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■ Original Article

Associations of Breastfeeding Duration and Reproductive Factors with Sarcopenia in Elderly Korean Women: A Cross-Sectional Study from the Korea National Health and Nutrition Examination Survey 2010–2011

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Background: Several studies have suggested that breastfeeding has a positive effect on long-term obesity, diabetes, hypertension, and hyperlipidemia. This study aimed to examine maternal bone health, muscle mass, and obesity based on breastfeeding duration.

Methods: This study was based on the Korea National Health and Nutrition Examination Survey 2010–2011. We selected 2,027 elderly women by screening survey participants with a history of delivery. Multivariate logistic regression analyses were performed to estimate the odds ratios (ORs) of sarcopenia, osteoporosis, and obesity among four breastfeeding groups.

Results: The OR of sarcopenia significantly decreased with increasing breastfeeding duration (OR, 0.27; 95% confidence interval [CI], 0.11–0.65; P for trend <0.001), whereas the OR of obesity significantly increased with increasing breastfeeding duration (OR, 2.56; 95% CI, 1.43–4.60; P for trend=0.009) after adjusting for potential confounding variables. We also found a positive correlation between the duration since last delivery and sarcopenia.

Conclusion: Our results suggest a negative correlation between prolonged breastfeeding and the prevalence of sarcopenia, and a positive correlation between prolonged breastfeeding and the prevalence of obesity. Further studies are needed to clarify the relationship between breastfeeding and sarcopenia in the future.

Keywords: Breast Feeding; Sarcopenia; Obesity; Osteoporosis

INTRODUCTION

Breastfeeding history has a positive effect on the health of women. Studies have suggested that long-term breastfeeding reduces the ovarian and breast cancer rates, as well as the risks of all-cause mortality,[1] hypertension, diabetes, hyperlipidemia, and cardiovascular disease.[2]

Although no previous study has assessed the relationship between muscle mass and breastfeeding, several studies have evaluated the association between bone health or obesity and breastfeeding, yielding controversial results. Wiklund et al.[3] found that lactation has a positive effect on bone size and strength. Okyay et al.[4] reported that a breastfeeding period of >1 year per child has a strongly positive correlation with osteoporosis (odds ratio [OR], 12.9; 95% confidence interval [CI], 3.1–52.6). Hwang et al.[5] demonstrated that the prevalence of osteoporosis is significantly higher in postmenopausal women with a history of prolonged breastfeeding (OR, 3.29; 95% CI, 1.485–7.299). Sichieri et al.[6] found a non-significant effect of breastfeeding on maternal weight. Bobrow et al.[7] showed that breastfeeding is associated with a long-term reduction in body mass index (BMI) among postmenopausal women (BMI, 25.88 kg/m^2 versus 26.39 kg/m^2). Wiklund et al.[8] suggested that long-term breastfeeding (duration >10 months) provides more protection against maternal obesity later in life than a breastfeeding duration of <6 months (BMI, 24.6 kg/m^2 versus 27.3 kg/m^2; P=0.001).

Although many studies have investigated breastfeeding and its related long-term health effects, no study has been conducted on the relationship between breastfeeding and sarcopenia. Therefore, in this study, we investigated maternal bone health, muscle mass, and obesity based on breastfeeding duration, by using a nationwide database in Korea.

METHODS

1. Study Population

This study was based on the Korea National Health and Nutrition Examination Survey (KNHANES) 2010–2011. The KNHANES is a nationally representative study articulated in six phases: phase I (1998), II (2001), III (2005), IV (2007–2009), V (2010–2012), and VI (2013–2014). This survey used a stratified, multistage probability sampling design for the selection of household units. Sampling weights were used to account for the complex sampling to represent the entire Korean adult population, which included stratification by the district at the first step and stratification by sex and age at the second step. The survey consisted of the health interview survey, health behavior survey, nutrition survey, and health examination survey. The participants were evaluated using self-administered questionnaires. Interviewers assisted those participants who had difficulties in self-administration.

