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Meat and milk intake in the rice-based Korean diet: impact on cancer and metabolic syndrome

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Over a few decades, Korean diet has changed from traditional diet, mainly composed of rice and vegetables, to Westernised diet rich, in meat and milk, along with the economic development and globalisation. Increasing prevalence of diet-related chronic diseases such as cancer and metabolic syndrome (MetS) is becoming a heavy burden to society and requires further attention. In this review, the association of meat and milk consumption with cancer and MetS among Koreans was discussed. Previous meta-analyses showed that meat intake was positively associated with increased risk of cancers, especially colon, as well as obesity and type 2 diabetes mellitus, and that the intake of milk and dairy products was negatively associated with colorectal cancer, obesity, and type 2 diabetes mellitus, based on studies conducted mostly in Western countries. In Korea and other Asian countries, the association of meat and milk intake with cancers were inconclusive and varied by types of cancers. Conversely, milk intake was negatively associated with MetS risk as reported in Western countries. The difference in results between Korea and Western countries might come from the differences in dietary patterns and study designs. Most Koreans still maintain traditional dietary pattern, although rapid change towards Westernised diet is underway among the younger age group. Randomised clinical trials or prospective cohort studies with consideration of combined effects of various dietary factors in Korea and other Asian countries are needed to elucidate the impact of meat and milk or related dietary patterns in their diet.

Meat and milk: Korean diet: Cancer: Metabolic syndrome

In recent decades, diet transitions have occurred in Asian countries along with the economic development and globalisation. Among these countries, South Korea experienced economic growth earlier than did most Asian countries and has shown significant dietary changes from traditional rice-based diet to the so-called Westernised diet[1–4]. Traditional Korean diet was composed mainly of rice and vegetables and very little meat and milk. Even though Koreans still maintain considerable part of rice-based diet, meat and milk consumption has increased dramatically and rice consumption has decreased among Koreans[5].

Concurrently, the burden of non-communicable diseases such as metabolic syndrome (MetS) and cancer has rapidly increased in Korea. Cancer has been the leading cause of death since 1983, and CVD and type 2 diabetes related to MetS also have been major causes of death[6]. These chronic diseases are well known to be associated with diet; many epidemiological studies have reported that meat consumption increased the risk of

Abbreviations: MetS, metabolic syndrome.

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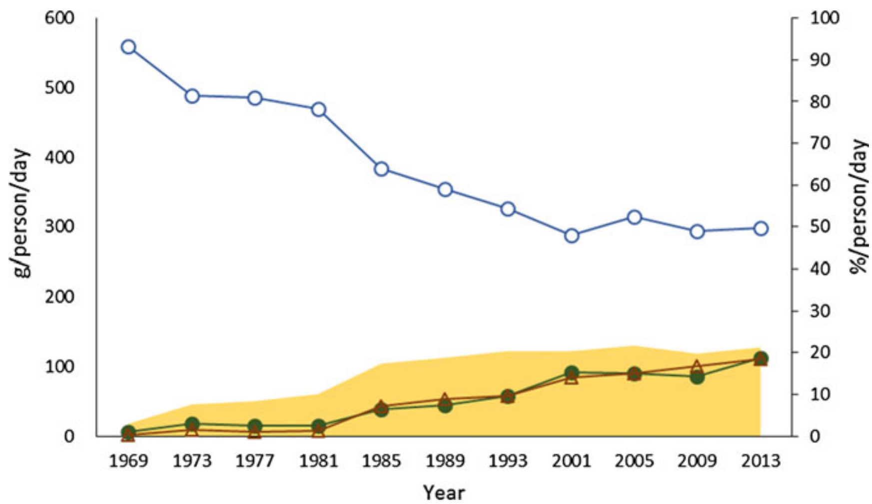

Fig. 1. (Colour online) Secular trend of food intake among Koreans. Grains (—○—), Meats (—●—), Dairy products (—△—), percentage of animal products (shaded). Data are from National Nutrition Survey (1969–1995), Korea National Health and Nutrition Examination Survey (1998–2013)[5].

metabolic diseases and cancer[7–11], while milk consumption reduced the risk[12–16].

Change of diet, especially increased consumption of meat and milk, seems closely related to higher rates of chronic diseases among Koreans. However, the impact of higher meat and milk intake on MetS and cancer can be somewhat different among Koreans from that among Western populations due to the combined effects of other dietary factors related to traditional Korean diet. Therefore, more extensive understanding of the association between meat and milk consumption and MetS and cancer among Koreans is needed to provide important insights for chronic disease prevention in Korea and also in other Asian countries which have rice-based dietary patterns. In the present paper, we aimed to discuss the association of meat and milk consumption with MetS and cancer among Koreans.

Change of dietary intake and disease pattern among Koreans

Change of dietary intake

Over the past several decades, Korean diet has undergone considerable changes. Several sources of data can be used to examine the change of diet. One such source is the food balance sheet. The amount of rice supplied per person was 213·0 g/d in 2013, 41 % decrease from that in 1980. Meanwhile, the amount of meat supplied per person was 134·8 g/d in 2013, 7 and 256 % increase from those in 2012 and 1980, respectively. The supply of milk and dairy products also increased from 29·5 g per person daily in 1980 to 168·2 g/d in 2013, an increment of 470 %[17,18].

