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Original

The Relationship Between Breast Feeding and Body Mass Index and Blood Pressure in Pre-School Children

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Abstract:

Introduction: It is generally accepted that breast feeding has a beneficial effect on the health of infants and children. The evidence that breast feeding protects against obesity is inconclusive also the influence of breast feeding on blood pressure in later life is uncertain. The major aim of this study was to assess the association between method of infant breast feeding and components of the body mass index and blood pressure in pre-school children.

Materials & Methods: In a cohort study, a total of 800 pre-school children, 359 (47.2%) males, and 402 (52.8%) females, born in 2003 in Yazd, Iran were selected based on a systematic stratified random model. Of eight hundred questionnaires sent, 761 (95%) were returned to the investigators. At 6 years, blood pressure was measured on the right arm at rest. Body mass index (BMI) was calculated by dividing the weight in kilograms by the square of height in meters (kg/m2).Data on infants feeding were collected respectively during first two years of life .Data were managed and analyzed using SPSS (SPSS, Inc, version 13.0)

Results: Of the 761 subjects included in this study, 452 (59.4%) were exclusively breast fed, 136 (17.9%) were bottle fed and 173 (22.7%) were partially breast fed. Body mass index was not significantly different between bottle feeding, partial and exclusive breast feeding groups (P=0.398) ..No relationship was found between method and duration of breast feeding, and systolic blood pressure (P=0.244), diastolic blood pressure (P=0.781) and mean blood pressure (P=0.483).

Conclusion: We did not find association between method of infant feeding, duration of breast feeding and systolic, diastolic mean blood pressures and also with body mass index

***Keywords*:** Breast Feeding; Child Day Care Centers; Body Mass Index; Blood Pressure; Child

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Introduction

It is generally accepted that breast feeding has a beneficial effect on health of infant and young children. Only a few studies have addressed its effects beyond the first years of life, and they showed that the method of feeding in infancy is associated with biological risk factors for cardiovascular disease [1].

Evidence is growing that blood pressure level in both childhood and young adulthood are influenced by factors operating early in life [2, 3] and are associated with later cardiovascular diseases [4]. Specially, several cohort studies suggest that blood pressure may be determined by early nutritional exposures, including sodium intake in infancy [5] consumption of formula feed [6] and breast feeding [7].

Although treatment of high blood pressure is beneficial [8], treated and well-controlled hypertensive adults still have a substantial excess mortality rate and reduced survival rates compared with normotensive people [9], which makes identification of the means of preventing hypertension in earlier life an important objective.

Obesity represents an important risk factor for cardiovascular disease. Childhood obesity is often associated with future development of hypertension. In addition, childhood obesity increases the risk of obesity in adulthood and is associated with cardiovascular disease risk factors such as hypertension, diabetes mellitus and dyslipidemia [10]. Thus the prevention of the onset of obesity during youth may be important in reducing the risk of coronary heart disease in later life. The evidence that breast feeding protects against obesity is inclusive: some studies showed a protective effect and others found no effect [11].

The current study aims to describe the relationship between breast feeding history with body mass index and blood pressure in pre-school years.

Materials & Methods

In a cross-sectional study, a total of 800 pre-school children, born in 2003 in Yazd, Iran were selected based on a systematic stratified random model. From this population, a two stage cluster samples of children were randomly selected. The primary sampling units were schools and secondary units were school classrooms. Informed consent was obtained from the mothers. Ethical approval was obtained from local ethics committees.

Of these children, 39 (5%) were excluded because their questionnaires were incomplete, therefore 761 subjects were eligible to be included. A total of 761 singleton, term infants, 359 (47.2%) males, and 402 (52.8%) females, born in 2000 were examined at 6 years old. Data on infant feeding was recorded retrospectively from parental questionnaire during the first two years of life and included duration of breast and formula feeding and time of introduction of formula feeds and solid foods. From these data three groups were identified. These groups were exclusive breast feeding for at least 6 months, partial breast feeding and exclusive bottle feeding. Exclusive breast feeding was defined as no solid, milk formula or other drinks (except vitamins,

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minerals, medication and/or water). Partial breast feeding was defined as breast feeding had been stopped or infant milk supplements were added before 6 months. Exclusive bottle feeding

defined no breast feeding at birth and solids introduced before 6 months.

