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# HOW MUCH INTAKE OF SODIUM IS GOOD FOR FRAILTY? : THE KOREAN FRAILTY AND AGING COHORT STUDY (KFACS)

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**Abstract:** *Objective:* The aim of this study was to determine how sodium intake can affect frailty, but not anorexia, in community-dwelling older adults in Korea. *Design:* This was a cross-sectional study. *Setting:* The study used data from the Korean Frailty and Aging Cohort Survey (KFACS), a multi-center longitudinal study addressing 10 centers across urban, rural, and suburban communities in Korea, between 2016 and 2017. *Participants:* A total of 954 older adults who underwent both 24-hour dietary recall assessment and physical function test during the first-year baseline investigation of the KFACS. *Measurements:* Frailty was determined according to the Fried frailty index (FFI). *Results:* Of the 954 participants, 461 (48.3%) were male and the mean age was 76.3 years old. The average daily sodium intake was 3857 mg. The frailty prevalence in first to third quartiles was 21.8%, 7.5%, and 5.4%, respectively, and increased in the fourth quartile of sodium intake to 8.9%. Using the second quartile of sodium intake (2504-3575 mg) as reference, the odds ratios of frailty were 1.64 (95% confidence interval: 0.84-3.22), 1.33 (0.57-3.06), and 4.00 (1.72-9.27) for the first (<2504 mg), third (3575-4873 mg), and fourth (≥4873 mg) quartiles, respectively, in a multivariate-adjusted analysis. *Conclusion:* Low sodium intake (<2504 mg) is related to frailty in older people, but it seems to be a less important factor than other nutritional factors. The prevalence of frailty did not increase up to a daily sodium intake of 3575 mg, but it increased upon a daily sodium intake higher than 3575 mg.

**Key words:** Aged, frailty, sodium intake, nutrition, Korea.

## Introduction

Population aging is a worldwide phenomenon, and Korea has one of the fastest aging populations in the world (1, 2). Increasing average life expectancies have led to an increased number of older adults with frailty, which is associated with significant economic, healthcare, and societal burdens (3). However, frailty can be prevented or postponed by early intervention, and efficient management is required (4). Some studies have shown that a high-protein diet with a moderate food amount can help prevent frailty, and, in particular, eating habits can be a major health determinant for older adults (5-7). However, due to a high incidence of anorexia with aging, nutritional intake is usually decreased in older people, leading to a lower consumption of nutrient-rich foods (8-10).

Sodium is an essential nutrient for health maintenance, and the recommended daily minimum sodium intake is 500 mg. However, an excessive sodium intake can increase the blood volume and the resistance of peripheral vessels, resulting in increased blood pressure. Excessive sodium intake has also been shown to be a risk factor for gastric cancer, metabolic abnormalities and cardiovascular disease (11-13). Sodium consumption in Korea is one of the highest in the world. The average daily sodium intake is above the recommended both in the total population (3,890 mg) and among people aged 65 years or older (3913 mg) (14, 15), which has led the World Health Organization (WHO) and the Korean Nutrition Society to limit the recommended daily sodium intake to 2000 mg or less (15, 16).

The salty taste threshold increases with age, causing older people to have a higher risk of excessive sodium intake than other age groups. In addition, the ability to excrete sodium also decreases with age due to a decreased ability of vessels to contract in the kidneys (17). However, excessive restriction of sodium in older people may reduce their overall energy intake as it can lower their appetite, and practical recommendations for this population should not simply emphasize a reduced salt intake (18).

Several studies have reported the effects of nutrition on frailty, but no studies have investigated the association between sodium intake and frailty. Thus, the aim of this study was to investigate the relationship between sodium intake and frailty, and to determine the optimal sodium intake that is least associated with frailty using data from the Korean Frailty and Aging Cohort Survey (KFACS).