Most of the information on food and nutrient intake was obtained from the National Nutrition Survey (1969–1995) and succeeding Korea National Health and Nutrition Examination Survey (1998–present). Based on these data, the proportion of animal product in Korean diet was under 10 % until the mid-1970s but increased to 21 % in 2013. Meat intake increased dramatically, 6·6 g in 1969, 67·8 g in 1995 and 105·0 g in 2013. Milk intake was under 10 g until 1981 and increased rapidly from the mid-1980s and is still gradually increasing, 79·7 g in 1998 and 111·4 g in 2013. However, rice intake has continuously decreased[5,19] (Fig. 1).

The change in the composition of food consumption has resulted in significant change of nutrient intake. Fat intake increased from 16·9 g in 1969 to 47·7 g in 2013. With respect to calcium intake, it moderately increased from 444 mg in 1969 to 506·8 mg in 2013. However, carbohydrate intake gradually decreased from 423 g in 1969 to 313·2 g in 2013 (Fig. 2). In addition, in 2013, more than half the population took vitamin C and calcium less than the estimated average requirement in almost every age group, and a high percentage of the elderly had vitamin A and riboflavin less than the estimated average requirement[5].

The aforementioned change was identified as diet transition from a traditional Korean diet that mainly consisted of rice and vegetables to a Westernised diet abundant in meat and milk in previous studies[1–3]. Kang *et al.* reported that the proportion of traditional dietary pattern was decreased over time and was less among the younger generation than in the older generation[4].

Change of the status of metabolic syndrome and cancer

In addition to diet transition, a shift in the pattern of diseases towards non-communicable diseases, such as cancer and MetS has occurred in Korea. Based on the Korea National Cancer Incidence Database, overall cancer incidence rate per 100 000 was 445·3 in 2012 which increased by 3·3 % annually from 1999 to 2012 (Fig. 3). Data from Statistics Korea indicated that cancer became the leading cause of deaths, responsible for one in four deaths, in 2012. Lung, liver, stomach

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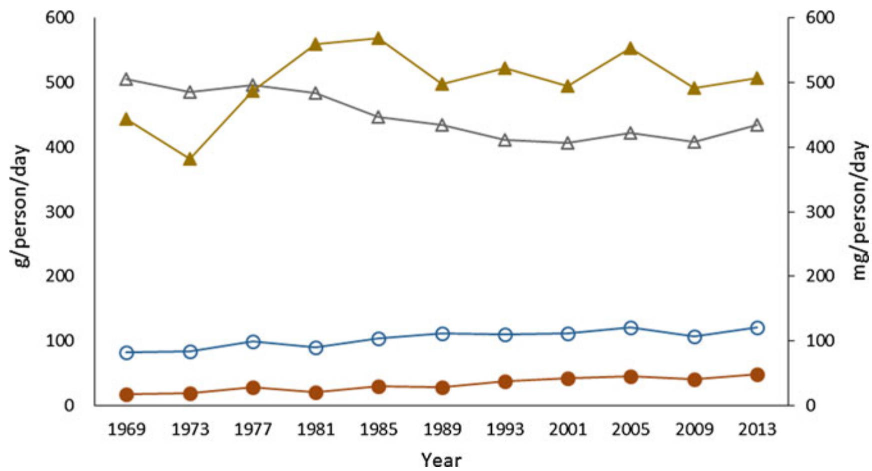

Fig. 2. (Colour online) Secular trend of nutrient intake among Koreans. Energy (—⊖—), Fat (—●—), Carbohydrates (—△—), Calcium (—▲—). Data are from National Nutrition Survey (1969–1995), Korea National Health and Nutrition Examination Survey (1998–2013)[5].

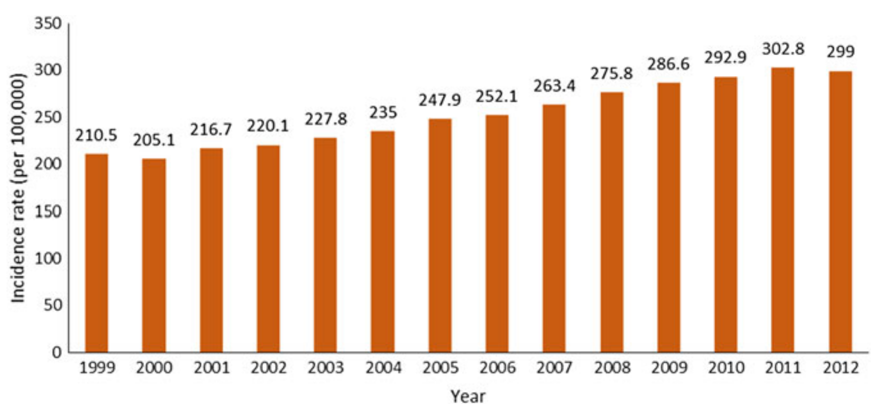

Fig. 3. (Colour online) Secular trend of cancer incidence among Koreans. Data are taken from Jung *et al.*[20]

and colon/rectum cancers were the main causes of cancer death. Heart disease, diabetes mellitus and hypertensive diseases associated with MetS were also leading causes of death in Korea, accounting for approximately 16 % of all deaths[20]. Prevalence of MetS in Korea was 24·9 % in 1998 and increased to 31·3 % in 2007 (Fig. 4)[21].

