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Quality of diet and level of physical performance related to inflammatory markers in community-dwelling frail, elderly people

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ABSTRACT

Objective: The aim of this study was to assess whether diet quality and functional status were associated with serum levels of interleukin (IL)-6 and tumor necrosis factor (TNF)-α in frail, elderly, community-dwelling individuals.

Methods: Seventy-eight frail, elderly individuals (age ≥65 y, usual gait speed <0.6 m/s and Mini Nutritional Assessment <24) participated in this cross-sectional study from the National Home Healthcare Services in Gangbuk-gu, Seoul, South Korea. Diet quality was assessed using mean adequacy ratio (MAR) of the diet, which was calculated by averaging the sum of the nutrient adequacy ratios (NAR) for the intakes of energy, protein, and 11 micronutrients. Grip strength was measured as an indicator of muscle strength, and short physical performance battery (SPPB) was measured as an indicator of physical performance. The levels of the inflammatory markers IL-6 and TNF-α were obtained from serum samples.

Results: MAR and NAR scores for phosphorus; vitamins A, B_1, and B_6; and niacin were negatively associated with IL-6 ($\beta = -0.006$, -0.004, -0.004, -0.007, -0.004, and -0.005, respectively; $P < 0.05$). SPPB score, as well as NAR scores for vitamin B_6, niacin, and vitamin C, were negatively associated with TNF-α ($\beta = -0.098$, -0.006, -0.006, and -0.004, respectively; $P < 0.05$).

Conclusion: MAR of the diet was inversely associated with IL-6 concentration in frail elderly individuals, and higher SPPB score was associated with lower levels of TNF-α. Results from the present study suggest that improving diet quality and physical performance might lower levels of inflammation in this frail, elderly population.

Introduction

Frailty, recognized as an important and common geriatric syndrome, is associated with problems including, but not limited to, reduced food intake, loss of lean body mass (sarcopenia), illness and its cachexic effects, and subsequent functional impairments that limit mobility [1]. Globally, the prevalence of frailty increases with age, from 6% in groups ages ≥54 y to 20% in groups ≥80 y without acute or chronic disease [2]. In a 2008 study in Korea, 8.3% of people ages ≥65 y were considered frail [3].

Most frail, elderly individuals suffer from low nutritional status and poor diet quality [4]. The elderly are at increased risk for low energy and protein intake as well as deficiency of several micronutrients, such as vitamins C, B_{12}, and A; folate; and zinc [5]. Indeed, evidence is emerging on the important correlation between diet, immunity, and frailty status in the elderly [6,7]. Several studies have reported that low nutritional status and poor diet quality may play a key role in increasing the proinflammatory response, specifically increased circulating cytokines such as interleukin (IL)-6 and tumor necrosis factor (TNF)-α; these cytokines in particular are associated with mortality in the elderly [1,8]. Therefore, several nutritional strategies have been introduced to improve cytokine levels in elderly individuals, such as modifying the level of macronutrients and providing an adequate level of micronutrients to increase diet quality [9]. In

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Korea, several studies have been performed to identify the relationship between nutritional status and serum IL-6 and TNF-α in the elderly [10,11]. To our knowledge, there are only a few studies to date regarding the association between diet quality and inflammation in frail elderly individuals. Meanwhile, several studies have reported that physical performance tends to be very low in frail elderly individuals, and a higher level of physical performance is associated with lower levels of proinflammatory cytokines, including TNF-α, in this population [12,13]. Therefore, it is meaningful to identify the associations between physical performance and levels of proinflammatory cytokines in this frail, older population.

To our knowledge, there are few studies that definitively assess the association between nutritional status, including diet quality, or physical training with proinflammatory cytokines in the elderly [14–16]. Based on these studies, we hypothesized that higher diet quality would be associated with lower levels of chronic proinflammatory cytokines (IL-6, TNF-α), and that higher physical performance would be associated with lower levels of chronic proinflammatory cytokines in frail, elderly people in South Korea.

Methods

Participants

This study was designed as a community-based, cross-sectional study of 87 individuals recruited from the National Home Healthcare Services (NHHS) database in Gangbuk-gu, Seoul, South Korea. All participants were ≥65 y, living at home, and receiving home health care services provided by NHHS workers (doctors, nurses, and dietitians). Because some elderly people live alone in their homes in South Korea, home healthcare services are common. Registration for NHHS is limited by family income, so only those below 120% of the national absolute poverty line qualify for the service. After providing written informed consent, 258 individuals in the NHHS database were screened to identify those who could not walk a 3-m course within 5 s at their usual pace (usual gait speed [UGS] <0.6 m/s) measured as the average of two trials [17]. As a result, 120 frail, elderly participants were examined by research assessors. Thirty participants did not meet the frailty criteria, and 3 declined to participate. Therefore, 87 frail, elderly people participated. Study participants who were involved in any kind of exercise or clinical nutrition program or who had acute infection (such as cold or flu) were excluded. Those who were unable to walk or were too functionally deteriorated to receive home health care services were automatically transferred to national long-term care service centers; thus, all eligible participants were able to walk, at a minimum, inside a room. Institutional Review Board of Ewha Womans University in Seoul, South Korea approved the study protocol.