## Materials and methods

### *Study population and protocol*

The study sample consisted of community-dwelling Korean older people aged 70-84 years who were enrolled in the KFACS in 2016 stratified by age and gender (19). The KFACS is a multi-center longitudinal study with 3,014 recruited subjects from 10 participating centers across urban,

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rural, and suburban communities in Korea, between 2016 and 2017. Out of 1,559 individuals recruited in the first year, 954 who answered 24-hour dietary recalls, underwent physical performance assessment and tests for frailty index were included in the present analysis.

***Definition of frailty***

The definition of frailty relied on the Fried frailty index (FFI), which has five components: unintended weight loss, poor grip strength, self-assessed exhaustion, reduced walking speed, and low physical activity level (20). One point was given for unintended weight loss of 4.5 kg or more in the last year. The grip strength of the dominant hand was measured using a hand dynamometer (Takei TKK 5401, Takei Scientific Instruments, Tokyo, Japan). In the first round of measurements, the grip strength of each hand was measured once, one at a time. A second round of measurements was performed after three minutes, in which the grip strength of each hand was alternately measured twice. The highest value for each hand was included in the analysis. One point was given for grip strength lower than 26 kg for males and lower than 18 kg for females (21). One point was given for exhaustion when the subject's response to either one of the questions from the Center for Epidemiological Studies-Depression (CES-D) scale, "I felt that everything I did was an effort" or "I could not get going", was yes for three or more days in a week (22). One point was given for walking speed below one meter per second after walking four meters at a normal rhythm (21). Metabolic Equivalent Task, in minutes per week (MET-min/week), was calculated to determine the physical activity level and one point was given for values below 494.65 kcal, for males, and below 283.50 kcal, for females, which corresponded to the lowest 20% of the gender-specific total energy consumed in a general population-based survey of older adults (23). Participants with a total score of 3 or more were classified as frail; those with a total score of 1-2 were classified as pre-frail, and those who did not score on any of the criteria were classified as robust.

***Measurement Methods***

Information on age, spouse presence, education level, drinking status, smoking status, physical activity level, use of medications, comorbidities, diabetes mellitus, hypertension, polypharmacy, and anorexia were obtained after face-to-face interviews. The weekly physical activity level was calculated using the International Physical Activity Questionnaire (IPAQ) and was expressed in kcal/week. Polypharmacy was defined as the ingestion of five or more prescribed medications. Anorexia was defined as a loss of appetite and/or reduced food intake based on a mini-nutritional assessment tool.

***Dietary intake assessment***

Dietary data were collected by trained interviewers using 24-hour dietary recalls during a weekday through face-to-face interviews. Visual aids, such as food pictures and measurement of bowls and plates, developed by the National Institute of Health, the Korea Center for Disease Control & Prevention (KCDC), were used to estimate the portion size. Interviewers were trained to use the standardized protocol and recorded the name, amount and type of food, all foods consumed at breakfast, lunch and dinner, and snacks consumed during the day before survey. Food and nutrient intakes were calculated using the 24-hour dietary recall assessment system of the National Institute of Health, KCDC, based on the National Rural Living Science Institute database (24).

***Blood Tests***

Blood samples were collected from each participant after a 12-hour overnight fast and were immediately processed, refrigerated, and transported in cold storage to the Central Testing Institution. Serum levels of sodium, potassium, and chloride were measured using an ion-selective electrode in a Cobas 8000 C702 analyzer (Roche, Germany).

***Statistical analysis***

Values of continuous variables were presented as the mean ± standard error (SE), and values of categorical variables were presented as proportions (%). Participants were grouped according to their quartiles of daily sodium intake and values were compared among the groups using one-way ANOVA, for continuous data, and the chi-square ($\chi 2$) test, for categorical data. The association between frailty and different quartiles of daily sodium intake was assessed by regression analysis. Odds ratios (ORs) and their corresponding 95% confidence intervals (CIs) were calculated using logistic regression analysis to assess the impact of the different quartiles of daily sodium intake on frailty, after adjusting for age, sex, alcohol consumption, smoking status, education level, spouse presence, physical activity, and total energy, protein, vitamin D, and vegetable intakes. The statistical analyses were performed using SPSS version 23.0 (IBM Corp., Chicago, IL, United States) and statistical significance was set at a P-value below 0.05.