Association of meat and milk consumption with cancer and metabolic syndrome

Meat and milk consumption and cancer and metabolic syndrome risk based on the results from meta-analyses

A joint report by the World Cancer Research Fund and the American Institute for Cancer Research recently concluded that there is convincing evidence on the association between red or processed meat and colorectal cancer, 'limited to suggestive' evidence on the association between red meat and cancer of oesophagus, lung, pancreas and endometrium; and between processed meat and cancer of oesophagus, lung, stomach and prostate[22]. Meta-analyses of cohort and case–control studies for the association between red meat consumption and stomach cancer risk showed that increased consumption of red meat could be a risk factor for gastric cancer[7] and breast cancer[8]. In addition, another meta-analysis of prospective studies reported the significant association between beef consumption and increased risk of colorectal cancer and colon cancer, but no association between pork or poultry and the risk of colorectal adenomas or cancer[9]. Poultry intake was rather associated with reduced risk of colorectal cancer[23].

Meat consumption has also been considered as a major risk factor for MetS. Recently, several meta-analyses showed significant associations between red meat or processed meat intake and MetS risk factors or related diseases. Meta-analysis of prospective cohorts[11] reported that consumption of processed meats was associated with 42 % higher risk of CHD and 51 % higher risk of diabetes.

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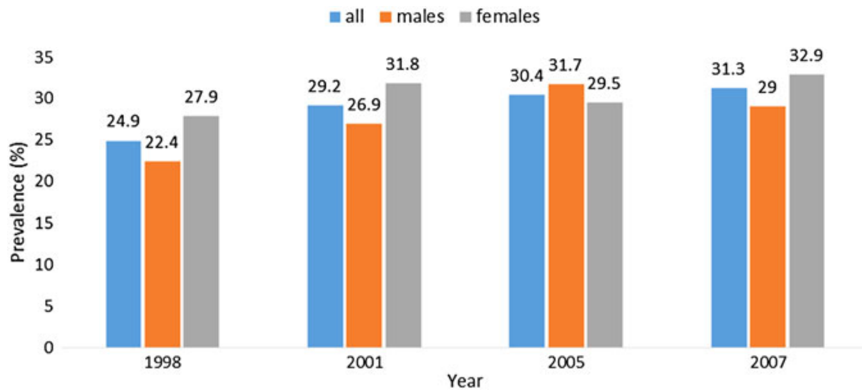

Fig. 4. (Colour online) Secular trend of metabolic syndrome prevalence among Koreans. Data are taken from Lim *et al.*[21]

In addition, consumption of unprocessed red meats was associated with 19 % higher risk of diabetes, but no risk of CHD[11]. A meta-analysis of observational studies by Rouhani *et al.*[10] showed consumption of higher amount of red and processed meats increased the risk of obesity.

Dairy consumption has long been thought to play a role in cancer development. Previous meta-analyses noted the association between milk consumption and cancer at specific sites. A meta-analysis of prospective cohort studies on dairy consumption and the risk of breast cancer[13] reported the decreased risk of breast cancer (relative risk (RR) 0·85, 95% CI 0·76, 0·95). Significant dose–response relationship of total dairy food, except milk, intake with breast cancer risk was also reported[13]. For colorectal cancer RR was 0·91 (CI 0·85, 0·94) per 200 g/d of milk intake and 0·83 (CI 0·78, 0·88) per 400 g/d of total dairy products by a meta-analysis of cohort[12]. Meanwhile, a meta-analysis on dairy consumption and gastric cancer risk[24] including twenty-three epidemiologic studies suggested that total dairy food, except milk, might be associated with a reduced risk of gastric cancer.

A series of meta-analyses have consistently suggested that increased milk intakes are associated with reduced risk of MetS and MetS-related diseases. A meta-analysis of randomised controlled clinical trials[14] examined the effect of dairy consumption on weight and body composition. Dairy consumption led to significantly greater reduction in fat mass and waist circumference and the effect was much greater with energy restriction. Another meta-analysis of randomised controlled trials[25] also reported beneficial effects of dairy consumption on body weight and fat loss under energy restriction, but the effects were not consistent in long-term or *ad libitum* studies. In addition, inverse association between low-fat and fluid dairy food consumption and elevated blood pressure was found in a meta-analysis of cohort studies[15]. Aune *et al.*[16] focused on dairy products and type 2 diabetes and concluded that there was an inverse association between consumption of total dairy product and low-fat dairy product, and risk of type 2 diabetes.

Association of meat and milk consumption with cancer and metabolic syndrome in Korea and other Asian countries

From previous meta-analyses, we could conclude that excessive intake of red meat can result in elevated risk of cancer and MetS, whereas high intake of milk and its product is associated with the reduced risk of cancer and MetS. However, because most previous studies on the health effect of meat and milk were conducted in Western populations, there is little understanding on the association between meat and milk intake, and cancer and MetS in Asians. To elucidate the impact of meat and milk consumption on cancer and MetS, epidemiological studies conducted in Asia, including Korea were further reviewed.