Of the 17,476 subjects in the KNHANES 2010–2011, 5,965 answered "yes" or "no" to questions about their breastfeeding experience. Among them, 2,027 women were older than 60 years. Written informed consent to use their data for further analyses was provided by all participants, who were given the right to refuse participation in accordance with the National Health Enhancement Act. This survey was approved by the Korea Centers for Disease Control and Prevention for the institutional review board (2010-02CON-21-C, 2011-02CON-06-C).

2. Definition of Socioeconomic Variables and Health-Related Factors

A self-administered questionnaire in the health interview survey was used to gather information about socioeconomic (age, sex, education level, and household monthly income) and health-related (smoking status, alcohol drinking, physical activity, menarche, menopause, hormone replacement therapy, breastfeeding duration, number of deliveries, age at first delivery, and age at last delivery) factors. The duration of breastfeeding was divided into four groups: 0–18, 19–36, 37–72, and >72 months. The education level was classified into ≤middle school and ≥high school. The participants answered the question "What is the average monthly income, including salaries, property income, pensions, government grants, and allowances, in your house?" The average monthly household income was calculated by dividing the monthly average household income by the number of families and was divided into two groups: low (within the first and second quartiles) and high (within the third and fourth quartiles).

Subjects who smoked cigarettes during the relevant survey periods were categorized as current smokers. Those who drink >7 cups of alcohol/d for men and 5 cups of alcohol/d for women, with a frequency of more than twice a week, were categorized as binge drinkers. The standard cup of alcohol drink is based on the guidelines of the National Institute on Alcohol Abuse and Alcoholism.[9] Subjects who engaged in vigorous physical activity at least 3 d/wk or moderate physical activity, including walking, at least 5 d/wk were categorized into the regular exercise group.[10] The total energy intake was calculated as the sum of energy intake (kcal) from food consumed during 24 hours, and was analyzed using the Computer Aided Nutritional Analysis program (CAN-Pro ver. 3.0 software; Korean Nutrition Society, Seoul, Korea).[11] Protein intake was defined as the sum of protein intake (g) from food consumed during 24 hours.

Menarche and menopause were recorded yearly. Hormone replacement therapy was defined as the percentage of the total treatment duration. The number of deliveries was defined as the total number of lifetime deliveries. The ages at first and last delivery were collected yearly.

3. Definition of Diseases

Body weight and height were measured to the nearest 0.1 kg and 0.1 cm, respectively, while the subjects were wearing light indoor clothes without shoes. BMI was calculated by dividing the weight (kg) by the square of the height (m^2), and obesity was defined as BMI ≥25 kg/m^2. Dual-energy X-ray absorptiometry (Discovery-W; Hologic Inc., Waltham, MA, USA) was used to measure whole and regional body compositions. Appendicular skeletal muscle mass (ASM) was calculated as the sum of the mass of skeletal muscle in the arms and legs,

assuming that all non-fat and non-bone tissues were skeletal muscles. Sarcopenia was defined as the value of the ASM divided by height squared that was <2 standard deviation (SD)s below the sex-specific mean of a young reference group;[12,13] the cutoff value was 5.45 kg/m^2 in women. Bone mineral density (BMD) values were converted into T-scores. The T-score was calculated using the following equation: T-score=(BMD of the participant–mean BMD of the reference population)/SD of the BMD of the reference population. The reference population comprised Asian, young, healthy female and male subjects, who underwent bone densitometry measurements (Discovery-W, Hologic Inc.).[14] Osteoporosis was defined as a T-score of ≤–2.5 SD of the BMD based on the World Health Organization criteria.[15]

4. Statistical Analysis

In the present study, all sampling and weight variables were stratified. All data for continuous variables are presented as means and standard errors (SEs). Data of categorical variables are presented as percentages and SEs. P-values were calculated to compare the four groups by using age-adjusted analysis of covariance. Multivariate logistic regression analysis was performed to estimate the ORs for multiple diseases in the four groups of breastfeeding duration. Age, alcohol, smoking, and physical activity were adjusted for in model 1. Model 2 was adjusted for the same variables as model 1 plus education and household income. Model 3 was adjusted for the same variables as model 2 plus total energy intake per day, total protein intake per day, duration after

menopause, and oral contraceptive use. SAS ver. 9.2 (SAS Institute Inc., Cary, NC, USA) was used for statistical analyses. All statistical tests were two-tailed, and statistical significance was set at P<0.05.