## Results

***General characteristics of the study population***

Among 954 individuals enrolled in the analysis, 461 (48.3%) were male and the mean age of participants was 76.3 years old. The mean daily sodium intake was 3857 mg. After sodium intake was divided into quartiles, there was a predominance of males, drinkers, six or more years of education and spouse presence, and a higher consumption of calories, proteins, and vegetables among the individuals with higher daily sodium intake. The prevalence of frailty decreased from the first to the third quartiles of daily sodium intake but increased in the fourth quartile (21.8%, 7.5%, 5.4%, and 8.9%, respectively; p=0.022). The same occurred with the prevalence of anorexia (28.5%, 22.2%, 14.6%, and 16.5%, respectively; p=0.001) (Table 1) The FFI calculation revealed higher intakes of total energy, proteins,

**Table 1**
Baseline participants' characteristics according to the quartiles of daily sodium intake (mg) (n=954)

| | Q1 (n=239) Na<2504 | Q2 (n=239) 2504≤Na<3575 | Q3 (n=239) 3575≤Na<4873 | Q4 (n=237) Na≥4873 | P* |
|---|---|---|---|---|---|
| Age (years) | 76.7±3.9 | 76.1±3.8 | 76.1±3.9 | 76.3±4.0 | 0.368 |
| Males, N (%) | 74 (31.0) | 98(41.0) | 135(56.5) | 154(65.0) | <0.001 |
| Alcohol drinkers | 69(28.9) | 88(36.8) | 86(36) | 104(43.9) | 0.009 |
| Smokers | 15(6.3) | 13(5.4) | 15(6.3) | 13(5.5) | 0.963 |
| Education > 6 years | 151(63.2) | 176(73.6) | 200(83.7) | 2079(87.3) | <0.001 |
| Living with a spouse | 128(53.6) | 145(60.7) | 174(72.8) | 182(76.8) | <0.001 |
| Body mass index (kg/m$^2$) | 24.4±3.2 | 24.5±2.8 | 24.3±3.2 | 24.4±2.7 | 0.851 |
| Physical activity (kcal/week), mean | 2,943.7±5,257.9 | 3,179.5±5,261.6 | 3,190.0±3,535.6 | 3,534.3±4,617.7 | 0.595 |
| Systolic blood pressure (mmHg) | 132.2±16.7 | 129.6±14.2 | 130.5±15.9 | 130.7±15.5 | 0.421 |
| Diastolic blood pressure (mmHg) | 77.9±9.6 | 76.6±8.9 | 76.9±8.7 | 78.0±9.0 | 0.207 |
| Diabetes Mellitus | 62(25.9) | 50(20.9) | 62(25.9) | 42(17.7) | 0.084 |
| Hypertension | 150(62.8) | 150(62.8) | 141(59) | 125(52.7) | 0.086 |
| Polypharmacy | 105(43.9) | 88(36.8) | 74(31) | 80(33.8) | 0.022 |
| Anorexia | 68(28.5) | 53(22.2) | 35(14.6) | 39(16.5) | 0.001 |
| Physical frailty | | | | | |
| Robust | 77(32.2) | 95(39.7) | 97(40.6) | 111(46.8) | <0.001 |
| Pre-frail | 110(46) | 126(52.7) | 129(54) | 105(44.3) | |
| Frail | 52(21.8) | 18(7.5) | 13(5.4) | 21(8.9) | |
| Sub-items of frailty | | | | | |
| Weight loss | 16(6.7) | 7(2.9) | 16(6.7) | 11(4.6) | <0.001 |
| Weakness | 74(31.0) | 56(23.4) | 43(18.0) | 39(16.5) | <0.001 |
| Exhaustion | 101(42.3) | 79(33.1) | 69(28.9) | 69(29.1) | 0.006 |
| Low activity | 31(13.0) | 29(12.1) | 25(10.5) | 26(11.0) | 0.872 |
| Slowness | 101(42.3) | 72(30.1) | 54(22.6) | 62(26.2) | <0.001 |
| Total energy intake (kcal) | 1,066.2±365.0 | 1,378.8±378.4 | 1,578.5±422.7 | 1,832.1±525.4 | <0.001 |
| Protein intake (g) | 36.0±15.8 | 49.7±18.1 | 59.8±19.2 | 73.1±25.7 | <0.001 |
| Vegetable intake (g) | 38.6±27.0 | 57.1±29.2 | 79.8±36.8 | 108.2±48.7 | <0.001 |
| Vitamin D intake (μg) | 4.9±7.8 | 4.1±5.3 | 5.4±7.6 | 6.9±9.3 | 0.001 |
| Sodium intake (mg) | 1,802.8±513.3 | 3,069.6±295.2 | 4,135.1±380.4 | 6,441.7±1,442.7 | <0.001 |
| Plasma Sodium level (mmol/L) | 140.9±2.5 | 141.3±2.1 | 141.5±2.4 | 141.3±3.0 | 0.048 |