The level of meat intake was very low in many Asian populations who had rice-based dietary pattern, but it began to rise rapidly since the late 20th century. Although meat consumption is still relatively low in Asians compared with Western populations, it requires more attention. Meat is a source of not only protein and various vitamins and minerals, but also SFA[26] which are well known to be a major risk factor for various chronic diseases[27,28]. Moreover, haem iron and non-haem iron, or some carcinogenic compounds such as heterocyclic amines and polycyclic aromatic hydrocarbons in meat are suspected to increase cancer risk[29,30].

As in studies involving Western populations, consuming high amount of red meat was reported as a significant risk factor for cancer by a recent Korean cohort study[31]. Red meat, especially processed red meat, consumption was positively associated with overall cancer incidence in men. Korean males who ate red meat above the World Cancer Research Fund and the American Institute for Cancer Research recommended amount of 43 g/d had 41 % higher risk of overall cancer. Considering the recommended amount of 43 g/d is smaller than one serving size for a Korean, this implies that even small amounts of red meat intake may increase the risk of cancer in Koreans. The researchers explained

Table 1. Meat consumption and cancer in Korean and other Asian countries

Author	Nation	Study design and population	Exposure	Outcome	Category	Results*
Chun *et al.*[32]	Korea	Case–control, 150 cases and 116 controls	Red meat intake	Colorectal cancer (I)	T1 *v.* T3 (<0·93/week *v.* >2·7/week)	OR 7·33 (2·98, 18·06)
Ko *et al.*[60]	Korea	Cohort, 9724 adults (30–90 years)	Meat frequency	Gastric cancer (I)	Low *v.* high	RR 0·91 (0·80, 1·03)
Wie *et al.*[31]	Korea	Cohort, 8024 adults	Red meat intake	Overall cancer (I)	<43 g/d *v.* ⩾43 g/d	HR Total 1·23 (0·96, 1·57) Male 1·41 (1·02, 1·94) Female 0·97 (95% CI 0·66, 1·44)
Kim[46]	Korea	Cohort, 2 248 129 adults (30–80 years)	Meat intake	Colorectal cancer (I)	⩽1/week *v.* ⩾4/week	HR 1·23 (1·13, 1·35)
Kim *et al.*[61]	Korea	Case–control, 125 cases and 247 controls	Meat frequency	Colon cancer (I)	<2/week *v.* >2/week	OR 1·72 (1·12, 2·76)
Kim *et al.*[33]	Korea	Case–control, 136 cases and 136 controls	Beef intake Pork intake	Gastric cancer (I)	Low *v.* High Low *v.* High	OR 1·67 (0·86, 3·27) OR 0·94 (0·45, 1·97)
Isa *et al.*[34]	China	Case–control, 487 cases and 469 controls	Red meat intake Preserved meat intake	Bladder cancer (I)	⩽1/week *v.* ⩾5/week Never *v.* 1/week	OR 1·8 (1·1, 3·0) OR 2·2 (1·0, 4·7)
Shen *et al.*[35]	China	Case–control, 498 cases and 498 controls	Fresh meat intake Preserved meat intake	Lung cancer (I)	Rarely + Sometimes *v.* frequently Rarely + Sometimes *v.* frequently	OR 4·41 (2·40, 8·12) OR 0·50 (0·35, 0·71)

I, incidence; OR, odds ratio; RR, relative risk; HR, hazard ratio; T, tertile.
*Values in parentheses are 95% CI.

the reason why the association was significant only in men as that the mean intake of red meat and the percentage of individuals who consumed more than the recommendation were higher in men. Later, a case–control study among Korean adults[32] added the evidence that red meat intake significantly increased risk for colorectal cancer incidence. However, there was a case–control study[33] which examined the association of beef or pork intake with gastric cancer and reported insignificant results. Similarly, findings from studies among Chinese population varied. Red meat intake and preserved meat intake were risk factors for bladder cancer[34], and fresh meat intake was a risk factor for lung cancer[35]. However, consumption of salt-preserved meats was associated with reduced risk of lung cancer in China[35] (Table 1).

Meat consumption seemed to increase the risk of MetS or its components in Asian countries. A series of observational studies among Chinese population demonstrated significant association between intake of red meat and excessive body fat, measured as abdominal obesity, high BMI, and overweight[36–38]. A large cohort study of Japanese population[39] reported significant effect of red meat consumption on the development of type 2 diabetes. The associations of processed red meat intake or poultry intake with type 2 diabetes risk were not found in the same study. The impact of meat on MetS among Koreans was not revealed due to limited information. However, considering Asian populations share common characteristics in their diet, it would be reasonable to expect similar results with other Asians (Table 2).

Milk, like meat, has not been an important component of traditional diet in Korea and most Asian countries until the late 20th century. However, milk and dairy foods have now become a crucial part of Korean diet. It is widely recommended to increase milk and dairy food consumption as a good source of calcium and other nutrients. A number of studies conducted in Western countries reported milk and dairy products have health benefits on chronic disease prevention[12–16]. Milk consumption of Koreans has rapidly increased since the 1980s, but the level of consumption is still relatively lower than that of Western countries. The proportion of people who drink milk less than one serving size daily was 84 %[40] and of those who drink milk less than once per week was 34 %[19] in Korea. The difference between frequent milk consumers and infrequent consumers seemed evident.

