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# Association between Maternal Feeding Practices and Excessive Weight Gain in Infants

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**Purpose:** The purpose of this study is to identify the association between maternal feeding practices and excessive weight gain in infants. **Methods:** This study adopted a cross-sectional design and included 240 pairs of mothers and their infants (129 boys and 111 girls) in public healthcare centers in the Daejeon area in South Korea. Via multivariate analyses, the association between maternal feeding practices and excessive weight gain in infants was identified. **Results:** Among 240 infants in this study, 39 (16.3%) infants gained excessive weight during 12 months after birth. Using multivariate logistic regression with adjustment for covariates, more than 7 months of exclusive breastfeeding was associated with a reduced likelihood of excessive weight gain in infants during the 12 months after birth (adjusted odds ratio: 0.39, 95% confidence interval: 0.02~0.81, *p*=.029). **Conclusion:** Based on these results, nurses in communities and clinics should educate mothers on the importance of longer durations of exclusive breast feeding and develop strategies for encouraging such behavior. Furthermore, support for exclusive breast feeding should be provided in various settings.

**Key Words:** Infant; Weight gain; Feeding behavior; Breast feeding

## INTRODUCTION

Infants are likely to develop rapid weight gain and obesity due to physiologic fat accumulation, changes in feeding patterns and eating habits [1]. Thus, infancy is considered a critical period for obesity prevention in children [2]. According to systematic reviews and meta-analysis, excessive weight gain in infancy is significantly associated with subsequent childhood obesity [3]. In addition, excessive weight gain of infants results from excessive energy intake and nutritional status [2]. In these contexts, the association between maternal feeding practices and excessive weight gain of infants needs to be investigated for development of interventional programs to prevent excessive weight gain in infants. Furthermore, identification of factors specific to the Korean population that are related to maternal feeding practices associated excessive weight gain in infants is essential because these factors may be different in different races or ethnicities [4]. In this connection, as prevalence of exclusive breastfeeding which providing only breast milk without other liquids including formula was 18.3% at 5~6 months after childbirth in 2016 [5], this low prevalence of exclusive breastfeeding was related with the situation that maternal leave was 12 weeks for working mothers, and breast feeding was not supported at the workplace [6]. Chubby infants were also considered as healthy and well-developed in Korea [7]. In this context, Korean people tend to encourage more eating, despite the infants' satiety cues [7]. Thus, associated factors with excessive weight gain in infants in Korea differ from those in western countries. However, most associated factors have been identified in Western countries [1-4]. In addition, excessive weight gain in infancy can be a result of different maternal feeding practices such as lack of exclusive breastfeeding [1], regular feeding without reflecting on signs of hunger in infants [1], overfeeding associated with parental behaviors e.g., feeding large amounts of formula [1], and early introduction of solid foods, i.e. before

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4~6 months of age [8]. However, the significance of associated factors such as exclusive breastfeeding is not consistent in previous studies [9]. In this connection, Lefebvre and John [9] suggested controlling covariates including prenatal (e.g. body mass index of mothers before pregnancy) and infants' factors (e.g. birth weight) apart from feeding habits of infants to confirm the association between maternal feeding practices and excessive weight gain in infants.

According to a model from developed by Monasta et al. [10], factors associated with excessive weight gain in young children can be categorized as children's factors, parental factors, and environmental factors. In the same vein, according to literature reviews, sex (boys) of infants [11], birth by cesarean section [11] and birth weight >4,000 g [1, 11] as infants' factors were positively associated with excessive weight gain in infants. In addition, maternal factors during the prenatal stage such as maternal pre-pregnancy obesity [1], excessive weight gain during pregnancy [10,11], smoking during pregnancy [10,11], depression during pregnancy [11], and gestational diabetes mellitus [11] were positively associated with excessive weight gain in infants. Parental factors also include maternal age at childbirth [10], parental body mass index (BMI) [10], current maternal employment status [10], and maternal educational level [10]. In addition, environmental factors include family history of diabetes mellitus [10] and current socioeconomic status of the family [10]. Thus, this study aimed to identify the significance of association between maternal feeding practices and excessive weight gain in infants after controlling the covariates including maternal factors during the prenatal stage, infants' factors, parental factors, and environmental factors.