Variables presented as means ± standard deviation (SD) or absolute and relative frequencies (percentages between parentheses). *P-value of one-way ANOVA, for continuous variables, and chi-square test, for categorical variables.

vegetables, vitamin D, and sodium in the frail group (Table 2).

***Odds ratios of frailty according to the quartiles of daily sodium intake***

Using the second quartile as the reference group (Model 1), the unadjusted ORs of frailty were 3.41 (95% CI: 1.93-6.04), 0.71 (95% CI : 0.34-1.48) and 1.19 (0.62-2.30) for the first, third and fourth quartiles, respectively. After adjusting for age, sex, body mass index, alcohol drinking, smoking status, education level, spouse presence, physical activity, polypharmacy, diabetes mellitus, hypertension, and total energy, protein, vegetables and vitamin D intakes (Model 3), this association remained statistically significant only for the highest quartile of daily sodium intake [OR = 4.0 (95% CI: 1.72-9.27), p = 0.001] (Table 3, Fig 1).

**Table 2**
Nutritional intake according to the physical frailty index, based on the Fried's criteria (n=954)

| | Robust (N=380) | Pre-frail (N=470) | Frail (N=104) | P* |
|---|---|---|---|---|
| Total energy (kcal) | 1,578.9±522.7 | 1,434.4±485.1 | 1,170.1±439.9 | <0.001 |
| Protein (g) | 59.7±26.3 | 53.6±21.8 | 40.5±20.1 | <0.001 |
| Vegetables (g) | 78.8±48.0 | 69.6±42.4 | 47.3±31.7 | <0.001 |
| Vitamin D (μg) | 5.7±7.1 | 5.4±8.4 | 3.6±5.8 | 0.037 |
| Sodium (mg) | 4105.8±1925.2 | 3814.7±1802.4 | 3138.1±1872.3 | <0.001 |

Variables presented as means ± standard deviation (SD).*P-value of one-way ANOVA.

**Table 3**
Odds ratios (ORs) (95% CI) of frailty according to the quartiles of sodium intake

| | quartiles of sodium intake(mg) | OR (95% CI) | P |
|---|---|---|---|
| Model 1 | Na<2504 | 3.41 (1.93-6.04) | <0.001 |
| | 2504≤Na<3575 | 1.00 (reference) | - |
| | 3575≤Na<4873 | 0.71 (0.34-1.48) | 0.355 |
| | Na≥4873 | 1.19 (0.62-2.30) | 0.597 |
| Model 2 | Na<2504 | 2.49 (1.33-4.64) | 0.004 |
| | 2504≤Na<3575 | 1.00 (reference) | - |
| | 3575≤Na<4873 | 0.84 (0.38-1.86) | 0.673 |
| | Na≥4873 | 1.59 (0.78-3.25) | 0.203 |
| Model 3 | Na<2504 | 1.64 (0.84-3.22) | 0.148 |
| | 2504≤Na<3575 | 1.00 (reference) | - |
| | 3575≤Na<4873 | 1.33 (0.57-3.06) | 0.502 |
| | Na≥4873 | 4.00 (1.72-9.27) | 0.001 |