Confounding factors

Infant sex, health status, birth weight, gestational age, self-reported height, self-reported pregnancy weight and age of birth of the child were identified as potential confounding factors.

Measurements

Birth weight data were abstracted directly from obstetric records. Weight and length at age 2 years was available from routine health visitor records.

Maternal height and maternal estimate of her own pregnancy weight and paternal height and weight were abstracted from questionnaire, interview and/or by phone. Each child underwent a physical examination including measurement of weight, height and blood pressure.

Height without shoes was measured to the nearest 0.l cm with a Leicester stadiometer and weight in underwear and without shoes was measured to the nearest 0.l kg with SECA scales. Our measure of paternal and childhood adiposity was body mass index (BMI, kg/m^2). Body mass index was calculated as weight (kg) divided by the square of height (m^2).

Parents' body mass index was derived from height and weight self report and was standardized within the study by sex.

For each child, age and sex specific body mass index (BMI) percentile was determined using 2000 centers for disease control reference values [12]. Children at or above the 95^{th} age and sex specific BMI percentile were considered obese, between 90-95^{th} percentile overweight, between 5-95^{th} percentile normal weight and equal or less than the 5^{th} percentile were considered underweight in accordance with US department of health and human services recommendations [13]. Blood pressure was the average of two measurements in the right arm, taken once before and once after the other examinations with a standard mercury sphygmomanometer and Velcro cuff, while the subjects were seated for at least five minutes. Systolic blood pressure was taken as Korothkoffs first phase and diastolic blood pressure as phase V.

Statistical Analysis:

1- Data were managed and analyzed using SPSS (SPSS, Inc, version 13.0)

2- Association of breast feeding with potential confounding quality factors were investigated by use of chi square and exact tests.

3-Association of breast-feeding and potential confounding factors with blood pressure was examined by linear regression.

4- The association between breast feeding and BMI investigated separately for sex, using linear model with contrast to test differences between breast feeding categories.

5- F-test was used to assess interactions between the effects of weight at birth and body mass index at age 6 on blood pressures and also evidence of statistical interaction breast feeding and sex.

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6- Multivariate linear regression controlled for maternal body mass index, paternal body mass index, newborn weight, weight at two years age and body mass index at 6 years.

Results

From cross-sectional study of 800 pre-school children, 761 (95%) subjects, 359 (47.2%) boys and 402 (52.8%) girls completed the questionnaires.

Mean birth weight for boys, girls and total study subjects were 3.120+0.590kg, 3.080±0.580 and 3.100 ± 0.585kg, respectively. There was no significant sex difference (P=0.343).

Mean weight of boys and girls at 2 years old were 18.6+3.6kg and 17.79 ± 3kg, respectively with significant sex difference (P=0.001).

Mean systolic blood pressure in boys (95.9 ± 11.lmmHg) was lower than girls (98.5 ± 10mmHg) (P=0.001), also the boys had slightly lower mean diastolic blood pressure (64 ± 8.lmmHg) than girls (66.3 ± 9.2mmHg) (P=0.003).

Mean duration of breast feeding was 20.6 ± 7.3 month with no significant sex difference (P=0.659, 95%CI 20.08 to 21.13, range 0-42 month).

Mean age of introduction of solid food was 5.76 ± 1.87 months. There was no significant sex difference (P=0.815).

Mean duration of formula feeding in boys (2.79 ± 6.85 months) and girls (3.05+7.44 months) were approximately similar (P=0.611)

Mean BMI of boys (15.11 ± 2.2) were higher than girls (14.74 ± 1.92), (P=0.013).