# METHODS

## 1. Design

This study used a cross-sectional design.

## 2. Participants

Participants in our study included mothers and their 12 months-old infants who visited public health centers located in Daejeon (metropolis), South Korea for immunization. Public health centers were selected by the convenience sampling method. The three included public health centers were located in Dong-gu, Jung-gu, and Seo-gu in Daejeon. Mothers and infants from each public health center were selected using the convenience sampling method according to the following inclusion and exclusion criteria. The inclusion criteria were as follows: (1) mothers who agreed to participate in this study, (2) infants who were born after 37 weeks of gestation with a birth weight of ≥ 2,500 g, and (3) mothers who were able to read and answer the questionnaires without assistance. The exclusion criteria were as follows: (1) children who were prematurely born or twins, (2) children with congenital disorders and other developmental and health problems that influence weight gain (e.g., diabetes mellitus, gastrointestinal disease, renal disease, heart disease, and endocrine disease), (3) children receiving medical and non-medical interventions for obesity management, and (4) infants who could not be measured with respect to length and weight because of developmental and health problems.

To verify the statistical power of our sample, a minimum of 170 pairs were required to achieve an odds ratio of 1.74 [12]. This calculation was based on the sample size of a previous study with an $\alpha$ of .05 and a logistic regression power of .80 (G*Power, version 3.1) [13]. This study involved 240 pairs of mothers (19~45 years) and their infants (129 boys and 111 girls).

## 3. Measurements

### 1) Outcome variable

Excessive weight gain. Adiposity of infants was evaluated using BMI to identify excessive weight gain in infants. Infants were weighed to the nearest 5 g in the supine position on a standard digital scale (Tanita Corporation of America Inc., Model BD 590, Illinois, USA) while they wore only a diaper. Supine length was measured to the nearest 0.1 cm from the top of to the soles of the feet using an infantometer (Seca North America, Model 417, CA, USA). Weight and length were measured twice, and the mean values were used to calculate the BMI. The BMI of each infant was calculated as: weight in kilograms divided by the height in meters squared; the BMI was then converted to a percentile, and ≥97th percentile on the sex- and age-specific growth chart for Korean children was considered as excessive weight gain [14].

A self-reported questionnaire based on the recall of mothers was used for measurements of independent variables and covariates. The recall of mothers regarding their experience during pregnancy and childbirth (e.g. smoking, health problems, birth weight of infants) showed good validity [15].

### 2) Independent variables

(1) Introduction timing of solid foods

The introduction timing of solid foods was evaluated with a single question on the month after birth when solid foods were introduced. The introduction timing of solid foods was categorized as follows: <4 months after birth, 4~6 months after birth, 7~11 months after birth, ≥12 months after birth [11].

(2) Duration of exclusive breastfeeding

The duration of exclusive breastfeeding was evaluated with a single question on the number of months during which the children were exclusively breastfed. The duration of exclusive breastfeeding was categorized as follows: <1 month, 1~6 months, ≥7 months [11].

(3) Feeding style according to infants' hunger and satiety cues

The maternal feeding style according to the infants' hunger and satiety cues was evaluated using the Infant Feeding Practices Questionnaire [16]. This instrument consisted of two items: first, "Did you feed the infant when the infant gave a cue for hunger without a fixed feeding schedule?" and second, "Did you feed the infant according to a fixed feeding schedule regardless of the infant's hunger and satiety cue?". Responses were marked as "never," "almost not," "occasionally," "often," and "always" for each item. Mothers who responded "often" and "always" for the first item and "never," and "almost never" for the second item were determined as having a responsive feeding style. Meanwhile, mothers who responded "never" and "almost never" for the first item and "often" and "always" for the second item were determined as having a non-responsive feeding style. Mothers with other responses were determined as having a mixed responsive and non-responsive feeding style.

## 4. Covariates

**1) Maternal factors during the prenatal stage**

(1) Pre-pregnancy weight

Maternal BMI was calculated to evaluate the pre-pregnancy weight of mothers using the self-reported height and weight before pregnancy. According to the criteria recommended by the Korean Society for the Study of Obesity [17], the BMI of each mother before pregnancy was used to classify them as underweight (<18.5 kg/m$^2$), normal weight (18.5 kg/m$^2$ and <23 kg/m$^2$), overweight (23 kg/m$^2$ and <25 kg/m$^2$), or obese (25 kg/m$^2$).

