagle Th. What effect does an exercise program for healthy pregnant women have on the mother, fetus, and child? Am Acad Phys Med Rehabil 2009; 1: 261-7.
7. ACOG Committee opinion. Exercise during pregnancy and the postpartum period. Obstet Gynecol 2002; 99(1): 171-3.
8. Silva S, Almeida A, Fernandes J. Maternal exercise during pregnancy increases BDNF levels and cell numbers in the hippocampal formation but not in the cerebral cortex of adult rat offspring. Plos One 2016; 2016: 1-15.
9. Robinson A, Bucci D. Physical exercise during pregnancy improves object recognition memory in adult offspring. Neuroscience J 2014; 256: 53-60.
10. Mousavi Asl A, Kharamin Sh, Hadinia A, Rakhsha HR, Poursamad A. [The effect of relaxation training to pregnant mothers on infant health indicators]. Armaghan Danesh 2009; 14(2): 97-104. (Persian)
11. Emami Afshar N, Torkzahrani S, Jalilvand P, Changizii N. [Prenatal education and preparation for childbirth]. 3rd ed. Tehran: The Ideal Echo Press; 2011. (Persian)
12. Najaf Abadi F, Zoalaktaf V, Bahador P. The impact of exercise on some type of physical fitness and healthy pregnant women. Modern Olympic Games 2014; 1(1): 71-82.

13. Hassan Abadi H, Bahri N. The impact of exercise on low back pain during pregnancy: a review. Women Gynecol Infertil 2014; 17: 16-28.
14. Mudd L, Owe K, Mottola M, Pivarnik J. Health benefits of physical activity during pregnancy: An international perspective. Med Sci Sports Exerc 2013; 45(2): 268-77.
15. Currie L, Woolcott Ch, Fell D, Armson A, Dodds L. The association between physical activity and maternal and neonatal outcomes: A prospective cohort. Matern Child Health J 2014; 18: 1823-30.
16. Artal R, O'Toole M. Guidelines of the American College of Obstetricians and Gynecologists for exercise during pregnancy and the postpartum period. Br J Sports Med 2003; 37(1): 6–12.
17. SMA statement the benefits and risks of exercise during pregnancy. Sport Medicine Australia. J Sci Med Sport 2002; 5(1): 11-9.
18. Nascimento S, Surita F, Kasawara K. Physical activity patterns and factors related to exercise during pregnancy: A cross sectional study. PLOS One 2015; 10(6): e0128953.
19. Mokberian M, Farokhi A, Tahmasebi Boroujeni Sh. The impact of exercise during pregnancy on infant health indicators. Motor Behav 2014; 18: 71-84.
20. Haakstad L, Bø K. Exercise in pregnant women and birth weight: a randomized controlled trial. BMC Pregnancy and Childbirth 2011; 11: 66.
21. Jukic A, Lawlor D, Juhl M, Owe K, Lewis B, Liu J, et al. Physical activity during pregnancy and language development in the offspring. Paediatr Perinat Epidemiol 2013; 27: 283-93.
22. Clapp J, Simonian S, Lopez B, Appleby-Wineberg S, Harcar-Sevcik R. The one-year morphometric and neurodevelopmental outcome of the offspring of women who continued to exercise regularly throughout pregnancy. Am J Obstet Gynecol 1998; 178(3): 594-9.
23. Shakeri M, Shahnawaz A, Shakibazadeh N. [Investigate the effect of physical activity during pregnancy on the physical activity levels of pregnant women]. School of Nursing and Midwifery, Tehran University of Medical Sciences (life) 2012; 18(3): 1-9. (Persian)
24. Sedaghati P, Arjmand A, Sedaghati N. Do regular exercise bicycle ergometer has an effect on the pregnancy outcome? J Pediatr 2006; 16(3): 325-31.
25. Rezavand N, Sayed Zadeh AH, Zanganeh M, Veisy F, Rezaei M, Mostofi S. The relationship of body mass index before pregnancy maternal newborn head circumference. Journal of Kermanshah University of Medical Sciences 2013; 17: 12. (Persian)
26. Tomic K, Sporis G, Tomic J, Milanovic Z, Zigmondovac-Kliac D, Pantelic S. The effect of maternal exercise during pregnancy on abnormal fetal growth. Croat Med J 2013; 54(4): 362-8.