Definition of frailty status

This study used the operational definition of *frailty* by the Interventions on Frailty Working Group [18]. For effective interventions to prevent or delay disability in the elderly in a public health setting, the working group provided a recommendation that we should select at least two operationalized variables among the eight domains of the frailty syndrome [18]. Accordingly, we selected study participants who met frailty criteria for both mobility and nutrition. Using this procedure, we were able to determine those who were more prone to the development or progression of disability [17–20]. The domains of mobility was assessed using UGS, and nutrition was measured using the Mini Nutritional Assessment (MNA) [3,17–21]. We used the cutoff points of UGS <0.6 m/s and MNA <24/30 points [21,22]. Using this process, we selected frail individuals who were eligible for the study among a population of community-dwelling elderly people [17,19,20].

Measurements of diet quality

To assess diet quality, mean adequacy ratio (MAR) was determined by a trained research dietitian. Dietary intake was assessed by three nonconsecutive 24-h recalls (one face-to-face and two by telephone, including 2 weekdays and 1 weekend day). Dietary data were coded by a trained dietitian, and nutrient analysis was carried out using the Computer Aided Nutritional Analysis Program, version 3.0 (Korean Nutrition Society, Seoul, South Korea). Diet quality was assessed using MAR, which was calculated by averaging the sum of the nutrient adequacy ratios (NAR) for the intakes of energy, protein, and 11 micronutrients (calcium, phosphorus, iron, zinc, vitamin A, thiamin, riboflavin, pyridoxine, niacin, vitamin C, and folate) [23]. NAR was a participant's daily intake of a nutrient divided by the Recommended Nutrient Intake as part of the Dietary Reference Intake; for energy, the NAR was the daily intake of energy divided by the estimated energy requirement. The NAR of each nutrient was then converted to a percentage, and percentages >100% were treated as 100% (i.e., adequate intake) [24].

Measurements of anthropometric status

Anthropometric data including body mass index (BMI), calf circumference (CC), and midarm circumference (MAC) also were collected. BMI was calculated as weight divided by height squared (kg/m^2). To obtain an accurate weight, a calibrated and reliable set of scales was used. Height was obtained for each individual with feet together, back and heels against the upright bar of the height scale, head approximately in the Frankfort horizontal plane ("look straight ahead"), and standing erect ("stand up tall" or "stand up real straight") with some assistance and demonstration when necessary [25]. MAC and CC were measured using a nonelastic but flexible plastic tape. MAC was measured at the midpoint between the acromial and olecranon processes on the right or nonaccess arm with the arm relaxed at the side, with the person standing if possible [26]. CC was measured at the point of greatest circumference without subcutaneous tissue on the left leg (or the right leg for left-handed persons) in a sitting position with the knee and ankle at a right angle and feet resting flat on the floor [27].

Muscle strength and physical performance

To assess grip strength (GS), an indicator of muscle strength, maximal handgrip strength was measured on the dominant hand [28] as the average of the two best results from several attempts [29] using a hand-grip dynamometer (Takei Scientific Instruments Co. Ltd., Tokyo, Japan).

Physical performance was assessed using short physical performance battery (SPPB) tests. The SPPB, a set of objective measurements of lower extremity physical performance, is highly predictive of subsequent disability, hospitalization, institutionalization, and mortality in community-dwelling elders in epidemiologic studies and outpatient clinics [30]. Objective data for walking speed, balance tests, and times for repeated chair stands were collected to create a global score that ranged from 0 (*worst performance*) to 12 (*best performance*) [30].

Inflammatory markers

After a 12-h overnight fast, peripheral venous blood samples were collected. Blood samples were obtained in serum-separate tubes that were kept on ice and centrifuged (3000*g*, 4°C, 10 min) within 2 h of blood collection; the supernatant was stored at −80°C until analysis. Proinflammatory cytokines (IL-6, TNF-α) in serum were quantified using enzyme-linked immunosorbent assays with commercially available immunoassay kits (Bio Source Cytoscreen human IL-6 and human TNF-α Ultra-Sensitive kits; BioSource International, Inc., Camarillo, CA, USA). The minimum detectable concentration was 0.10 pg/mL for IL-6 and 0.09 pg/mL for TNF-α. The interassay coefficient of variation was 7% for both kits. All assays were performed in duplicate for the cytokine measures, and the average of the two measures was used in the analyses. Samples were not collected from nine participants; therefore, analyses were performed with 78 samples.

Sample size

We expected to have 90% a priori power based on the squared multiple correlation ρ2 of 0.20, three predictors, and $\alpha = 0.05$. The sample size was calculated using G*power software, version 3.1 (University Kiel, Germany).

Statistical analysis

Initial analyses included Student's *t* test to compare means between sex groups and analysis of variance to compare means among age groups for demographic characteristics, anthropometric data, and dietary data. Proportions were compared using χ^2 tests. We then used multiple linear regression to examine associations between each model of age and sex (independent variable) and muscle strength, physical performance, and log of the concentrations of inflammatory markers (dependent variable) adjusted for age, sex, and the Charlson comorbidity index. Lastly, multiple linear regression analyses were conducted between each model of diet quality and physical performance (independent variable) and the log of the concentration of each inflammatory markers (dependent variable), adjusted for age, sex, and the Charlson comorbidity index. $P < 0.05$ was considered significant. Statistical tests were performed