Body mass index at age 6 years was positively associated with birth weight (P=0.000, r=0.163), weight at age 2 years (P=0.000, r=0.361), mother's BMI (P=0.002, r= 0.112), father's BMI (P=0.000, r=0.15), and mean blood pressure at age 6 years (P=0.001, r=0.118)

Table1 shows the distribution of BMI percentile at age 6 years by duration of breast feeding. Breast feeding was unrelated to BMI in pre-school children in both sexes (P=0.398).

F tests were used to examine the interaction between duration of breast feeding and size (BMI) at age 6 years.

Table 2 shows the mean systolic pressure of boys and girls by duration of breast feeding.

There was no association between duration of breast feeding and systolic blood pressure. Systolic blood pressure and breast feeding were not significantly different between boys and girls.

Table 3 shows mean diastolic blood pressure of boys and girls by duration of breast feeding at age 6 years. There was no association between duration of breast feeding and diastolic blood pressure.

Also duration of breast feeding and diastolic blood pressure was not significantly different between two genders.

Also no relationship was observed between duration of breast feeding and means blood pressure in two genders. Mean blood pressure was calculated by SBP+2DBP/3.

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Our study showed the systolic, diastolic and mean blood pressures in obese and overweight subjects which were significantly higher than normal weight ones (P=0.000), while normal weight subjects had significantly lower blood pressure than underweight ones ($P \leq 0.01$).

Table 1 shows the distribution of BMI percentile at age 6 years by duration of breast feeding. Breast feeding was unrelated to BMI in pre-school children in both sexes (P=0.398). F tests were used to examine the interaction between duration of breast feeding on size (BMI) at age 6 years.

Table 1) Distribution of BMI percentile at age 6 years by duration of breast feeding

Duration of BF	**<5th Underweight**		**Wt ≥5th <90th Normal weight**		**≥90th <95th Overweight**		**≥95th obese**		**Total**	
N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	
0-6	2	2.9	62	91.2	1	1.5	3	4.4	68	8.9
7-12	1	2.9	31	91.2	2	5.9	0	0	34	4.5
13-18	7	7.7	79	86.8	2	2.2	3	3.3	91	12
19-24	29	5.1	474	83.5	33	5.8	32	5.6	568	74.5
Total	39	5.1	646	84.9	38	5	38	5	761	100

Table 2) Mean SBP of boys and girls by duration of breast feeding at age 6 years

Duration of breast feeding	**Male**					**Female**				
	N	Mean	SD	Min	Max	N	Mean	SD	Min	Max
0-6	28	95.9	1.04	8	12	40	97.8	0.95	8	12
7-12	19	92.1	0.86	8	11	15	97	0.88	8	11
13-18	51	96.4	1.06	8	14	40	97	1.07	8	12
19-24	261	96.1	1.14	8	15	307	98.8	1.01	8	12
Total	359	95.9	1.11	8	15	402	98.5	1.00	8	12
P value			0.489					0.623		

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Also there was no significant difference between overweight and underweight subjects by SBP, diastolic BP and mean blood pressures (P value=0.657).

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Table 4 shows the distribution of BMI at age 6 years by exclusive and non-exclusive breast feeding of the 761 subjects included in this study

Table3. Mean DBP of boys and girls by duration of breast feeding at age 6 years

Duration of breast feeding	Male					Female				
	N	Mean	SD	Min	Max	N	Mean	SD	Min	Max
0-6	28	64.6	0.84	6	8	40	65.5	0.96	4	8
7-12	19	60.5	0.23	6	7	15	64	0.83	6	8
13-18	51	63.3	0.71	6	8	40	66.7	0.94	6	8
19-42	261	64.9	0.84	6	8	307	66.5	0.91	6	9
Total	359	64.4	0.81	6	8	402	66.3	0.92	6	9
P value			0.099					0.702		

Table 4. Distribution of BMI percentile at age 6 years by exclusive and non-exclusive breast feeding