RESULTS

The basic characteristics of the subjects are shown in Table 1. The mean breastfeeding durations among the four groups (0–18, 19–36, 37–72, and >72 months) were 11.0±0.4, 31.0±0.4, 58.1±0.5, and 128.6±1.6 months, respectively (P<0.001). The mean age among the four groups was 66.3±0.5, 66.1±0.3, 68.9±0.3, and 74.2±0.3 years, respectively (P<0.001). The prevalence of obesity and osteoporosis in the four groups increased as the duration of breastfeeding increased (35.5%, 41.4%, 39.9%, and 38.7% for obesity and 32.9%, 36.5%, 47.8%, and 59.5% for osteoporosis, respectively; P<0.001). The prevalence of sarcopenia in each group was 29.2%, 27.7%, 24.9%, and 22.8%, respectively. The number of deliveries in the four groups was 2.4±0.1, 2.7±0.1, 3.7±0.1, and 5.3±0.1, respectively (P<0.001).

Table 2 presents the ORs of sarcopenia, osteoporosis, and obesity based on breastfeeding duration. The ORs of sarcopenia decreased with increasing breastfeeding duration in the four groups in model 3 (OR [95% CI]: 0.82 [0.42–1.60], 0.42 [0.20–0.87], and 0.27 [0.11–0.65], respectively) with significant P for trend (<0.001). Concerning osteoporosis, the ORs significantly increased with increasing breastfeeding duration in the unadjusted setting (P trend <0.001); however, after adjust-

Table 1. Basic characteristics of study participants according to breast feeding duration

Characteristic	Duration of breast feeding (mo)				P-value*
	0–18 (n=163)	19–36 (n=408)	37–72 (n=673)	>72 (n=783)	
Age (y)	66.3±0.5	66.1±0.3	68.9±0.3	74.2±0.3	<0.001
Education (%)					<0.001
≤Middle school	96 (63.4)	322 (82.4)	611 (92.3)	767 (99.3)	
≥High school	66 (36.5)	85 (17.6)	61 (7.7)	13 (0.7)	
House income (%)					<0.001
Low	101 (37.8)	278 (70.9)	480 (72.1)	619 (79.6)	
High	29 (32.2)	124 (29.1)	185 (27.9)	154 (20.4)	
Current smoking (%)	9.3±2.9	4.0±1.1	4.1±1.0	3.0±0.8	0.002
Binge drinking (%)	16.5±3.8	12.3±2.2	9.9±1.6	9.1±1.4	<0.001
Regular exercise (%)	12.5±3.1	17.2±2.3	14.6±1.7	16.3±1.7	<0.001
Obesity (%)	35.5±4.4	41.4±3.1	39.9±2.4	38.7±2.3	<0.001
Osteoporosis (%)	32.9±4.8	36.5±3.7	47.8±3.1	59.5±2.9	<0.001
Sarcopenia (%)	29.2±4.8	27.7±3.4	24.9±2.7	22.8±2.6	<0.001
Total energy intake (kcal)	1,697.3±54.2	1,584.4±30.4	1,496.6±24.0	1,409.9±1.1	<0.001
Protein intake (g)	56.3±2.1	52.8±1.6	47.5±1.0	42.5±1.1	<0.001
Menarche (y)	16.0±0.2	16.2±0.1	16.5±0.1	16.7±0.4	<0.001
Menopause (y)	49.7±0.4	49.3±0.3	48.8±0.3	48.1±0.2	<0.001
Hormone replace therapy (%)	18.6±3.0	19.2±2.2	11.8±1.5	4.3±0.8	<0.001
Breast feeding duration (mo)	11.0±0.4	31.0±0.4	58.1±0.5	128.6±1.6	<0.001
No. of deliveries	2.4±0.1	2.7±0.1	3.7±0.1	5.3±0.1	<0.001
Age at first delivery (y)	26.1±0.4	24.4±0.2	23.0±0.2	21.4±0.1	<0.001
Age at last delivery (y)	30.1±0.4	29.4±0.3	31.4±0.2	34.2±0.2	<0.001
Duration from last delivery (y)	36.2±0.6	36.7±0.4	37.5±0.3	40.1±0.3	<0.001

Values are presented as mean±standard error or number (%).
*Analyzed using age-adjusted analysis of covariance.

