DAIRY RESEARCH INSTITUTE
NUTRITION • PRODUCTS • SUSTAINABILITY

NATIONAL DAIRY COUNCIL®

Metabolic Syndrome

Metabolic syndrome is a cluster of metabolic abnormalities that, when present, approximately doubles an individual's risk of cardiovascular disease and increases the likelihood they will develop type 2 diabetes by 5 times. Approximately 34% of U.S. adults meet the criteria for metabolic syndrome, which has been increasing in prevalence largely due to the rising incidence of obesity. Although genetics influences the development of metabolic syndrome, modifiable lifestyle factors including dietary choices also play a role. This report provides an overview of available science evaluating the role of dairy foods in metabolic syndrome and its individual risk factors.

Scientific Status Report

In partnership with National Dairy Council, the Dairy Research Institute® is providing this report for informational purposes only. The Dairy Research Institute expresses no opinion about the suitability of the information for use and suggests that any recipient obtain appropriate expert advice with regard to any statements or information herein contained. Although efforts are made to ensure that the information is complete and accurate, the Dairy Research Institute, its officers, employees and agents cannot and do not offer any representation or warranties, express or implied, as to the accuracy, completeness, currency or suitability of the information provided, whether based on warranty, contract, tort or any other legal theory and whether or not advised of the possibility of such damages. In no event shall the Dairy Research Institute or its affiliates be liable for any damages whatsoever arising out of the use, inability to use or the resulting use of information herein provided. All damages, including without limitation direct or indirect, special, incidental, consequential or punitive are hereby excluded to the fullest extent allowed by law. Any and all liability for the content or any omissions from this information, including any inaccuracies, errors or misstatements is expressly disclaimed.

Introduction

Metabolic syndrome is a cluster of metabolic abnormalities that increases an individual's risk of developing type 2 diabetes and cardiovascular disease.[1] A diagnosis of metabolic syndrome is made when three or more of the following risk factors are present:

- Abdominal obesity - ≥ 102 cm (≥ 40 inches) in men; ≥ 88 cm (≥ 35 inches) in women.
- Elevated triglyceride levels - ≥ 150 mg/dL (1.7 mmol/L) or receiving drug treatment of elevated triglycerides.
- Low HDL cholesterol levels - < 40 mg/dL (1.03 mmol/L) in men; < 50 mg/dL (1.3 mmol/L) in women; or receiving drug treatment for reduced HDL cholesterol.
- Raised blood pressure - ≥ 130 mm Hg systolic blood pressure or ≥ 85 mm Hg diastolic blood pressure, or receiving antihypertensive drug with a history of hypertension.
- Elevated fasting glucose - ≥ 100 mg/dL or receiving drug treatment for elevated glucose.[1]
- In addition to the above, individuals with metabolic syndrome typically display elevated markers of inflammation and abnormalities in blood coagulation.[1]

Approximately 34% of U.S. adults meet the criteria for metabolic syndrome, according to government health surveys conducted between 1999 and 2006, which represents an increase from 29% in similar surveys conducted between 1988 and 1994.[2,3] The increased prevalence of metabolic syndrome in the U.S. and worldwide is attributed largely to the obesity epidemic.[4] With the growing prevalence of metabolic syndrome and evidence that persons with metabolic syndrome are approximately twice as likely to develop cardiovascular disease and five times more likely to develop type 2 diabetes than those without this syndrome,[5] there is an urgent need to address this serious public health issue.

Although genetics influences the development of metabolic syndrome, modifiable lifestyle factors including dietary choices also play a role.[1,4] Emerging scientific research indicates that consumption of dairy products and dairy components may help reduce the risk of metabolic syndrome.[1]

Milk, Milk Products, and Metabolic Syndrome

A number of observational studies, both cross-sectional and prospective, have demonstrated an association between increased dairy product consumption and lower incidence of metabolic syndrome in various populations.[6,7,8] After combining data from cross-sectional studies, researchers reported that consumption of 3 to 4 servings/day of dairy foods was associated with a 29% reduced risk of developing metabolic syndrome compared with intake of less than 2 servings/day of dairy.8

