



Review Paper

Role of Milk, Dairy Products and Milk Components Used in the Management of Metabolic Syndrome

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Abstract

Milk and its products are among the most essential food diets used throughout human lifecycle. However the relatively high saturated fat content in the milk raises issues of potential risk factor for MetS with its increasing prevalence that has become a global burden. This review paper gives information from the recent studies on milk, dairy products and factors in milk with evidence obtained from epidemiological, experimental, and biochemical studies which contribute in the management of MetS. Several epidemiological evidences show that dairy products intake and physical activities play significant role in the regulation of MetS and its related complications. Vast experimental studies highlight dairy protein (whey and casein) milkfat, calcium, vitamin D, potassium and magnesium as major dietary component used in the management of Metabolic risk factors though more comprehensive studies are required to give better understanding of the mechanisms under which milk, dairy products and its components contribute to metabolic health.

Keywords: Milk, dairy products, dairy components and metabolic syndrome.

Introduction

Metabolic syndrome (MetS) is a health related condition caused by clusters of several cardio metabolic risk conditions namely; Hypertension, abdominal or central obesity, dyslipidemia and hyperglycemia also considered as Type 2 diabetes mellitus (T2DM)¹⁻⁴. Metabolic disorders may later results into the development of Cardiovascular diseases and diabetes^{3,5}. People with MetS are twice in 5-10 years more vulnerable to developing CVD and have about 5-fold exposure to increase development of T2DM⁶. CVD are the highest cause of death in the world with deaths about 17.5 million, 8.2 million deaths due to cancer and 1.5 million deaths as a result of diabetes^{2,7-10}. Comparing to healthy persons free from the syndrome, individual with metabolic abnormalities are 3 times more chances to die of stroke and 2 times likely to suffer from heart attack and 5 times more chances of getting T2DM. It's reported that out of 200 million people with diabetes, about 80% of them die as a result of CVD⁴.

Although several epidemiologic studies show a higher prevalence of MetS more among men than in women at a rate of 31.4% and 27.0% depending on the ethnicity¹¹. A study conducted in Taiwan however indicated MetS prevalence being high in women (56.8%), lower in men (36.3%)¹². A similar study in Turkey (2009) highlight prevalence being high in women (40%) and low in men 28%¹³. The prevalence of MetS in teens is estimated to be 30% to 50% and among adults worldwide is about 20% to 30% and its increase is as a result of

unhealthy dieting, lack of physical activities, tobacco, excessive alcohol intake and the obesity epidemic¹⁴. Stress and aging too are among the causes of MetS⁴. However, MetS complications may exist among all age groups, lean healthy persons and also in individuals with good physiological conditions to those with excessive low management of MetS and are overweight or obese⁶. Metabolic syndrome is one of the major emerging health burdens that should be encountered by individuals, governments, states and health practitioners. It has a high rate of morbidity, mortality and an increased economic impact on both individuals and government during management¹⁵. Due to the above increased prevalence and burdens, this paper highlights general signs of MetS, importance of milk, dairy products and dairy components that can be used to alleviate MetS burdens.

Etiology of Mets, significance of milk, dairy products and milk components in the management of metabolic diseases

Etiology of MetS and its complications are scientifically reported as not limited to single causation, but complex and have a multi factorial roots of origin². The main goal of controlling MetS is to reduce the major risk factors of the syndrome through diet therapy and lifestyle modifications that aim at regulation of body weight, bad fat in the body and hypertension to all people with the syndrome¹¹. Recently, there are significant interest however in the use of milk and dairy products with more emphasis on milk protein, vitamin D, magnesium in particular as factors to improve metabolic health⁶.

Table-1
Cut off points for metabolic syndrome according to WHO, IDF and NCEP ATP 111⁴

MetS Risk factor	WHO (Main criterion + two factors)	IDF (Main criterion + two factors)	NCEP ATP (Combination of three factors)
BMI (kg/m ²)	>30	-	-
Abdominal obesity (men/women)	WHR< 0. 9/0.85	Waist≥ 94/80	Waist> 102/88
Triglycerides (mmol/l)	≥ 1.7	> 1.7	> 1.7
HDL cholesterol (mmol/l)(men/women)	< 0.9/1.0	< 1.03/1.29	<1.03/1.29
Blood pressure(mmHg)	≥140/90	> 130/>85 or present	≥ 130/≥85
Type 2 diabetes	Present	Present	-
Impaired tolerance test	7.8-11.1	-	-
Fasting glucose (mmol/l)	≥6.1	≥5.6	>5.6
Urinary albumin excretion	≥20µg/min or≥30mg/g	-	-