Model 1: Not adjusted: Model 2: Adjusted for age, sex, body mass index, drinking and smoking status, education, spouse, physical activity, polypharmacy, DM, and HTN. Model 3: Adjusted for age, sex, body mass index, alcohol, smoking, education, spouse, physical activity, polypharmacy, DM, HTN, total energy intake, protein, vegetables, and vitamin D intakes.

## Discussion

The prevalence of frailty was significantly higher in the first quartile of daily sodium intake, even after adjusting for age, sex, body mass index, smoking and drinking status, disease and physical activity. However, after additional adjustment for total energy, protein and vegetable intakes, the association lost significance, suggesting that, in the group with lowest sodium intake, a decreased intake of calories and proteins, rather than sodium, may be more associated with frailty.

In contrast, no significant association between sodium intake and frailty was seen in the group with the highest sodium intake after adjustment for age, sex, body mass index, smoking and drinking status, comorbidities, physical activity, but the association reached statistical significance after additional adjustment for total energy, protein and vegetable intakes (Table 3). These results were probably due to a negative confounding effect or a suppressor effect (25). Although low sodium intake showed to be associated with frailty in older people, the association may be weaker when compared to other nutritional factors like low protein or total energy intake. Also, the risk of frailty did not increase at a daily sodium intake of up to 3575 mg, which is higher than the recommended daily intake (2000 mg); however, a daily intake higher than 3575 mg may increase the risk of frailty. Therefore, older people at risk of frailty may actually need an adjustment rather than a strict control of the daily sodium intake, especially because sodium intake may stimulate their appetite.

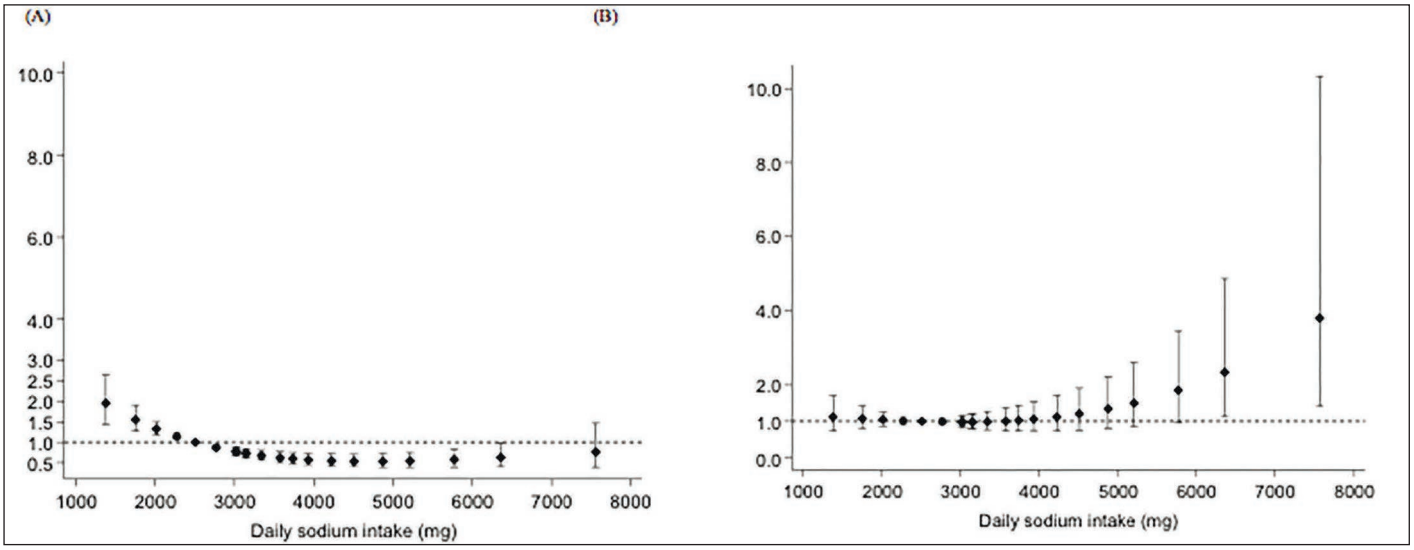
Recent studies on cardiovascular diseases and mortality have shown similar patterns regarding sodium intake. It is worth mentioning that the current cut-offs for recommended sodium intake are controversial. Graudal et al. (26) found that the association of dietary sodium intake with cardiovascular disease and all-cause mortality had a U-shaped pattern. Furthermore, Mente et al. (27) found that the healthy range of sodium intake was between 3-5 g per day, and the range corresponding to the lowest mortality rate was between 4-6 g per day.