A more recent systematic review of 10 cross-sectional and three prospective cohort studies found that in seven of 13 studies (i.e., five of the 10 cross-sectional and two of the three prospective studies) published between 2000 and 2009 dairy intake was inversely associated with metabolic syndrome.7 The researchers concluded that the majority of observational studies indicate a beneficial effect of dairy consumption on risk of metabolic syndrome.[7] Additionally, they suggest that failure to control for confounding factors, limited information regarding dairy intake (e.g., type, quantity, fat content), and use of different criteria to diagnose metabolic syndrome may explain inconsistent findings observed in some studies.[7]

Following publication of the above review, a recent prospective study found that, after adjusting for confounding variables including body mass index (BMI), consumption of dairy products other than cheese and the calcium density of the diet (amount of calcium/1,000 calories) each was associated with a significantly lower incidence of metabolic syndrome.[9] This study examined the relationship between dairy products and the nine-year cumulative incidence of metabolic syndrome in 3,435 adults enrolled

in the Epidemiological Study on the Insulin Resistance Syndrome (DESIR) in France. Intakes of dairy foods and calcium were determined using a food frequency questionnaire at the beginning of the study and after three years. The findings showed that not only was dairy intake associated with reduced incidence of metabolic syndrome, but also with some risk factors for metabolic syndrome. Specifically, consumption of dairy products other than cheese and the calcium density of the diet were associated with reduced incidence of type 2 diabetes or impaired fasting glucose.9 Also, consumption of dairy products other than cheese, cheese alone, and the calcium density of the diet, were associated with a lower nine-year diastolic blood pressure and with lower BMI gain over time.[9] Higher cheese intake and the calcium density of the diet were associated with lower triglyceride levels and a lower nine-year increase in waist circumference. Recently, a comprehensive analysis of data from the Oslo Health Study found that a higher frequency of self-reported cheese intake in adults was significantly associated with a lower likelihood of having metabolic syndrome, fewer metabolic syndrome risk factors, and improvements in individual metabolic syndrome components.[10]

To date, no randomized controlled trials have been conducted to directly determine the impact of dairy foods on the development or incidence of metabolic syndrome.7 However, a few trials have demonstrated either a neutral or beneficial effect of dairy foods on components of metabolic syndrome such as triglyceride levels, blood pressure, fasting glucose, and/or waist circumference.[11,12,13] A recent randomized clinical trial in 40 overweight or obese adults (19 men and 21 women) with metabolic syndrome showed that an adequate intake of dairy foods (>3.5 servings/day) consumed as part of a weight maintenance diet for 12 weeks significantly reduced biomarkers of oxidative and inflammatory stress, two factors commonly observed in individuals with metabolic syndrome, compared with a low dairy intake (<0.5 servings/day).[14] Adequate dairy intake also improved certain components of metabolic syndrome (e.g., elevated waist circumference, high blood pressure, and insulin resistance).

Intake of Dairy Components and Metabolic Syndrome

The specific physiological mechanism(s) by which dairy foods affect metabolic syndrome and its related disease outcomes (i.e., cardiovascular disease, type 2 diabetes) is yet to be fully elucidated. However, components in dairy foods may provide protection against metabolic syndrome by modulating risk factors associated with this condition.[15,16,17] As reviewed by Rice and colleagues, specific dairy components – milkfat, vitamin D, calcium, magnesium, potassium, and whey protein – may individually or collectively exert a beneficial effect on various elements of metabolic syndrome, including blood lipid levels, blood pressure, fasting glucose, and body composition.[17] The following are some of dairy food components' effects on risk factors for metabolic syndrome:

- Milkfat: the composition (i.e., more medium-chain fatty acids) and type of saturated fat, level of monounsaturated fat, bioactive fatty acids, and/or a combination of these constituents may contribute to milkfat's neutral or beneficial effects on risk factors for metabolic syndrome. For example, the unique position of some saturated fatty acids on the triglyceride backbone in milkfat may help prevent hypercholesterolemia and high blood triglyceride levels typically observed with diets high in saturated fat.[17,18] Milkfat is also comprised of approximately 25% of oleic acid, a monounsaturated fatty acid shown to have beneficial effects on blood lipid levels, and central adiposity, as well as a neutral or beneficial effect on blood pressure and glycemic response and insulin sensitivity.[17,19,20] Emerging evidence indicates that trans-palmitoleic acid, another monounsaturated fatty acid in milkfat, is associated with an improved blood lipid profile, insulin resistance, waist circumference, and BMI.[21] Conjugated linoleic acid (CLA), a group of positional and geometric isomers of linoleic acid including rumenic acid (a trans fatty acid produced naturally by ruminant animals) in milkfat, has been shown to have beneficial effects on blood lipid and lipoprotein levels in experimental animals,[22] but this finding has not been confirmed in humans.[23]