A substantial number of epidemiological studies aimed to verify the impact of milk on chronic disease risk in Korea and other Asian countries. In Korea, Kim *et al.*[33] reported significant inverse association between milk and milk products and gastric cancer risk with case–control study design, whereas Chun *et al.*[32] reported a positive association between milk intake and colorectal cancer risk with similar study design. In China, a case–control study on bladder cancer[34] reported strong health benefits of dairy foods, and another case–control study demonstrated potential protective effects of milk intake on breast cancer[41]. In Japan, a case–control study[42] found statistically significant inverse association between calcium and vitamin C intake and colorectal cancer, and potential inverse association between milk and other dairy food intake, and colorectal cancer risk. In a Japanese cohort study[43], the associations with other cancers were unclear, except the

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Table 2. Meat consumption and metabolic syndrome in Korean and other Asian countries

Author	Nation	Study design and population	Exposure	Outcome	Category	Results*
Wang *et al.*[36]	China	Cross-sectional, 16 822 adults (18–75 years)	Total red meat intake	Abdominal obesity (P)	Q1 *v.* Q4	OR Male 1·27 (1·07, 1·49) Female 1·12 (0·97, 1·29)
			Fresh red meat intake		Q1 *v.* Q4	OR Male 1·25 (1·06, 1·47) Female 1·16 (1·01, 1·34)
			Fatty fresh red meat intake		Q1 *v.* Q4	OR Male 1·22 (1·03, 1·44) Female 1·17 (1·01, 1·36)
			Lean fresh red meat intake		Q1 *v.* Q4	OR Male 0·95 (0·75, 1·22) Female 0·90 (0·72, 1·12)
Xu *et al.*[38]	China	Cross-sectional study, 23 316 adults (⩾35 years)	Red meat intake	Excess body weight (P) (BMI ⩾ 24)	Low *v.* High	OR 1·19 (1·09, 1·30)
Li *et al.*[37]	China	Cross-sectional, 6826 children (7–17 years)	Meat and meat products intake	Overweight (P)	<200 g/d *v.* ⩾ 200 g/d	OR 1·5 (1·2, 1·8)
Kurotani *et al.*[39]	Japan	Cohort, 63 849 adults (45–75 years)	Total meat intake	Type 2 diabetes (I)	Q1 *v.* Q4	OR Male 1·44 (1·05, 1·99) Female 1·11 (0·76, 1·62)
			Total red meat intake		Q1 *v.* Q4	OR Male 1·58 (1·14, 2·20) Female 0·99 (0·67, 1·45)
			Unprocessed red meat intake		Q1 *v.* Q4	OR Male 1·51 (1·10, 2·06) Female 1·04 (0·72, 1·50)
			Processed red meat intake		Q1 *v.* Q4	OR Male 1·15 (0·90, 1·46) Female 1·05 (0·79, 1·40)
			Poultry intake		Q1 *v.* Q4	OR Male 1·03 (0·81, 1·30) Female 0·97 (0·74, 1·27)

P, prevalence; I, incidence; OR, odds ratio; Q, quartile.
*Values in parentheses are 95% CI.

association between increased butter and milk intake and deaths from hematopoietic neoplasm. Another cohort study focusing on prostate cancer[44] showed that higher milk intake resulted in higher risk of prostate cancer and suspected calcium and fatty acids as the causative agents (Table 3). The findings of these studies were inconsistent. The results from a few studies on milk and MetS conducted in Asia were consistent. A study using the third Korea National Health and Nutrition Examination Survey data[45] showed that overweight adults who consume milk more frequently had significantly lower risk of MetS. The inverse relationship was supported by a study by Kim *et al.*[46] which reported significant association between higher consumption of milk or yoghurt and lower risk of MetS based on the fifth Korea National Health and Nutrition Examination Survey data. The study also found the association between higher dairy food intake and lower risk of MetS components, namely abdominal obesity, high fasting glucose and low-HDL cholesterol level. Additionally, the prevalence of MetS was significantly lower in subjects with higher dairy foods. Furthermore, Shin *et al.*[47] analysed the data of middle-aged Koreans from Anseong and Ansan cohort and suggested that dairy product consumption might reduce the risk of MetS, especially abdominal obesity. In subjects who consumed milk and dairy products once daily, the risk of MetS reduced by about 21 and 25 %, respectively. Another study in Japan[48] revealed that among three types of dairy products classified by fat content, only full-fat dairy products had significant inverse relationship with fasting insulin and homeostasis model of insulin resistance index (Table 4).