(2) Weight gain during pregnancy

Weight gain during pregnancy was evaluated using a single question: "How much weight did you gain during pregnancy?" By applying the weight-gain criteria during pregnancy, according to the pre-pregnancy weight status of Korean women, the appropriate weight-gain range was determined as 16.7~24.7 kg for underweight, 11.5~21.5 kg for normal weight, 8.0~17.7 kg for overweight, and 7.5~21.9 kg for obese women [18]. Weight gain that was less than the appropriate range was considered as insufficient weight gain and that more than the appropriate range was considered as excessive weight gain.

(3) Gestational diabetes mellitus

Gestational diabetes mellitus was evaluated via a single question regarding the mothers' diagnosis of diabetes mellitus during pregnancy. Responses were marked as yes or no.

(4) Smoking during pregnancy

Smoking during pregnancy was evaluated with a single question regarding the mothers' active smoking experience. Responses were marked as yes or no.

(5) Depression during pregnancy

Depression during pregnancy was evaluated with a single question regarding the mothers' diagnosis or treatment for depression during pregnancy by a psychiatrist. Responses were marked as yes or no.

**2) Infants' factors**

Sex. Sex was categorized as boy or girl.

(1) Birth by cesarean section

Birth by cesarean section was evaluated with a single question about the birth of their children. Responses were marked as yes or no.

(2) Birth weight

Birth weight of children was evaluated with a single question about the birth weight of the children. The birth weight was categorized into <2,500 g, 2,500~<4,000 g, and ≥4,000 g [1].

**3) Parental factors**

Parental factors were evaluated as follows. Maternal age at childbirth was evaluated with a single question on the age of mother at the time of childbirth. Responses were categorized as follows: ≤20 years, 21~25 years, 26~30 years, 31~35 years, and >35 years. Parental BMI was evaluated using the self-reported height and weight of mothers and fathers. BMI of mothers and fathers was classified as un-

derweight (<18.5 kg/m$^2$), normal weight (≥18.5 kg/m$^2$ and <23 kg/m$^2$), overweight (≥23 kg/m$^2$ and <25 kg/m$^2$, or obese (≥25 kg/m$^2$) [17]. Parental weight status was categorized as non-overweight both parents, overweight/obesity in one parent, and overweight/obesity in both parents. Current maternal employment was evaluated with a single question regarding the current employment status of the mothers. Responses were marked as unemployed (housewife), part-time employment, or full-time employment. Finally, maternal educational level was categorized as follows: less than high school, high school, Junior college (2~3 years), and more than university (university and graduate school).

**4) Environmental factors**

Family history of diabetes mellitus was evaluated with a single question regarding the presence of diabetes mellitus among immediate maternal and paternal family members. Responses were marked as yes or no. Current socioeconomic status of the family was evaluated with a single question regarding perceived current socioeconomic status of the family. Responses were categorized into high, middle, and low.

### 5. Data Collection and Ethical Considerations

Data collection was conducted by a researcher and three research assistances with master's degree in nursing from between June and August 2017. The research assistances contacted all mothers who visited the public health centers for immunization of their infants and confirmed that the mothers met the eligibility criteria. After that, the researcher explained the purpose, data collection procedure and how to complete the questionnaire, to mothers who met the eligibility criteria. The researcher distributed and collected questionnaires before mothers left the public health centers after immunization of their infants. Total 262 mothers was recruited and 22 mothers refused to answer the questionnaire. Among the 22 mothers, 10 mothers wanted to leave the public health centers without delay and 12 mothers did not want to share private experience and information during pregnancy. The researcher and research assistances performed measurements of weight and supine length in the public health centers.

All research procedures were approved by the institutional review board of the research institute at which the study was conducted (IRB No. 2-1046881-A-N-01-2017-HR-025). The mothers were informed of their right to refuse to participate or to withdraw from the study at any stage. Written informed consent was obtained from mothers who participated in this study.