- Vitamin D: Vitamin D-fortified cow's milk is the leading food source of vitamin D in the American diet.[24] Vitamin D may have a beneficial impact on metabolic health by favorably influencing blood lipids and lipoproteins, improving insulin sensitivity, and possibly lowering blood pressure, but data remain inconclusive.[25]

- Calcium, potassium and magnesium: milk is the leading source of calcium, potassium, and magnesium in the diet of Americans aged 2 years and older.[24] Results from randomized controlled trials have demonstrated that calcium has a neutral or beneficial effect on blood lipid levels, potentially mediated by increased excretion of fecal fat.[17,26] Other studies have shown that calcium, as well as potassium and magnesium, may lower blood pressure.[27] Calcium may also have a beneficial effect on metabolic health by its favorable effects on body weight and body composition.[28]

- Whey protein: milk protein, particularly whey protein, may favorably modify several risk factors associated with metabolic syndrome. Studies have shown that intake of whey protein is associated with improved blood lipid profile, blood pressure control, insulin sensitivity.[17,29,30] Additionally, other studies have demonstrated that increased whey protein intake, as compared to carbohydrate, may improve body composition when accompanied by regular resistance exercise or as part of a weight management program.[17,31,32]

Conclusion

Emerging evidence, primarily from epidemiological studies, suggests that consumption of dairy foods is inversely associated with metabolic syndrome and its risk factors. According to the 2010 Dietary Guidelines for Americans, moderate evidence indicates that "intake of milk and milk products is associated with a reduced risk of cardiovascular disease and type 2 diabetes and with lower blood pressure in adults."[33] Although specific mechanisms have yet to be fully elucidated, there is evidence that dairy food components may have a neutral or beneficial effect on risk factors for metabolic syndrome. However, further research, particularly randomized controlled trials including specific types of dairy foods, is necessary to verify findings from epidemiological investigations supporting a beneficial role of dairy foods on metabolic syndrome. Also, well-controlled trials are needed to clarify potential mechanisms by which dairy food components contribute to dairy foods' beneficial effects on metabolic syndrome.6,[17,34]

To-date, findings related to dairy food intake and metabolic syndrome are promising and provide another reason to consume 3 cups of low-fat or fat-free milk and milk products every day for Americans 9 years and older as part of a healthful diet recommended by the 2010 Dietary Guidelines for Americans[33] and USDA's MyPlate (www.choosemyplate.gov).

References

1. Grundy, S.M., J.I. Cleeman, S.R. Daniels, et al. Diagnosis and management of the metabolic syndrome: an American Heart Association / National Heart, Lung and Blood Institute Scientific Statement. Circulation 112: 2735-2752, 2005.

2. Ervin, R.B. Prevalence of metabolic syndrome among adults 20 years of age and over, by sex, age, race and ethnicity, and body mass index: United States, 2003-2006. Natl. Health Stat. Report 13: 1-7, 2009.

3. Mozumdar, A., and G. Liguori. Persistent increase of prevalence of metabolic syndrome among U.S. adults: NHANES III to NHANES 1999-2006. Diabetes Care 34: 216-219, 2011.

4. Bruce, K.D., and M.A. Hanson. The developmental origins, mechanisms, and implications of metabolic syndrome. J. Nutr. 140: 648-652, 2010.

5. Grundy, S.M. Metabolic syndrome pandemic. Arterioscler. Thromb. Vasc. Biol. 28: 629-636, 2008.

6. Tremblay, A., and J.A. Gilbert. Milk products, insulin resistance syndrome and type 2 diabetes. J. Am. Coll. Nutr. 28: 91s-202s, 2009.

7. Crichton, G.E., J. Bryan, J. Buckley, et al. Dairy consumption and metabolic syndrome: a systematic review of findings and methodological issues. Obes. Rev. 12: e190-e201, 2011.

8. Pittas, A.G., J. Lau, F.B. Hu, et al. Review: the role of vitamin D and calcium in type 2 diabetes. A systematic review and meta-analysis. J. Clin. Endocrinol. Metab. 92: 2017-2029, 2007.