Potential impact of dietary pattern on the association between meat and milk consumption and cancer and metabolic syndrome

We could find slight difference between the associations found in Western countries and in Asian countries. The difference could be attributed to the fact that Asians

Table 3. Milk consumption and cancer in Korean and other Asian countries

Author	Nation	Study design and population	Exposure	Outcome	Category	Results*
Chun *et al.*[32]	Korea	Case–control, 150 cases and 116 controls	Milk and dairy product intake	Colorectal cancer (I)	T1 *v.* T3 (<1·1/week *v.* >5·3 week)	OR 2·42 (1·10, 5·31)
Ko *et al.*[60]	Korea	Cohort, 9724 adults(30–90 years)	Dairy products frequency	Gastric cancer (I)	Almost never *v.* 1–4/month	RR 1·15 (0·78, 1·70)
Kim *et al.*[33]	Korea	Case–control, 136 cases and 136 controls	Milk and milk products intake	Gastric cancer (I)	Low *v.* high	OR 0·68 (0·34, 1·36)
Isa *et al.*[34]	China	Case–control, 487 cases and 469 controls	Dairy product intake	Bladder cancer (I)	Never *v.* ⩾1/week	OR 0·5 (0·3, 0·7)
Zhang *et al.*[41]	China	Case–control, 438 cases and 438 controls	Dairy product (dry weight) intake	Breast cancer (I)	T1 *v.* T3	OR 0·83 (0·54, 1·27)
Mizoue *et al.*[42]	Japan	Case–control, 836 cases and 831 controls	Milk intake	Colorectal cancer (I)	Q1 *v.* Q5	OR 0·60 (0·40, 0·91)
			Total dairy foods intake		Q1 *v.* Q5	OR 0·76 (0·48, 1·18)
Kurahashi *et al.*[44]	Japan	Cohort, 43 435 male adults	Milk intake	Prostate cancer (I)	Q1 *v.* Q4	OR 1·53 (1·07, 2·19)
Matsumoto *et al.*[43]	Japan	Cohort, 11 606 adults	Milk intake	Stomach cancer (M)	Not everyday *v.* everyday	HR 0·70 (0·34, 1·43)
				Lung cancer (M)	Not everyday *v.* everyday	HR 0·88 (0·52, 1·51)
				Liver cancer (M)	Not everyday *v.* everyday	HR 0·83 (0·27, 2·54)
				Pancreas cancer (M)	Not everyday *v.* everyday	HR 0·97 (0·33, 2·90)
				Bile duct cancer (M)	Not everyday *v.* everyday	HR 0·70 (0·20, 2·47)
				Colon cancer (M)	Not everyday *v.* everyday	HR 1·26 (0·57, 2·78)
				Blood cancer (M)	Not everyday *v.* everyday	HR 3·17 (0·99, 10·17)

I, incidence; M, mortality; OR, odds ratio; RR, relative risk; HR, hazard ratio; T, tertile; Q, quartile.
*Values in parentheses are 95% CI.

Table 4. Milk consumption with metabolic syndrome in Korean and other Asian countries

Author	Nation	Study design and population	Exposure	Outcome	Category	Results*
Shin *et al.*[47]	Korea	Cohort, 7240 adults (40–69 years)	Milk intake	Metabolic syndrome (I)	None *v.*⩾7/week	HR 0·79 (0·67, 0·92)
			Dairy products	Metabolic syndrome (I)	None *v.* ⩾7/week	HR 0·75 (0·64, 0·88)
Kim[46]	Korea	Cross-sectional, 4862 adults (⩾19 years)	Milk intake	Metabolic syndrome (P)	None or rarely *v.* ⩾1/d	OR 0·71 (0·55, 0·93)
			Yogurt intake	Metabolic syndrome (P)	None or rarely *v.* ⩾1/d	OR 0·71 (0·48, 1·05)
Kwon *et al.*[45]	Korea	Cross-sectional, 4890 adults (⩾19 years)	Milk intake	Metabolic syndrome (P)	Q1 *v.* Q4 (rarely *v.* ⩾1/d)	OR 0·85 (0·68, 1·06)
Akter *et al.*[48]	Japan	Cross-sectional, 496 employee (20–68 years)	Total dairy intake	Fasting insulin (μU/ml)	Q1 *v.* Q4	– (NS)
				Fasting glucose (mg/dl)		– (NS)
				HOMA-IR index		– (NS)
			Full-fat dairy products	Fasting insulin (μU/ml)	Q1 *v.* Q4	– (P for trend = 0·02)
				Fasting glucose (mg/dl)		– (NS)
				HOMA-IR index		– (P for trend = 0·02)
			Low-fat dairy products	Fasting insulin (μU/ml)	Q1 *v.* Q4	+ (NS)
				Fasting glucose (mg/dl)		– (NS)
				HOMA-IR index		+ (NS)

I, incidence; P, prevalence; HR, hazard ratio; OR, odds ratio; Q, quartile; HOMA-IR, homeostasis model assessment of insulin resistance.
*Values in parentheses are 95% CI.