### 6. Data Analysis

SPSS (version 22.0 for Windows, IBM, Armonk, NY, USA) was used for data analysis. Descriptive statistics were calculated to describe the characteristics of outcome variable (excessive weight gain), independent variables (maternal feeding practices), and covariates (maternal factors in prenatal stage, infants' factors, parental factors, and environmental factors). In addition, excessive weight gain in infants was determined by factors on different levels including infants', parental and environmental level. On this multilevel structure, a single-level analysis with factors at individual level might miss important group-level effects called as atomistic fallacy [19]. Thus, using multivariate analyses on multilevel model with logistic regression, the association between maternal feeding practices and excessive weight gain in infants were identified. A two-sided significance level of $p<.05$ indicated statistical significance.

## RESULTS

### 1. Excessive Weight Gain of Infants

Among the 240 infants in this study, 39 (16.3%) gained excessive weight during 12 months after birth.

### 2. Characteristics of Maternal Feeding Practices

Table 1 shows characteristics of maternal feeding practices and covariates. Most mothers (81.3%) introduced solid foods to their infants at 4~6 months after birth. In addition, 18.7% of mothers introduced solid foods to their infants at 7~12 months after birth. Among 52.5% of mothers, the duration of exclusive breastfeeding was 1~6 months after child birth. In addition, 32.5% of mothers exclusively fed breast milk for more than 7 months after childbirth. More than half of the mothers (65.0%) had a mixed non-responsive and responsive feeding style, while only 18.7% of mothers had a responsive feeding style according to their infants' hunger and satiety cue.

### 3. Association between Maternal Feeding Practices and Excessive Weight Gain in Infants

A multilevel logistic analysis was performed to assess the association between maternal feeding practices and excessive weight gain in infants (Table 2). In the first

**Table 1.** Characteristics of Maternal Feeding Practice and Covariates associated Excessive Weight Gain of Infants (*N*=240)

| Variables | | Categories | n (%) | M±SD | Range |
|---|---|---|---|---|---|
| **Independent variables** | | | | | |
| Maternal feeding practices | Introduction timing of solid foods (months after birth) | <4 | 0 (0.0) | | |
| | | 4~6 | 195 (81.3) | | |
| | | 7~11 | 45 (18.7) | | |
| | | ≥12 | 0 (0.0) | | |
| | Duration of exclusive breastfeeding (month) | None | 36 (15.0) | | |
| | | 1~6 | 126 (52.5) | | |
| | | ≥7 | 78 (32.5) | | |
| | Feeding style according to infants' hunger and satiety cues. | Non-responsive | 39 (16.3) | | |
| | | Responsive | 45 (18.7) | | |
| | | Mixed with non-responsive and responsive | 156 (65.0) | | |
| **Covariates** | | | | | |
| Maternal factors in prenatal stage | Pre-pregnancy weight by BMI | Under weight | 51 (21.3) | 21.02±3.12 | 15.82~30.85 |
| | | Normal weight | 153 (63.7) | | |
| | | Overweight | 18 (7.5) | | |
| | | Obese | 18 (7.5) | | |
| | Weight gain during pregnancy | Insufficient | 117 (48.8) | | |
| | | Appropriate | 108 (45.0) | | |
| | | Excessive | 15 (6.2) | | |
| | Gestational diabetes mellitus | Yes | 18 (7.5) | | |
| | | No | 222 (92.5) | | |
| | Smoking during pregnancy | Yes | 12 (5.0) | | |
| | | No | 228 (95.0) | | |
| | Depression during pregnancy | Yes | 3 (1.3) | | |
| | | No | 237 (98.7) | | |
| Infants' factors | Sex | Boys | 129 (53.7) | | |
| | | Girls | 111 (46.3) | | |
| | Birth by cesarean section | Yes | 120 (50.0) | | |
| | | No | 120 (50.0) | | |
| | Birth weight (g) | <2,500 | 15 (6.3) | 3,300±0.49 | 1,960~4,400 |
| | | 2,500~<4,000 | 213 (88.7) | | |
| | | ≥4,000 | 12 (5.0) | | |
| Parental factors | Maternal age of child birth (year) | ≤20 | 3 (1.3) | 31.61±4.56 | 19~45 |
| | | 21~25 | 21 (8.7) | | |
| | | 26~30 | 57 (23.8) | | |
| | | 31~35 | 99 (41.2) | | |
| | | >35 | 60 (25.0) | | |
| | Parental BMI | Non-overweight of both parents | 24 (10.0) | | |
| | | Non-overweight of mothers & overweight or obesity of fathers | 135 (56.2) | | |
| | | Overweight or obesity of mothers & non-overweight of fathers | 24 (10.0) | | |
| | | Overweight or obesity of both parents | 57 (23.8) | | |
| | Current maternal employment | Unemployed | 189 (78.7) | | |
| | | Part time | 9 (3.8) | | |
| | | Full time | 42 (17.5) | | |
| | Maternal education level | Less than high school | 9 (3.7) | | |
| | | High school | 42 (17.5) | | |
| | | Junior college of 2~3 years | 66 (27.5) | | |
| | | More than University | 123 (51.3) | | |
| Environmental factors | Family history of diabetes mellitus | Yes | 96 (40.0) | | |
| | | No | 144 (60.0) | | |
| | Current socioeconomic status of the family | High | 18 (7.5) | | |
| | | Middle | 179 (81.7) | | |
| | | Low | 43 (10.8) | | |