Table 2. Odds ratios of disease prevalence according to duration of breast feeding

Variable	Duration of breast feeding (mo)				P for trend
	0–18	19–36	37–72	>72	
Sarcopenia					
Unadjusted	1	0.93 (0.53–1.64)	0.80 (0.46–1.40)	0.72 (0.42–1.24)	<0.001
Model 1	1	1.01 (0.54–1.89)	0.60 (0.32–1.12)	0.34 (0.17–0.68)	<0.001
Model 2	1	1.14 (0.60–2.19)	0.63 (0.30–1.30)	0.38 (0.16–0.89)	0.002
Model 3	1	0.82 (0.42–1.60)	0.42 (0.20–0.87)	0.27 (0.11–0.65)	<0.001
Osteoporosis					
Unadjusted	1	1.17 (0.64–2.16)	1.87 (1.08–3.22)	2.99 (1.70–5.27)	<0.001
Model 1	1	1.24 (0.62–2.51)	1.44 (0.74–2.80)	1.19 (0.59–2.40)	0.89
Model 2	1	1.28 (0.62–2.64)	1.37 (0.67–2.80)	1.29 (0.61–2.73)	0.71
Model 3	1	1.18 (0.55–2.53)	1.24 (0.60–2.58)	1.19 (0.55–2.58)	0.81
Obesity					
Unadjusted	1	1.28 (0.79–2.10)	1.21 (0.79–1.85)	1.15 (0.74–1.78)	0.92
Model 1	1	1.68 (0.99–2.83)	1.75 (1.07–2.87)	2.33 (1.41–3.86)	0.002
Model 2	1	1.70 (0.97–2.96)	1.67 (0.98–2.85)	2.22 (1.28–3.85)	0.01
Model 3	1	1.94 (1.10–3.43)	1.99 (1.14–3.48)	2.56 (1.43–4.60)	0.009

Values are presented as odds ratios (95 % confidence intervals). Model 1: adjusted for age, alcohol, smoking, and physical activity; model 2: adjusted for variables considered in model 1+body mass index, level of education, and house income; and model 3: adjusted for variables considered in model 2+total energy intake per day, total protein intake per day, duration after menopause, and oral contraceptive use.

Table 3. Odds ratios of sarcopenia according to childbirth parameters

Variable	No. of deliveries	Age at first delivery	Age at last delivery	Duration from last delivery
Unadjusted	0.93 (0.84–1.03)	1.01 (0.96–1.07)	0.998 (0.97–1.03)	1.04 (1.01–1.08)
Model 1	0.78 (0.67–0.90)	1.05 (0.99–1.12)	0.95 (0.91–0.99)	1.05 (1.01–1.10)
Model 2	0.78 (0.65–0.95)	1.02 (0.95–1.10)	0.95 (0.91–0.99)	1.06 (1.01–1.12)
Model 3	0.79 (0.64–0.97)	1.05 (0.95–1.10)	0.95 (0.91–1.002)	1.05 (0.99–1.11)

Values are presented as odds ratios (95% confidence intervals). Model 1: adjusted for age, alcohol, smoking, and physical activity; model 2: adjusted for variables considered in model 1+body mass index, level of education, and house income; and model 3: adjusted for variables considered in model 2+total energy intake per day, total protein intake per day, duration after menopause, and oral contraceptive use.

ing for multiple confounding variables, all significances disappeared in models 1, 2, and 3. Concerning obesity, the ORs increased with increasing breastfeeding duration in the four groups in model 3 (OR [95% CI]: 1.94 [1.10–3.43], 1.99 [1.14–3.48], and 2.56 [1.43–4.60], respectively) with significant P for trend (0.009).