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Table 5. Dietary patterns and cancer in Korean and other Asian countries

Author	Nation	Study design	Dietary pattern	Outcome	Effect size (95% CI)
Pham *et al*.[49]	Japan	Cohort, 63 403 adults (40–79 years)	1. Vegetable (high intakes of vegetables and fruits) 2. Animal food (high intakes of meats and fish) 3. Dairy product	Stomach cancer (M)	HR, Q1 *v*. Q4 Male 1. 1·15 (0·83, 1·59) 2. 1·02 (0·73, 1·45) 3. 0·72 (0·52, 0·99) Female 1. 0·99 (0·63, 1·57) 2. 1·31 (0·78, 2·21) 3. 0·77 (0·48, 1·23)
Kumagai *et al*.[50]	Japan	Cohort, 44 097 adults (40–79 years)	1. Japanese (high intake of soyabean products, fish, seaweeds, vegetables and fruits) 2. Animal food (high intake of meat and butter) 3. DFA (high-dairy, high-fruit-and vegetables, low alcohol)	Colorectal cancer (I)	HR, Q1 *v*. Q4 1. 1·04 (0·84, 1·30) 2. 0·99 (0·80, 1·23) 3. 0·76 (0·60, 0·97)
				Colorectal cancer (I)	HR, Q1 *v*. Q4 1. 1·01 (0·77, 1·32) 2. 0·87 (0·66, 1·13) 3. 0·89 (0·66, 1·19)
				Rectal cancer (I)	HR, Q1 *v*. Q4 1. 1·05 (0·73, 1·51) 2. 1·23 (0·86, 1·76) 3. 0·56 (0·37, 0·84)
Hirose *et al*.[51]	Japan	Case–control, 1885 cases and 22 333 controls (women)	1. Prudent (high intake of vegetables, fruits, soyabean curd, fish and milk) 2. Fatty (high intake of meat and fatty foods) 3. Japanese (high intake of rice and miso soup) 4. Salty (high intake of pickles, salted foods)	Breast cancer (I)	OR, Q1 *v*. Q4 1. 0·73 (0·63, 0·84) 2. 0·99 (0·85, 1·14) 3. 1·04 (0·90, 1·20) 4. 1·04 (0·90, 1·19)
Masaki *et al*.[62]	Japan	Cohort, 5765 adults	1. Vegetables and fruits 2. Western breakfast (high intake of bread, butter, cheese, coffee, etc.) 3. Meat (pork, beef, chicken, etc.) 4. Rice/snack	Stomach cancer (I, M)	RR, Q1 *v* Q4 1. 0·78 (0·42, 1·44) 2. 0·71 (0·40, 1·24) 3. 1·10 (0·64, 1·89) 4. 1·19 (0·71, 2·02)
Zhang *et al*.[53]	China	Cohort, 132 837 adults (40–74 years)	1. Vegetable-based 2. Fruit-based 3. Meat-based	Liver cancer (I, M)	HR, Q1 *v*. Q4 1. 0·58 (0·40, 0·84) 2. 1·13 (0·78, 1·64) 3. 1·18 (0·83, 1·69)
Zhang *et al*.[41]	China	Case–control study, 438 cases and 438 controls (25–70 years)	1. Vegetable–fruit–soya–milk–poultry–fish 2. Refined grain–meat–pickle	Breast cancer (I)	OR, Q1 *v*. Q4 1. 0·26 (0·17, 0·42) 2. 2·58 (1·53, 4·34)

I, incidence; M, mortality; CI, confidence interval; HR, hazard ratio; OR, odds ratio; RR, relative risk; Q, quartile.

consume much lower amounts of meat and milk than do Western populations and that Asians have rice-based dietary pattern distinct from Western diet. However, there is little information on the role of meat and milk in Asian populations with extensive consideration on dietary backgrounds. Therefore, the evaluation of the overall diet quality with dietary pattern analysis to capture the combined effects of various dietary factors on cancer and MetS in Asian populations can be useful to expand our understanding.

In Japan, the dietary patterns with high dairy foods, fruit and vegetables significantly decreased cancer risks in stomach, rectum and breast[49–51]. However, the findings from the studies focused on the effect of dietary patterns with high animal food on various types of cancer were inconsistent[49–51]. In a Chinese study, vegetable-rich dietary patterns were significantly associated with lower risks of liver and breast cancer and meat-rich dietary patterns were associated with higher risk of breast cancer[52,53] (Table 5). The findings from epidemiologic studies conducted in Asian countries which have the rice-based dietary pattern might provide useful information that can be applied to Korean population. More studies focusing on dietary patterns and MetS among Asians have suggested that high intake of milk and dairy products were related to the decreased risk of MetS. Japanese subjects who usually had milk and yoghurt in their breakfast were less likely to have MetS and high blood pressure[48]. Thai females who possessed the so-called healthy dietary pattern composed of high intakes of beans, fruits, soya milk and fish also had lower risk of MetS[54]. Furthermore, Korean adults with dietary patterns abundant in vegetables, meats and dairy foods showed lower incidence of MetS compared

Table 6. Dietary patterns and metabolic syndrome (metS) in Korean and other Asian countries