Overweight and Obesity

Visceral obesity and insulin resistance are the major two risk factors for the pathophysiology of metabolic syndrome^{11, 2}. The above two interrelated risk factors really makes it difficult to single out which one plays the most predominant role in the cause of MetS¹⁵. However; Obesity causes insulin resistance, due to subsequent lipid deposition in the adipose tissues particularly visceral deposits that secretes inflammatory cytokines resulting to both insulin resistance and reduced insulin mediated glucose uptake leading to obesity^{6,4,16}. T2DM, CVD, hypertension, dyslipidemia, and insulin resistance are among the consequences of obesity^{6, 17}.

Unhealthy diet, physical inactivity, hormone imbalance, adipose tissue dysregulation, genetics, inflammation, drugs, ethnicity and age are among the factors that contribute to MetS pathophysiology^{6,15}.

The primary goal of management of obesity is reduction in total body weight to a BMI less than 25 kg/m² and a waist circumference less than 102 cm for men and less than 88 cm in women in a period of 6–12 months among overweight and obese individual⁶. Consumption of milk whey protein and casein leads to increase in satiety and also helps to reduce appetite by inhibiting cholecystokinin from gastric secretion, increased secretion of leucine (glucagon-like peptide) and glucose dependent insulinotropic polypeptide¹⁸.

These compounds suppress secretion of ghrelin hence contributing to weight control a major factor for body adipose fat reduction and increase of insulin secretion¹⁹⁻²¹.

Calcium and vitamin D are among the bioactive milk components widely studied for their effects on body weight and adipose tissue reduction². On a reduced-calorie diet¹⁶, calcium and vitamin D regulate weight and body fat through modification of both lipogenesis, thermogenesis thereby increasing lipid fecal excretion²².

A number of human studies indicate that dietary calcium increases fecal fat excretion by forming insoluble calcium-soaps with fatty acids in the intestine therefore decreasing fatty acid absorption in the body hence leading to weight loss²². Results from several studies show that participants who consumed less calcium from milk sources gained more weight and hence had higher body mass index (BMI) as compared to those who consumed more calcium from dairy sources. Increasing dietary calcium intake from about 400 - 1,000 mg/day through the consumption of two cups of yogurt every day helped to decreased blood pressure and an unexpected of 4.9 kg reduction in body fat¹⁶. Calcium and other components in milk, cheese and yogurt have great influence in regulating body fat and weight gain. In a study were laboratory mice were fed diets high in calcium from either skimmed milk powder had reduced body weight and body fat gain^{23,16,24}.

In a study that was conducted in 903 healthy individuals of 15-16 years included 2 servings per day (1 serving=200ml of milk, 125g of yoghurt and or 28g of cheese showed a significant reduction in body fat and weight loss^{2,17,25}. Studies also conducted in 34 over weight men and women showed that intake of 600ml of skimmed milk at breakfast had a strong satiety effect than isocaloric intake of juice²⁶. A number of meta-analysis studies²⁷ reviewed the effect of over 29 randomised trials with the majority of the participates confirming the positive significant use of dairy products in the hypocaloric diets used in weight reduction but there is also need of energy restriction diet for beneficial results, therefore this gives less information to use milk only as precaution for slimming.

Results from an observational study regarding high fat dairy foods, obesity, and CVD found no evidence that dairy fat or high-fat dairy foods resulted into obesity or increased risk of cardiovascular disease. Results also showed that consuming high-fat dairy foods within dietary limits helped to reduce obesity²⁸. The same study further suggested that in contrast to

the present scientific information and dietary guidelines recommending the intake of reduced fat milk and dairy products, there is yet no enough clear evidence to avoid dairy fat. The suggestions to consider milk and dairy as complex foods with effects on health could not be a reason enough to avoid consumption of dairy products considering only one single nutrient (saturated fat) and its isolated biomarkers of disease risk such as blood lipids. However, it is better to consider reduced-fat milk and dairy products.