BMI percentile	Exclusive BF		Non-exclusive BF		Total	
	N	%	N	%	N	%
$\leq 5^{th}$	28	6.2	11	3.6	39	5.1
$>5^{th}<90^{th}$	374	82.7	274	88.0	646	84.9
$\geq 90^{th}<95^{th}$	26	5.8	12	3.9	38	5.0
$>95^{th}$	24	5.3	14	4.5	38	5.0
Total	452	59.4	309	40.6	761	100

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Table 5. Mean of boys and girls blood pressures by method of infant feeding at age 6 years

Blood pressure	Exclusive BF			Non-exclusive BF			P value
	N	Mean BP	SD	N	Mean BP	SD	
Systolic	452	97.6	1.08	309	96.7	1.03	0.244
Diastolic	452	65.5	0.88	309	65.3	0.87	0.781
Mean BP	452	76.2	0.82	309	75.8	0.82	0.483

Level of obesity in term of body mass index did not differ regarding the method of infant feeding (P=0.204). The differences regarding the method of infant feeding with respect to body mass index were similar in boys and girls (p>0.05).

Table 5 shows mean (±SD) blood pressure at age 6 years by exclusive and non-exclusive breast feeding. Systolic, diastolic and mean blood pressures did not differ regarding the method of infant feeding, P=0.244, 0.781 and 0.483, for systolic, diastolic and mean blood pressures, respectively.

Discussion

Our study demonstrated that formula feeding and timing of solid foods did not influence weight at age of 2 years. Haschke etal [14] reported that children who were fed according to WHO recommendation had lower weight from 6 to 12 months, but between 12 and 36 months of age, differences between exclusive and non-exclusive breast fed group were small and not relevant. Duration of breast feeding was negatively correlated with increment in weight until 12 and 24 months but not until 36 months of age. Forsyth et al [15] reported that formula feeding and timing of solid foods did not influence weight at age 2 years. Lastly it was also shown that a shorter duration of breast feeding was associated with obesity in children and adolescents [16,17] and the introduction of solid foods before 15 weeks was associated with heavier and fatter children in the age range 6-10 years [1].

Breast feeding has been found to be protective against childhood overweight in many studies [18, 19, 20]. We found no evidence that breast feeding influenced body mass index or obesity in pre-school boys and girls. Our finding was consistent with some studies that have failed to find a link between breast feeding and body mass index [21, 22, 23]. Previous reports of beneficial effects on obesity may be due to uncontrolled confounding factors and selection bias [22].

We did not find any association between duration of breast feeding and systolic or

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diastolic blood pressures. Our findings were in agreement with several studies [23, 24, 25].

In some studies mean SBP was lower in breast fed compared with bottle fed infants, but mean DBP was similar among breast fed and bottle fed infants [26].

In our study, there were not any association between exclusive breast feeding (for at least 6 months), blood pressure and body mass index. Although, other studies indicated partial as well as exclusive breast feeding lowered blood pressure [25, 27].

One study showed that blood pressure was higher in children and adolescents if they were breast fed for more than three months [21].

In one systematic review and meta-analysis, results of relationship between breast feeding and blood pressure were: mean systolic BP was lower in breast fed infants compared with bottle-fed infants according to 10 observations from eight studies. Seven observations (from six studies) showed no or little difference in SBP among breast fed versus formula-fed infants. When the original study was continued into adolescence (age 13-16 years) receiving breast milk was associated with a 2-7 mmHg reduction in blood pressure [28].

Also the results of 13 observations (12 studies) on DBP were: Mean DBP was lower among breast fed infants according to nine observations from eight studies. Four observations (from four studies) showed no or little difference in DBP between breast fed and formula fed infants [28].

No relationship was observed between birth weight and systolic or diastolic pressure in current study. This result was in agreement with some studies [29, 30].

In current study, systolic and diastolic blood pressures were higher in females than males. Also we previously reported that systolic and diastolic pressures were higher in females than males [31]. Although in one study DBP was higher in males when compared to females and SBP was similar in males and females [32]. Another study showed that males had higher SBP and DBP than females [33].