The ORs of sarcopenia based on childbirth parameters are presented in Table 3. The OR (95% CI) of sarcopenia was 0.79 (0.64–0.97) with number of deliveries in model 3. The OR (95% CI) of sarcopenia was 1.05 (0.95–1.10) with age at first delivery and 0.95 (0.91–1.002) with age at last delivery in model 3. The OR of sarcopenia was 1.06 (1.01–1.12) with the duration from last delivery in model 2; however, the OR was 1.05 (0.99–1.11) in model 3.

DISCUSSION

This study showed that sarcopenia has a negative association and obesity has a positive association with prolonged breastfeeding in women older than 60 years. We also found a positive association between the duration since last delivery and sarcopenia.

The results of this study were comparable to those of previous studies. Ki et al.[16] reported that prolonged breastfeeding was associated with greater BMI and waist circumference (WC) among postmeno-

pausal women (BMI: OR, 1.54; 95% CI, 1.19–2.0 and WC: OR, 1.67; 95% CI, 1.29–2.17). Sichieri et al.[6] found that the effect of breastfeeding on maternal weight was not significant. Bobrow et al.[7] reported that breastfeeding was associated with a long-term reduction in BMI among postmenopausal women (BMI, 25.88 kg/m^2 versus 26.39 kg/m^2). Wiklund et al.[8] suggested that long-term breastfeeding (duration >10 months) provides more protection against maternal obesity later in life than a breastfeeding duration of <6 months (BMI, 24.6 kg/m^2 versus 27.3 kg/m^2; P=0.001).

Several mechanisms have been suggested to explain the association between breastfeeding and obesity. The roles of breastfeeding in relation to obesity are also debatable. Prolactin released during breastfeeding may enhance estrogen levels and fat tissue storage. In contrast, prolactin inhibits lipogenesis and inhibits glucose uptake from adipose tissue, and fat deposition patterns induced during pregnancy can be reversed by breastfeeding.[8]

Several studies have evaluated the relationships between sarcopenia and obesity, insulin resistance, and osteoporosis. Dodds et al.[17] showed that persons with normal or increased BMI (18.5 kg/m^2 or above) were at a reduced risk of developing sarcopenia (obesity: OR, 0.07; 95% CI, 0.03–0.15). Srikanthan et al.[18] suggested that sarcopenic obesity, to a greater extent than either sarcopenia or obesity alone, is

strongly associated with insulin resistance (OR, 1.74; 95% CI, 1.67–1.87; P<0.0001). However, Bijlsma et al.[19] showed that sarcopenia is inversely associated with insulin resistance. Lee et al.[20] suggested that sarcopenia was significantly associated with osteoporosis. It has been hypothesized that sarcopenia worsens with decreasing estrogen level. Messier et al.[21] reported that menopause is associated with a rapid decline in muscle mass.

The relationship between breastfeeding and sarcopenia is not fully understood. Rolland et al.[22] suggested that estrogen, the level of which increases during breastfeeding, might prevent muscle mass loss. Messier et al.[21] suggested that estrogen could have a direct effect on muscle mass, as it has been shown that skeletal muscle contains estrogen beta-receptors on the cell membrane, in the cytoplasm, and on the nuclear membrane. A direct potential mechanistic link could exist between low estrogen levels and decreased protein synthesis.[21] Another explanation is that breastfeeding has a positive effect on sarcopenia through decreasing insulin resistance.[23] Rolland et al.[22] showed that sarcopenia is associated with increasing body fat and intramyocellular fat mass accompanying increased insulin resistance. Therefore, breastfeeding may improve insulin resistance, which might reduce sarcopenia.

This study has several limitations. First, this is a cross-sectional study; therefore, determining the cause-and-effect relationship between sarcopenia and breastfeeding was difficult. Second, recall bias or concealment could occur in the question of breastfeeding duration because the KNHANES used self-administered questionnaires. Finally, variables that were not considered during analyses may be hidden. Despite these limitations, to the best of our knowledge, this is the first study to elucidate the link between breastfeeding and sarcopenia in a large number of Korean women.

In conclusion, prolonged breastfeeding might have a positive effect on sarcopenia in elderly women. Further experimental studies and large prospective long-term studies will be needed to clarify the relationship between breastfeeding and sarcopenia in the future.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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