Author	Nation	Study design and population	Dietary pattern	Outcome	Effect size (95% CI)
He *et al.*[58]	China	Cross-sectional, 2196 adults (⩾18 years)	1. Dairy and eggs 2. Organ meat and poultry 3. Coarse grains and beans 4. Refined grains and vegetables	MetS (P)	OR, Q1 *v* Q5 Male 1. 1·54 (0·88, 2·68) 2. 1·63 (0·93, 2·87) 3. 1·50 (0·87, 2·61) 4. 0·60 (0·32, 1·14) Female 1. 0·45 (0·26, 0·79) 2. 0·70 (0·41, 1·22) 3. 1·09 (0·73, 1·65) 4. 0·98 (0·55, 1·77)
Aekplakorn *et al.*[54]	Thailand	Cross-sectional, 5872 adults (30–59 years)	1. Meat (high intake of red meat, processed meat and fried foods) 2. Healthy (high intake of beans, vegetables, wheat and dairy products) 3. Carbohydrate (high intake of rice, fermented fish, etc.)	MetS (P)	OR, Q1 *v* Q4 Male 1. 1·01 (0·82, 1·23) 2. 0·91 (0·67, 1·23) 3. 1·82 (1·31, 2·55) Female 1. 0·94 (0·72, 1·21) 2. 0·72 (0·52, 0·99) 3. 1·60 (1·24, 2·08)
Arisawa *et al.*[59]	Japan	Cross-sectional, 513 adults (35–70 years)	1. Prudent (high intake of vegetables, fruits and milk) 2. High fat and Western (high intake of fried foods and meat) 3. Bread and dairy products 4. Seafood	MetS (P)	OR 1. 0·77 (0·56, 1·03) 2. 1·08 (0·83, 1·42) 3. 0·89 (0·69, 1·14) 4. 1·14 (0·91, 1·44)
Akter *et al.*[48]	Japan	Cross-sectional, 460 employee (21–67 years)	1. Healthy Japanese (high intake of vegetables, fruits and soya products) 2. Animal food (high intake of fish, meat and egg) 3. Westernised breakfast (high intake of bread, milk and yogurt)	MetS (P)	OR, T1 *v* T3 1. 1·35 (0·55, 3·30) 2. 1·54 (0·73, 3·24) 3. 0·39 (0·16, 0·95)
Song *et al.*[57]	Korea	Cross-sectional, 4730 adults (20 years)	1. Traditional (high intake of rice and kimchi) 2. Korean healthy (modified Korean-style diet) 3. Meat and alcohol	MetS (P)	OR 1. Reference 2. 0·92 (0·75, 1·13) 3. 1·21 (0·92, 1·58)
Hong *et al.*[56]	Korea	Cross-sectional, 406 adults (22–78 years)	1. Korean traditional (high intake of refined grains, onion and garlic, vegetable oil, soya product, Korean seasonings, etc.) 2. Alcohol and meat 3. Sweets and fast foods 4. Fruit and dairy	MetS (P)	OR, Q1 *v* Q4 1. 2·03 (1·05, 3·92) 2. 1·16 (0·58, 2·34) 3. 0·81 (0·41, 1·61) 4. 0·46 (0·22, 0·95)
Baik *et al.*[55]	Korea	Cohort study, 5251 adults (40–69 years)	1. Healthy (high intake of mixed grain rice, vegetables, meat, poultry and dairy foods) 2. Unhealthy (high intake of refined white rice and low intake of dairy foods)	MetS (I)	RR, Q1 *v*. Q5 1. 0·76 (0·60, 0·97) 2. 1·12 (0·92, 1·37)

I, incidence; P, prevalence; CI, confidence interval; OR, odds ratio; RR, relative risk; Q, quartile.

with dietary patterns characterised by high intake of refined white rice and low intake of dairy foods[55]. Hong *et al.*[56] clearly demonstrated that ‘fruit and dairy’ pattern was significantly associated with reduced risk of MetS and its components, namely impaired fasting glucose, hypertriglyceridaemia. Interestingly, ‘alcohol and meat’ pattern which can be regarded as the Westernised dietary pattern was not associated with risk of MetS due to relatively low-fat intake even among subjects with ‘alcohol and meat’ pattern. In addition, ‘Korean traditional’ dietary pattern with high intake of soya sauce, refined grains and vegetables was associated with increased MetS risk, indicating the importance of adequate proportion among carbohydrate, protein and fat. However, another observational study involving Korean adults[57] reported ‘meat and alcohol’ pattern was associated with increased risk of elevated blood glucose, elevated serum TAG and elevated blood pressure compared with traditional Korean dietary pattern mainly of rice and kimchi[58,59] (Table 6).

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The findings of these studies suggest that the differences in dietary pattern can lead to different roles of meat and milk in diet among Korean, other Asians and Western populations. The unique finding from Korean studies was that even 'meat and alcohol' pattern, very likely to be Western-style diet, can be regarded as rice-based diet with fat intake relatively higher than other patterns, but still moderate compared with typical Western diet. Most Koreans still maintain traditional dietary pattern, being high in carbohydrate, low in fat and high proportion of plant foods, although rapid change towards Westernised diet is ongoing among the younger generation[4]. The differences in study designs might also have influenced the results. Randomised clinical trials or prospective cohort studies with consideration of combined effects of various dietary factors in Korea and other Asian countries will be helpful to elucidate the role of meat and milk or related dietary patterns in their diet.

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Authorship

H. J. formulated the research question and critically reviewed the manuscript; S. J. contributed to the collation of evidence and wrote the draft of the manuscript; K. H. and S. C. also contributed to the collation of evidence.

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