Recent studies about association between birth weight and childhood and adulthood blood pressures are conflicting: a study of children 6-16 years old reported that blood pressure was inversely related to birth weight [34]. Another study indicated a strong and consistent inverse association between birth weight and SBP level from childhood to young adulthood and diastolic BP in young adulthood [35]. Whereas other study did not showed the effect of birth weight on blood pressure in 10 year- old children, it suggested that other environmental factors operating in childhood may be more important [36]. We did not observe the effect of birth weight on SBP and DBP in pre-school children after adjusting for current body mass index. Another study demonstrated that birth weight was not associated with blood pressure among 7-8 year-old children. Compared with middle birth weight group, in the lowest and highest birth weight groups, boys had higher SBP in the higher BMI category $\geq 13.5 kg/m^2$) and girls had higher SBP in both lower and higher BMI categories [30]. Findings of our study were consistent with previous studies as

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we also found no relationship between birth weight and blood pressure at age 6 years [29 30, 36].

In current study, comparison of three BMI groups (underweight, normal weight and overweight or obese) with regard to mean blood pressure, mean SBP and mean DBP were also examined.

The current study showed that increase in the sex-adjusted BMI was associated with an increase in SBP, DBP and mean blood pressures in overweight, obese and normal weight pre-school children.

Also in our study, blood pressure in obese and lean groups was higher than normal weight subjects, but the difference was not statistically significant between lean (underweight) and overweight or obese pre-school children.

Findings of our study were consistent with many previous studies which reported that obese children had significantly higher BP than non-obese children [31,38]. However our study showed SBP and DBP were associated with BMI and blood pressure in obese, overweight and none-obese children, but not in lean pre-school children because lean children had higher BP than normal weight.

Study strengths and limitation

The main strengths of our study were availability of measures of birth weight, weight, height at ages of 2 and 6 years and BMI and blood pressure at age 6 years. The overall response proportion was good (98%) and from the participants, 94.5% had complete data on all variables included in multivariable model. A related weakness of the study was that measurement of infant feeding among parents giving this information relied on parents' recall after 6 years. The impact of this limitation is difficult to assess. Selection bias is possible, because, data collection of breast feeding was based on the memory of the parents. In addition we didn't have detail of some potential confounding factors including socioeconomic and behavior characteristics.

Conclusion

We demonstrated that the formula feeding and timing of solid foods did not influence weight at the age of 2 years.

We found no relationship between birth weight and blood pressure at age 6 years after adjusting for current body mass index, but body mass index at age 6 years was associated with birth weight. Our study did not show any association between exclusive breast feeding, blood pressure and body mass index. We did not observe any association between method of infant feeding, duration of breast feeding and systolic, diastolic and mean blood pressure at age 6 years. Our findings suggest that the method of infant feeding itself is unlikely to influence body mass index (obesity). Furthermore, outcomes of our study may reflect uncontrolled bias caused by confounding and selection.

We concluded that an increase in BMI was associated with increase in SBP and DBP in normal weight and obese children. Also lean (BMI $<5^{th}$ percentile) children had higher blood pressure than normal weight children, but there

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was no difference between lean and obese children regarding blood pressure.

Low birth weight in combination with high current BMI was seen to be of particular importance in development of high blood pressure.

The evidence that breast feeding protects against obesity is inclusive: some studies showed a protective effect and others found no effect.

It is clear, however, that our study provide no support for blood pressure lowering effect of breast feeding and prevention of obesity in pre-school children. Breast milk contains a number of anti-inflammatory, hormonal and growth factors that are not found in formula feeds, and animal and human studies suggest that breast feeding may lead to permanent changes in physiology and metabolism [37, 38].

Meanwhile, breast feeding remains the preferred method in infant feeding for at least four to six months of life, based on its beneficial influences on infectious diseases, psychosocial and cognitive development which may be apparent with increasing age. However further studies in large populations are needed to confirm these findings.

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