The average daily sodium intake in the present study was 3857 mg, similar to that found among people aged 65 years or older in the Korea National Health and National Health and Nutritional Examination Survey (KNHNES) in 2012 (3913 mg), and nearly two times higher than the current recommended intake. Korean people traditionally consume seasoned soups and stews, and pickled vegetables, which have a high sodium content. This dietary pattern is considered to be a major cause of the excessive sodium intake among Koreans [28, 29] and is an important health issue for Korean older people, as high sodium intake has been associated with increased risk of several chronic diseases, including cardiovascular diseases, and all-cause mortality (30, 31). For this reason, the Korean Nutrition Society currently recommends a daily sodium intake of 2 g or less for prevention and management of chronic diseases (15).

However, dietary sodium is strongly related to energy intake (18) due to its inclusion in a wide variety of foods and food preparations (32). Also, dietary sodium intake is related to appetite. Indeed, a high salt intake is known to increase fasting ghrelin levels (33).

Restricting salty foods can also lead to a deficient intake of other micronutrients, as sodium-rich foods usually contain other

**Figure 1**
Odds ratios (ORs) of frailty according to different daily sodium intakes




(A) Adjusted for age and sex. (B) Adjusted for age, sex, body mass index, alcohol, smoking, education, spouse, physical activity, polypharmacy, DM, HTN, total energy intake, protein, vegetables and vitamin D intakes, and anorexia.

beneficial minerals. Therefore, practical recommendations for older people should not only focus on a reduced salt intake but also ensure an adequate intake of sodium and other nutrients (18).

Interestingly, additional adjustment for anorexia did not significantly change the association between frailty and sodium intake in this study, which suggests that the excessive sodium intake implies a higher risk of frailty than does anorexia.

This study has several limitations. The most important limitation is selection bias, as participants had to be ambulatory to come to the study centers and spend several hours undergoing questionnaires, cognitive tests, physical tests and various laboratory and imaging assessments. Therefore, severely frail community-dwelling older adults were most likely excluded during recruitment. Also, nutritional assessment was based only on single 24-hour recalls. Therefore, the data are prone to a wide within-person variation, and the nutritional information may have been insufficient for an objective comparison. Finally, our study had a cross-sectional design, which does not guarantee causality.

On the other hand, the sample size is relatively large and representative of the Korean population of community-dwelling older adults aged 70-84 years old. To the best of our knowledge, this is the first study to reveal a relationship between sodium intake and frailty. A longitudinal study is required for a more accurate evaluation.

## Conclusion

Low sodium intake in older adults was associated with frailty, but the association may be weaker compared to other nutritional parameters, such as low protein or total energy intake. Also, the risk of frailty did not increase at a daily sodium intake of up to 3575 mg, which is higher than the current recommended intake of 2000 mg; however, a daily intake of more than 3575 mg may increase the risk of frailty.