BMI=body mass index.

model, covariates such as maternal factors in prenatal stage (e.g. pre-pregnancy weight), Infants' factors (e.g. birth by cesarean section), parental factors (e.g. maternal age at childbirth), and environmental factors (e.g. family history of diabetes mellitus) were entered. Of maternal factors in the prenatal stage, overweight and obese mothers before

**Table 2.** Association between Maternal Feeding Practices and Excessive Weight Gain in Infancy (*N*=240)

| Variables | | Categories | Model 1 | | | Model 2 | | |
|---|---|---|---|---|---|---|---|---|
| | | | aOR | 95% CI | *p* | aOR | 95% CI | *p* |
| Maternal factors in prenatal stage | Pre-pregnancy weight (Ref.: non-obesity) | Overweight or obese | 5.14 | 1.25~21.15 | .023 | 1.46 | 0.20~10.82 | .710 |
| | Weight gain during pregnancy (Ref.: appropriate) | Insufficient | 0.90 | 0.35~2.32 | .820 | 0.36 | 0.11~1.22 | .102 |
| | | Excessive | 4.64 | 0.65~33.07 | .125 | 3.14 | 0.22~45.63 | .402 |
| Infants' factors | Sex (Ref.: girls) | Boys | 0.87 | 0.35~2.11 | .751 | 1.08 | 0.37~3.20 | .884 |
| | Birth by cesarean section (Ref.: no) | Yes | 3.26 | 1.31~8.13 | .011 | 3.33 | 1.18~9.37 | .023 |
| | Birth weight (Ref.: < 2,500 g) | 2,500 g~ < 4,000 g | 0.32 | 0.06~1.71 | .182 | 0.24 | 0.04~1.67 | .151 |
| | | ≥ 4.000 g | 0.41 | 0.03~5.51 | .498 | 0.14 | 0.01~3.47 | .233 |
| Parental factors | Maternal age of child birth (year) (Ref.: ≤ 30) | 31~35 | 4.27 | 1.15~15.77 | .030 | 5.02 | 0.96~26.37 | .057 |
| | | 35 ≤ | 3.34 | 0.81~13.68 | .095 | 4.83 | 0.94~24.92 | .060 |
| | Parental BMI (Ref.: non overweight of both parents) | Non overweight of mother & overweight of father | 6.15 | 1.16~32.71 | .033 | 3.08 | 1.34~7.09 | .008 |
| | | Overweight or obesity of mother & non overweight of fathers | 2.65 | 0.65~10.89 | .177 | 3.00 | 0.68~13.33 | .149 |
| | | Overweight or obesity of both parents | 6.54 | 1.19~35.93 | .031 | 5.53 | 2.41~12.73 | .003 |
| | Current maternal employment (Ref.: unemployed) | Part time or full time | 2.95 | 1.10~7.94 | .032 | 6.96 | 1.83~26.46 | .004 |
| | Maternal education level (Ref.: less than high school & high school) | Junior college of 2~3 years | 1.62 | 0.46~5.65 | .451 | 1.71 | 0.40~7.24 | .468 |
| | | More than University | 1.12 | 0.33~3.84 | .855 | 1.91 | 0.44~8.25 | .385 |
| Environmental factors | Family history of diabetes mellitus (Ref.: no) | Yes | 4.69 | 1.50~14.69 | .008 | 5.30 | 2.10~12.34 | .002 |
| | Current socioeconomic status of the family (Ref.: high) | Middle | 1.38 | 0.62~3.10 | .431 | 1.34 | 0.54~3.12 | .523 |
| | | Low | 1.56 | 0.74~3.28 | .243 | 1.78 | 0.74~4.28 | .195 |
| Maternal feeding practices | Introduction timing of solid foods (Ref.: ≤ 6 months) | ≥ 7 months | | | | 1.85 | 0.17~3.62 | .755 |
| | Duration of exclusive breastfeeding (Ref.: none) | ≤ 6 months | | | | 1.46 | 0.11~1.76 | .249 |
| | | ≥ 7 months | | | | 0.39 | 0.02~0.81 | .029 |
| | Feeding style (Ref.: responsive) | Non responsive | | | | 2.07 | 0.87~4.93 | .261 |
| | | Mixed with non-responsive and responsive | | | | 0.98 | 0.37~2.59 | .870 |