Hypertension

High systolic or diastolic blood pressure above 140/90 mm Hg is another criterion for metabolic syndrome¹¹. Whey proteins contains ACE-inhibiting peptides (lactokinins),²¹ has potential effects on blood pressure²⁹. Hydrolyzed whey protein is fundamental in the inhibit of ACE in vitro, leading to the repeated inhibition of angiotensin II hormone³⁰. Whey protein doesn't only help in blood pressure management, it also helps in the regulation of fatty acid synthase expression that later resulted into adipocyte lipogenesis³¹. In a study were overweight and obese individuals consumed 54g/day of whey protein for a period of 12 weeks showed a significant reduction in both systolic and diastolic blood pressure³. Lean proteins, low-fat dairy products and reduced saturated fat diet rich in fruits and vegetables in take helped to reduce blood pressure in African Americans. Milk potassium and calcium alongside other dairy product nutrients helps to stabilize and maintain healthy blood pressure^{3,16,32}. A daily consumption of 1,000–1500 mg of calcium is sufficiently suggested to lower blood pressure especially to individuals who are responsive¹⁶.

Magnesium is fundamental in the reduction of elevated blood pressure since it helps in relaxing the muscles that control blood vessels, ensuring free flow of blood and it also equalizes potassium and sodium level in the blood³³.

Seven different studies of about 45000 participants, among which 11500 were hypertensive, 70% of them reported significant inverse relationship between hypertension and low fat dairy intake. Another study carried out among 335 Australian children who were subjected to milk consumption at an early age of 18 months had low blood pressure values at 8 years particularly in those who consumed at least 2 servings/day¹⁹.

According to the DASH trials, it recommended that a daily consumption of a diet consisting three servings of low-fat dairy foods, about 8-10 servings of fruits and vegetables per day and a low intake of low diets with saturated fat significantly reduced blood pressure among adults in a period of two weeks^{34,16}.

A study among individuals who followed blood pressure lowering lifestyle such as weight loss physical activities and minimizing alcohol consumption experienced the greatest numerical decreases in blood pressure^{16,35}.

Results from the Oslo health observational study indicated that frequent intake of cheese significantly reduced diastolic blood pressure, serum triglycerides and waist circumference, and increased HDL cholesterol production positively. Furthermore a similar study carried out among French participants showed that frequency of cheese intake also reduced triglyceride levels and waist circumference over 9 years. There is need for more studies to confirm these results⁷.

Elevated Fasting Glucose

Diabetes with high fasting plasma glucose (FPG) between 100 mg/dL and 126 mg/dL or greater leads to T2DM, premature death, disability, and increased risk of CVDs. Physical inactivity, insulin resistance, overweight and obesity are among the risk factors⁹.

Several studies suggest the possibilities of dairy products in diabetes etiology though some studies suggest controversial research evidences of some types of dairy products have association with risk factors of T2DM³⁶. Milk consumption plays a role in decreasing risk of insulin resistance syndrome¹⁶. Results from three meta-analyses of epidemiological studies indicated that consumption of milk and dairy products helps in lowering the risks of T2DM though the mechanism is not perfectly clear^{2,27,37}. However its suggested that whey and casein milk proteins stimulate the release of insulin that has a potential to regulate body tissue glucose and also helps to suppress postprandial blood glucose excursions⁶.

Study carried out in T2DM individuals confirmed that intake of 18 g of whey protein as part of breakfast or lunch lead to greater in sulintropic responses by circulating levels of the gut peptide glucose dependent insulintropic polypeptide (GIP), and it also suppresses postprandial glycaemia more than lactose and a non isoenergetic non-dairy protein³⁸. Intake of 55 g of whey protein before lunch suppresses postprandial glucose in T2DM individuals by stimulating much insulintropic and gut peptide (GIP and cholecystokinin, CCK) responses³⁹.

A study carried out in more than 3,000 adults for a period of 10 years indicated that participants who were overweight but consumed dairy products more than 35 times per week suffered 72% less incidences of insulin resistance syndrome than those who consumed dairy products less than 10 times per week¹⁶. Another study carried out in 37185 women also reported an inverse correlation of milk and dairy consumption as a risk of diabetes. This relation was high in skimmed milk products at 4% risk reduction for 1 additional serving per day. These effects are attributed to milk protein and Fat acid (trans palmitoleic acid) that trigger increase of insulinemic response, decrease glycemic fluctuations in the body and increase secretion of GIP and GIP-1^{19,3}.

In addition, a cohort study conducted among 16,835 healthy individuals and 12,403 diabetic participants by European Prospective Investigation into Cancer and Nutrition (EPIC)

results confirmed the inverse effect of cheese and fermented dairy products consumption with reduced incidences of diabetes. In this study still, participants who consumed 55 g of cheese and yoghurt per day was associated with a 12% reduced incidence of T2DM⁴⁰.