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*Conflict of interest:* The authors have no potential conflicts of interest to disclose.

*Ethics statement:* Our research plan was approved by the Institutional Review Board of the Kyung Hee University, and written consent was obtained from each subject prior to commencement of the study (approved NO. KMC IRB 2018-05-039).

## References

1. Statistics Korea. Korea Statistical Information System (KOSIS). 2013;2014:.
2. Wan He, Daniel Goodkind, and Paul Kowal. International Population Reports, An Aging World: 2015, U S Census Bureau 2016;P95/16-1
3. Fried LP, Ferrucci L, Darer J, Williamson JD, Anderson G. Untangling the concepts of disability, frailty, and comorbidity: implications for improved targeting and care. J Gerontol A Biol Sci Med Sci 2004;59:255-63
4. Hardy SE, Dubin JA, Holford TR, Gill TM. Transitions between states of disability and independence among older persons. Am J Epidemiol 2005;161:575-84.
5. Kobayashi S, Suga H, Sasaki S. Diet with a combination of high protein and high total antioxidant capacity is strongly associated with low prevalence of frailty among old Japanese women: a multicenter cross-sectional study. Nutr J. 2017;16(1):29.
6. Matteo Cesari, Physical Frailty and Sarcopenia: Development of a Framework for Supporting Interventions Against Incident Mobility Disability, Ann Geriatr Med Res 2017; 21(2): 42-48 https://doi.org/10.4235/agmr.2017.21.2.42
7. Fried LP. "Interventions for human frailty: physical activity as a model." Cold Spring Harbor perspectives in medicine (2016): a025916.
8. Morley JE. Pathophysiology of the anorexia of aging. Curr Opin Clin Nutr Metab Care 2013;16;1:27–32.
9. Martone AM, Onder G, Vetrano DL et al. Anorexia of aging: a modifiable risk factor for frailty. Nutrition 2013;5;10:4126–33.
10. Porter Starr KN, McDonald SR, Bales CW. Nutritional Vulnerability in Older Adults: A Continuum of Concerns. Curr Nutr Rep 2015;4;2:176–84.
11. Strazzullo P, D'Elia L, Kandala NB, Cappuccio FP. Salt intake, stroke, and cardiovascular disease:meta-analysis of prospective studies. BMJ. 2009; 339:b4567. [PubMed: 19934192]
12. Koo S, Kim Y, Kim MK, Yoon JS, Park K. Nutrient intake, lifestyle factors and prevalent hypertension in Korean adults: results from 2007-2008 Korean National