OR=odds ratio; aOR=adjusted OR; CI=confidence interval; Ref.=reference.

pregnancy were associated with an increased likelihood of excessive weight gain in infants during 12 months after birth (adjusted Odds Ratio [aOR]: 5.14, 95% Confidence Interval [CI]: 1.25~21.15, $p$=.023). Of infants' factors, birth by cesarean section was associated with an increased likelihood of excessive weight gain in infants during 12 months after birth (aOR: 3.26, 95% CI: 1.31~8.13, $p$=.011). Of prenatal factors, 31~35 years of maternal age at child birth was associated with an increased likelihood of excessive weight gain in infants during 12 months after birth (aOR: 4.27, 95% CI: 1.15~15.77, $p$=.030). In addition, among parental factors, non-overweight mothers and overweight or obesity in fathers (aOR: 6.15, 95% CI: 1.16~32.71, $p$=.033) as well as overweight or obesity in both parents were associated with an increased likelihood of excessive weight gain in infants during 12 months after birth (aOR: 6.54, 95% CI: 1.19~35.93, $p$=.031). Part time or full time employment of mothers were also associated with an increased likelihood of excessive weight gain in infants (aOR: 2.95, 95% CI: 1.10~7.94, $p$=.032). Of environmental factors, family history of diabetes mellitus was associated with an increased likelihood of excessive weight gain in infants during 12 months after birth (aOR: 4.69, 95% CI: 1.50~14.69, $p$=.008).

In the second model, independent variables regarding maternal feeding practices and the covariates were entered. Of maternal feeding practices, more than 7 months of exclusive breastfeeding was associated with reduced likelihood of excessive weight gain in infants (aOR: 0.39, 95% CI: 0.02~0.81, $p$=.029). As covariates, among infants' factors, birth by cesarean section was associated with increased likelihood of excessive weight gain in infants (aOR: 3.33, 95% CI: 1.18~9.37, $p$=.023). Of parental factors, non-overweight mothers and overweight or obesity in fathers (aOR: 3.08, 95% CI: 1.34~7.09, $p$=.008) as well as overweight or obesity in both parents were associated with increased likelihood of excessive weight gain in infants during 12 months after birth (aOR: 5.53, 95% CI: 2.41~12.73, $p$=.003). Part time or full time employment of mothers were also associated with an increased likelihood of excessive weight gain in infants during 12 months after birth (aOR: 6.96, 95% CI: 1.83~26.46, $p$=.004). Of environmental factors, family history of diabetes mellitus was associated with an increased likelihood of excessive weight gain in infants during 12 months after birth (aOR: 5.30, 95% CI: 2.10~12.34, $p$=.002).