Three prospective cohorts studies that were conducted in the US indicated that intakes of total dairy products was not significantly associated with the risk of T2DM but it highlighted that high consumption of low-fat fermented dairy products such as yoghurt significantly reduced the risk of T2DM^{41,36}. However, there is need for more studies to establish mechanisms under which yogurt consumption can control both insulin resistance and obesity.

Dyslipidemia

Dyslipidemia is a risk factor of MetS caused by elevated triglycerides i.e.; elevated low-density lipoprotein cholesterol (LDL-C) and low-high density lipoprotein cholesterol (HDL-C). People with high triglycerides of 200 mg/dL or more, with a non-HDL-C of 130 mg/dL or more and a low 40mg/dL or less of HDL-C are considered to be at a high risk of MetS and should be admitted for treatment with aim of reducing LDL-C levels to less than 70 mg/dL^{11,42,43}.

Though there is a questionable association of saturated fat with a risk of CVD risk³⁰. Evidences show that consumption of three or more servings of dairy food per day helps in the reduction risk of CVD and T2DM^{30,44,45}. Even if there are some concerns that consuming more dairy products means consuming more saturated fat and cholesterol. Studies do not clearly indicate a positive correlation between dairy products and heart disease⁴⁶.

It's genetically proved that different individuals appear to have different response to dietary fat. Epidemiological studies^{47,44} suggest that intake of full-fat dairy products and saturated fat increase some MetS risk biomarkers. Several studies show reduced risk of MetS in individuals consuming low-fat dairy products and *either* or no association or insignificant increase in risk of MetS with full-fat dairy consumption¹⁶.

Studies show that milk fat increases HDL-C, hence maintaining a HDL-C:TC ratio which is helps in the reduction of CVD risks^{48,30}. This because Stearic and Palmitic acids found in milkfat occupy the sn-2 position of triglycerides (TG). This unique position of saturated fatty acids in milkfat affects postprandial metabolism hence prevention of hypercholesterolemia and elevated serum TG which would however lead to MetS risks⁴⁹. Milkfat is composed of over 25% mono unsaturated fatty acid (MUFA) oleic acid (cis 9-18:1)⁵¹. Intake of milk fat MUFA helps to protect against MetS risk factors⁵⁰.

The American Heart Association recommends intake of fat-free cheese or cheese made of at least 1% fat and other low-fat dairy products and to lower cholesterol intake, reduce saturated fat

intake to not more than 5-6% of total calories. In a study were participants consumed about 14g/day of saturated fat from cheese for a period of 8 weeks of results indicated no increases in total or LDL cholesterol⁷.

Due to high levels of calcium in cheese, higher intake of cheese lowers triglyceride levels and waist circumference^{45, 52}. The Oslo Health studies provide evidence that increased frequency of cheese consumption in adults resulted in a lower risk of MetS. Other trials have show beneficial or neutral effects of dairy foods on MetS risks such as blood pressure, triglyceride levels, fasting glucose and waist circumference^{45,32}. Study carried in 5344 men and 6150 women subjected to consumption of all types of cheese and soft drinks showed that frequency of cheese intake lowered the risk of MetS compared to soft drinks³⁵.

A number of recent reviews on dairy food intake and risk of cardiovascular disease briefly summarizes that consumption of dairy foods regardless of the fat content has not shown increased risks of CVD and, or that intake of high fat dairy products contributes to risk of CVD. It is also concluded that dairy intake helps in reduction of overall CVD risk²².

Conclusion

It is no doubt that there is a high prevalence of MetS in the world leading to complications like diabetes, hypertension, obesity and CVDs among others. Excess intake of saturated fats, caloric imbalance, physical inactivity, alcohol and cigarette use being the highest risk factor for the etiology of the MetS burdens. Many studies suggest that intake of dairy foods is reduces risks of metabolic syndrome and the emphasis is attributed to calcium, Vitamin D, magnesium, potassium, milk fat, whey and casein milk proteins that are rich in yoghurt, cheese among other dairy products. Lifestyle interventions such as increasing physical activities, weight reduction, controlled alcohol use and to stop Smoking are one of the possible suggestions for prevention and control of MetS complications.

There is need for further more studies to detail the importance of milk and components in dairy products in human metabolic health and give specific recommendations in the diets aiming in the management of MetS complications without significant contraindications.

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