Health and Nutrition Examination Survey. Korean J Community Nutr 2012;17: 329-40.
13. Nan HM, Park JW, Song YJ, Yun HY, Park JS, Hyun T, et al. Kimchi and soybean pastes are risk factors of gastric cancer. World J Gastroenterol 2005;11:3175-81.
14. Tak, YJ, et al. "Excessive Sodium Intake and Related Factors According to Energy Intakes Among Korean Elderly: A Nationwide Cross-Sectional Study." Journal of the Korean Geriatrics Society 18.4 (2014): 185-198.
15. The Korean Nutrition Society. Dietary reference intakes for Koreans [Internet]. Seoul: The Korean Nutrition Society; c2014 [cited 2014 Aug 14]. Available from: http://www.kns.or.kr/Download/2010KDRIs_open_final.pdf.
16. World Health Organization. Guideline: Sodium intake for adults and children [Internet]. Geneva: World Health Organization; c2014 [cited 2014 Jul 21]. Available from: http://www.who.int/nutrition/publications/guidelines/sodium_intake/en/.
17. Appel LJ, Espeland MA, Easter L, Wilson AC, Folmar S, Lacy CR. Effects of reduced sodium intake on hypertension control in older individuals: results from the Trial of Nonpharmacologic Interventions in the Elderly (TONE). Arch Intern Med 2001;161:685-93
18. Morley, John E. "Why do physicians fail to recognize and treat malnutrition in older persons?." Journal of the American Geriatrics Society 39.11 1991; 1139-1140.
19. Won CW, Lee Y, Choi J, Kim KW, Park Y, Park H, Oh I, Ga H, Kim YS, Jang HC. Starting construction of frailty cohort for elderly and intervention study. Annals of Geriatric Medicine and Research 2016; 20: 114-7.
20. Fried LP, Tangen CM, Walston J, Newman AB, Hirsch C, Gottdiener J, et al. Frailty in older adults: evidence for a phenotype. J Gerontol A Biol Sci Med Sci 2001;56: M146-56.
21. Chen LK, Liu LK, Woo J, Assantachai P, Auyeung TW, Bahyah KS, et al. Sarcopenia in asia: consensus report of the asian working group for sarcopenia. J Am Med Dir Assoc 2014;15:95-101.
22. Orme J, Reis J, Herz E. Factorial and discriminate validity of the Center for Epidemiological Studies depression (CES-D) scale. J Clin Psychol. 1986;42:28–33.
23. Son J, Kim S, Won C, Choi H, Kim B, Park M. Physical frailty predicts medical expenses in community-dwelling, elderly patients: three-year prospective findings from living profiles of older people surveys in Korea. European Geriatric Medicine. 2015;6(5):412-6
24. Kim SY, Kang MS, Kim SN, Kim JB, Cho YS, Park HJ, Kim JH. Food composition tables and national information network for food nutrition in Korea. Food Sci Ind 201;44:2-20
25. MacKinnon, David P., Jennifer L. Krull, and Chondra M. Lockwood. "Equivalence of the mediation, confounding and suppression effect." Prevention science 1.4 2000;173-181
26. Graudal NJ, Jürgens G, Baslund B, Alderman MH. Compared with usual sodium intake, low- and excessive-sodium diets are associated with increased mortality: a meta-analysis. Am J Hypertens 2014; 27(9): 8.
27. Mente A, O'Donnell M, Rangarajan S, et al. Associations of urinary sodium excretion with cardiovascular events in individuals with and without hypertension: a pooled analysis of data from four studies. Lancet 2016; 388(10043): 465–75. doi: 10.1016/s0140-6736(16)30467-6. PubMed PMID:27216139; eng.
28. Lee HS, Duffey KJ, Popkin BM. Sodium and potassium intake patterns and trends in South Korea. J Hum Hypertens 2013; 27:298-303.
29. Song DY, Jong E, Shim JE, Lee JE. Trends in the major dish groups and food groups contributing to sodium intake in the Korea National Health and Nutrition Examination Survey 1998-2010 Korean J Nutr 2013; 46(1): 72 – 85, http://dx.doi.org/10.4163/kjn.2013.46.1.72
30. Larsen SC, Angquist L, Sorensen TI, Heitmann BL. 24h urinary sodium excretion and subsequent change in weight, waist circumference and body composition. PLoS One. 2013; 8: e69689. doi: 10.1371/journal.pone.0069689.
31. Venezia A, Barba G, Russo O, Capasso C, De Luca V, Farinaro E, et al. Dietary sodium intake in a sample of adult male population in southern Italy: results of the Olivetti Heart Study. Eur J Clin Nutr 2010;64(5):518–24. doi: 10.1038/ ejcn.2010.22. PubMed PMID:20216559; eng.
32. Bailey RL, Parker EA, Rhodes DG, Goldman JD, Clemens JC, Moshfegh AJ, et al. Estimating sodium and potassium intakes and their ratio in the American diet: data from the 2011–2012 NHANES. J Nutr 2016; 146: 745–750. doi: 10.3945/jn.115.221184
33. Zhang, Yong, et al. "Elevation of Fasting Ghrelin in Healthy Human Subjects Consuming a High-Salt Diet: A Novel Mechanism of Obesity?." Nutrients 8.6 (2016): 323.