## DISCUSSION

This study identified factors associated with excessive weight gain in Korean infants. In this study, more than 7 months of exclusive breastfeeding was associated with reduced likelihood of excessive weight gain in infants. According a systematic review and a meta-analysis, increasing the exclusivity and duration of breastfeeding were strongly associated with reduced likelihood of childhood obesity [20]. In the same vein, children who exclusively breastfed for more than 6 months had a leaner body shape at 5 years of age [21]. Furthermore, Harder [20] proposed a dose-dependent association between longer duration of breastfeeding (up to 9 months) and decreased risk of overweight in children.

According to Bartok and Ventura [22], behavioral and physiological characteristics of breastfeeding had preventative effects on excessive weight gain in infants. Among the behavioral characteristics, breastfeeding encouraged infants' self-regulation of energy intake [22]. Previous studies have reported that infants have the ability to regulate the feeding amount and intervals in response to their nutritional need. However, bottle-feeding mothers tended to better regulate the feeding amount because they could visually assess and monitor it [23]. Consequently, maternal feeding behaviors may lead to overfeeding and restrictive feeding practice by not responding to infants' cues of satiety and hunger [24]. Meanwhile, breastfeeding mothers were more likely to trust their infants' ability to self-regulate and responded to the infants' satiety and hunger cues [24]. Thus, breastfed infants compared to formula-fed infants had a decreased risk for excessive weight gain with lower prevalence of overfeeding due to a sensitive maternal response towards the infants' hunger and satiety cues [25].

On the physiological characteristics, breast milk contains proportionally more lactose for fueling the metabolism of the central nervous system, and specific fats and cholesterol for building the tissues of the central nervous system [26]. In contrast, protein and mineral content is relatively higher in formula milk from cows that experience rapid gains in body size [26]. Thus, the higher protein and mineral content of cow's milk would support rapid development of skeletal and smooth muscles, bones, and connective tissues [26]. In these contexts, the higher protein content in formula is considered a significant component associated with excess physical growth including weight gain in infants [26]. In addition, a higher omega-6/omega-3 ratio in formulas milk than breast milk might stimulate adipocyte growth and differentiation [27]. Meanwhile, breast milk rather than formulas contains many bioactive factors (e.g. immunoglobulins, live cells, enzymes, pituitary hormones) that might control infant metabolism,

appetite, caloric intake etc. that induce physiological effects on body fat levels and weight gain patterns [28]. Moreover, breast milk but not formula contains leptin which regulates energy expenditure and the neuroendocrine axes as a satiety factor [29]. Thus, weight gain in exclusively and longer breast fed infants would be less rapid than that in formula fed infants. In most previous studies, exclusive breast feeding and longer duration of breastfeeding was associated with reduced likelihood of overweight in young children [20]. Thus, nurses in communities and clinics should educate on the importance of exclusive breast-feeding for longer durations and develop strategies for encouraging such behavior and practices. In addition, support for exclusive breast-feeding should be provided in various settings (e.g. schools, workplaces, public spaces).

This study had several limitations. First, data from mothers using self-administered questionnaires could compromise the results due to social desirability biases (e.g., breastfeeding, and smoking). Second, this study used a cross-sectional survey design that limits inferences of causality between the independent and dependent variables. Thus, well-organized cohort studies are recommended in future to verify the causality of the effect observed in this study. Third, participants were selected with convenient sampling methods that sample was taken from mothers visited conveniently selected three public centers. Thus, further investigations with the samples collected with random sampling methods are needed to improve generalization of the findings. Finally, only a few factors were included in the covariates for identification of associated factors excessive weight gain in Korean infants. Thus, further studies are suggested with various potential factors associated factors excessive weight gain in Korean infants such as familiar and social factors (e.g. beliefs regarding overweight of young children, cultural value regarding providing high calorie food to children, and perception regarding weight control behaviors according to gender of children proposed by Davison et al. [30]).

## CONCLUSION

In this study, more than 7 months of exclusive breastfeeding was associated with reduced likelihood of excessive weight gain in infants. This result suggests that nurses in communities and clinics should educate on the importance of exclusive breast-feeding for longer durations and develop strategies for encouraging such behavior and practice. In addition, support for exclusive breast-feeding should be provided in various settings.

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