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## Original Research

# High dietary calcium intake and a lack of dairy consumption are associated with metabolic syndrome in obese males: the Korean National Health and Nutrition Examination Survey 2010 to 2012



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## ABSTRACT

Metabolic syndrome (MetS) has been increasing rapidly worldwide and is associated with elevated risks of cardiovascular disease and mortality. The relationship between MetS and dietary calcium intake is controversial. We hypothesized that high dietary calcium intake is associated with MetS in males and that the associations vary according to obesity status. Using data from the Korean National Health and Nutrition Examination Survey V, a cross-sectional survey of Korean civilians was conducted from January 2010 to December 2012 to test these hypotheses. Data from a total of 5946 males were analyzed with no association observed between dietary calcium intake and the presence of MetS. However, males deriving high calcium intake levels from dairy products had a lower prevalence of MetS than did those who did not ingest such products (adjusted odds ratio [OR], 0.75; 95% confidence interval [CI], 0.58–0.96). In obese males, the highest dietary calcium intake was positively associated with the presence of MetS (adjusted OR, 1.61; 95% CI, 1.12–2.36). However, obese males who consume dairy products had a lower prevalence of MetS than did those who did not consume such products (adjusted OR, 0.51; 95% CI, 0.29–0.90). In conclusion, the results suggest that the high dietary calcium intake, in the absence of dairy product consumption, was associated with the increased prevalence of MetS in obese males. Additional studies are required to determine whether dietary calcium intake affects the development of MetS.

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Abbreviations: 25(OH)D, 25-hydroxyvitamin; BMI, body mass index; CI, confidence interval; CVD, cardiovascular disease; eGFR, estimated glomerular filtration rate; HDL, high-density lipoprotein; KNHANES, Korean National Health and Nutrition Examination Survey; MetS, metabolic syndrome; OR, odds ratio.

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## 1. Introduction

Metabolic syndrome (MetS) has become increasingly common worldwide [1,2]. Metabolic syndrome is a constellation of metabolic risk factors including hyperglycemia, dyslipidemia, increased blood pressure, and abdominal obesity and is associated with an increased risk of cardiovascular disease (CVD) and all-cause mortality [3-5]. Thus, MetS is a major public health issue. (See Figure.)

Several factors including obesity, physical inactivity, smoking, and alcohol consumption influence the development of metabolic risk factors [6]. Specific nutrients and dietary patterns, including calcium intake, are also associated with such risk factors [7-10]. Calcium is abundant in the human body and plays crucial roles in structural support and biological functioning [11]. Dairy products are well-known sources of calcium [12], and additional sources include seaweeds, nuts, beans, broccoli, and kale. Recently, several foods and drinks such as tofu, cereals, breads, and orange juice have been fortified with calcium [13].

Several studies have investigated the relationships among dietary calcium intake, metabolic risk factors, and CVD; however, the results have been controversial. Calcium intake was inversely associated with waist circumference [8] and the presence of hypertension [9] and was beneficial to serum lipid levels in animal studies [10,14,15]. In other studies, calcium intake reduced the risks of stroke [16] and coronary artery disease [17,18]. Wang et al [19] reported a U-shaped relationship between dietary calcium intake and cardiovascular mortality; however, Li et al [20] found that dietary calcium intake was not associated with an elevated risk of myocardial infarction, stroke, or cardiovascular mortality. Moreover, Michaëlsson et al [21] reported that high calcium intake was associated with higher rates of CVD and all-cause mortality. On the other hand, associations between the levels of calcium intake from dairy products and metabolic risk factors are of particular concern. Several studies found that high intake levels of dairy products improve metabolic profiles [22], reducing blood pressure, dyslipidemia, abdominal obesity, and insulin resistance, all of which increase the risks of diabetes and CVD [23,24].

Although the relationship between dietary calcium intake and MetS is thus of major medical interest, few relevant

studies have been performed in Korea [25]. We hypothesized that MetS is positively associated with high dietary calcium intake and negatively associated with the consumption of dairy products or calcium intake from dairy products in Korean males. Moreover, we hypothesized that the associations would be more marked in obese males, compared with males of normal weight. Using data from the Korean National Health and Nutrition Examination Survey (KNHANES), we evaluated whether total dietary calcium intake, calcium intake from dairy products, or consumption of dairy products was associated with the prevalence of MetS in Korean males. We also examined whether such associations were enhanced in obese males.

## 2. Methods and materials

### 2.1. Study population

We used data collected from KNHANES V (conducted from January 2010 to December 2012). The KNHANES is implemented by the Korea Centers for Disease Control and Prevention at 3-year intervals to assess the public health status and to provide baseline data for the development, establishment, and evaluation of public health policies in Korea. The KNHANES participants are noninstitutionalized individuals 1 year or older, selected using a stratified, multistage, cluster probability sampling design to ensure independent and homogeneous sampling during each survey; sampling is nationally representative. Data are collected by a variety of means, including household interviews, anthropometric and biochemical measurements, and nutritional status assessments [26]. All protocols were approved by the Institutional Review Board of the Korea Centers for Disease Control and Prevention, and all participants provided informed written consent.

In the KNHANES V, we originally evaluated 6779 males. We excluded those for whom demographic information or values for major variables were missing ( $n = 694$ ), those with abnormal daily energy intake ( $<500$  kcal or  $>5000$  kcal;  $n = 116$ ), and those with reduced kidney function (estimated glomerular filtration rate [eGFR]  $<30$  mL/min per  $1.73$  m<sup>2</sup>;  $n = 23$ ). Therefore, the current study population consisted of 5946

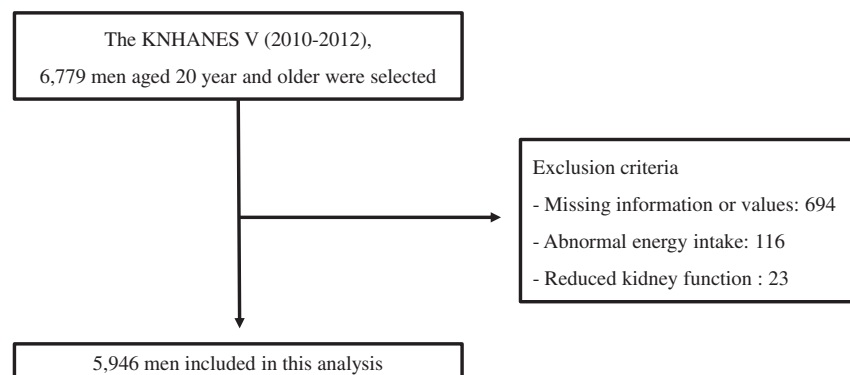


Figure – Recruitment of participants for the KNHANES V and derivation of the population used in this study.

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