27. Memai Ashraf AL, Tayyip R, Amini M, Ajorloo A, Shakibayi P. [The effects of aerobic exercise on pregnancy and its consequences]. Journal of Nursing and Midwifery, Tehran University of Medical Sciences (life) 2006; 12(3): 35-41. (Persian)
28. Oberoi S. Updating income ranges for Kuppuswamy's socio-economic status scale for the year 2014. Indian J Public Health 2015; 59(2): 156-7.
29. Squires J, Twombely E, Bricker D, Potter L. ASQ-3 user's guide. Brookes Publishing Co; 2009. Available from: http://agesandstages.com/wp-content/uploads/2015/02/asq3_technical_report.pdf.
30. Ghodsi Z, Asltoghiri M. Maternal exercise during pregnancy and neonatal outcomes in Iran. Procedia Soc Behav Sci 2012; 46: 2877-81.
31. Barakat R, Perales M, Garatachea N, Ruiz J, Lucia A. Exercise during pregnancy. A narrative review asking: what do we know? Br J Sports Med 2015; 49: 1377-81.
32. Seefeldt V. Physical activity and well-being. USA: American Alliance for Health, Physical Education, Recreation and Dance Publications; 1986.
33. Kjøbli E, Bach R, Skogseth H, Jacobsen G. The Scandinavian Small-for-Gestational Age (SGA) pregnancy and birth cohort – A source to continual insight into fetal growth restriction and long term physical and neurodevelopmental health in mother and offspring. Norsk Epidemiologi 2016; 26(1-2): 145-54.
34. Wylie A, Sundaram R, Kus Ch Ghassabian A, Yeung E. Maternal Pregnancy Obesity and Achievement of Infant Motor Developmental Milestones in the Upstate KIDS Study. Obes J 2015; 23 (4): 907-13.
35. Vestergaard1 M, Obel C, Henriksen TB, Sørensen HT, Skajaa E & Østergaard J. Duration of breastfeeding and developmental milestones during the latter half of infancy. Acta Paediatr 1999; 88: 1327-32.
36. Pereira K, Saccani R, Valentini N. Cognition and environment are predictors of infants' motor development over time. Fisioterapia e Pesquisa J 2016; 23(1): 59-67.
37. Dosman C, Andrews D, Golden K. Evidence-based milestone ages as a framework for developmental surveillance. Paediatr Child Health 2012; 17(10): 561-8.

38. Casas M, Chatzi L, Carsin AE. Maternal pre-pregnancy overweight and obesity, and child neuropsychological development: two Southern European birth cohort studies. Int J Epidemiol 2013; 42: 506-17.
39. Berger S, Adolph K. Learning and development in infant locomotion. Prog Brain Res 2007; 164: 237-55.
40. Angulo-Barroso R, Schapiro L, Liang W. Motor development in 9-month-old infants in relation to cultural differences and iron status. Dev Psychobiol 2011; 53(2): 196-210.
41. Hollenstein T. Twenty years of dynamic systems approaches to development: Significant contributions, challenges and future directions. Child Dev Perspect 2011; 5(4): 256-9.
42. Malina R. Motor development during infancy and early childhood: overview and suggested direction for research. Int J Sport Health Sci 2004; 2: 50-66.
43. Zoghi A, Shojaei M, Ghasemi A. The impact of a motor affordance intervention on motor and cognitive development of young children. Int J Ment Health Addiction 2015; 13: 6.
44. ACOG Committee opinion. Physical activity and exercise during pregnancy and the postpartum period. Committee opinion No.650. Obstet Gynecol 2015; 126: 135-42.
45. Hopkins S, Cutfield W. Exercise in pregnancy: Weighing up the long-term impact on the next generation. Impact Exerc Offspring 2011; 39(3): 120-7.
46. Toosi M, Akbarzadeh M. The effect of aerobic exercises on maternal outcomes: a randomized controlled clinical trial. Women's Health Bullet 2016; 3(4): e31337.
47. Velikonja T, Edbrooke-childs J, Sleed M, Brown A, Deighton J. The psychometric properties of the Ages and Stages Questionnaires for use as population outcome indicators at 2.5 years in England: A systematic review. Child Care Health Dev 2016; 43(1): 1-17.
48. Veldhuizen S, Clinton J, Rodriguez Ch, Wade T, Cairney J. Concurrent validity of the ages and stages questionnaires and Bayley Developmental Scales in a general population sample. Acad Pediatr 2015; 15(2): 231-7.