9. Fumeron, F., A. Lamri, C.A. Khalil, et al. Dairy consumption and the incidence of hyperglycemia and the metabolic syndrome. Diabetes Care 34: 813-817, 2011.

10. Hostmark, A.T., and S.E. Tomten. The Oslo Health Study: cheese intake was negatively associated with the metabolic syndrome. J. Am. Coll. Nutr. 30: 182-190, 2011.

11. Hilpert, K.F., S.G. West, D.M. Bagshaw, et al. Effects of dairy products on intracellular calcium and blood pressure in adults with essential hypertension. J. Am. Coll. Nutr. 28: 142-149, 2009.

12. Van Meijl, L.E., and R.P. Mensink. Low-fat dairy consumption reduces systolic blood pressure, but does not improve other metabolic risk parameters in overweight and obese subjects. Nutr. Metab. Cardiovasc. Dis. 21: 355-361, 2010.

13. Zemel, M.B., D. Teegarden, M. Van Loan, et al. Dairy-rich diets augment fat loss on an energy-restricted diet: a multicenter trial. Nutrients 1: 83-100, 2009.

14. Stancliffe, R.A., T. Thorpe, and M.B. Zemel. Dairy attenuates oxidative and inflammatory stress in metabolic syndrome. Am. J. Clin. Nutr. 94: 422-430, 2011.

15. Pfeuffer, M., and J. Schrezenmeir. Milk and the metabolic syndrome. Obes. Rev. 8: 109-118, 2006.

16. Scholz-Ahrens, K.E., and J. Schrezenmeir. Milk minerals and the metabolic syndrome. Int. Dairy J. 16:1399-1407, 2006.

17. Rice, B.H., C.J. Cifelli, M.A. Pikosky, et al. Dairy components and risk factors for cardiometabolic syndrome: recent evidence and opportunities for future research. Adv. Nutr. 2: 396-407, 2011.

18. German, J.B., R.A. Gibson, R.M. Krauss, et al. A reappraisal of the impact of dairy foods and milkfat on cardiovascular disease risk. Eur. J. Nutr. 48: 191-203, 2009.

19. Gillingham, L.G., S. Harris-Janz, and P.J. Jones. Dietary monounsaturated fatty acids are protective against metabolic syndrome and cardiovascular disease risk factors. Lipids 46: 209-228, 2011.

20. Alonso, A., V. Ruiz-Gutierrez, and M.A. Martinez-Gonzalez. Monounsaturated fatty acids, olive oil and blood pressure: epidemiological, clinical and experimental evidence. Public Health Nutr. 9: 251-257, 2006.

21. Mozaffarian, D., H. Cao, I.B. King, et al. Trans-palmitoleic acid, metabolic risk factors, and new-onset diabetes in U.S. adults: a cohort study. Ann. Intern. Med. 153: 790-799, 2010.

22. Lock, A.L., J. Kraft, B.H. Rice, et al. Biosynthesis and biological activity of rumenic acid: a natural CLA isomer. In: *Trans Fatty Acids in Human Nutrition*. 2nd ed. Destaillats, F., J.-L. Sebedio, F. Dionisi, and J.-M. Chardiny (Eds). Bridgwater: the Oily Press, 2009, p. 195-230.

23. Chardigny, J.-M., F. Destaillats, C. Malpuech-Brugere, et al. Do *trans* fatty acids from industrially produced sources and from natural sources have the same effect on cardiovascular disease risk factors in healthy subjects? Results of the *trans* Fatty Acids Collaboration (TRANSFACT) study. Am. J. Clin. Nutr. 87: 558-566, 2008.

24. Dairy Research Institute®, Proprietary NHANES 2003-2006 analyses, Ages 2+ years. Data source: Centers for Disease Control and Prevention, National Center for Health Statistics, National Health and Nutrition Examination Survey. Hyattsville, MD: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, 2003-2004; 2005-2006. http://www.cdc.gov/nchs/nhanes.htm.

25. Muldowney, S., and M. Kiely. Vitamin D and cardiometabolic health: a review of the evidence. Nutr. Res. Rev. Dec 1: 1-20, 2011.

26. Lorenzen, J.K., and A. Astrup. Dairy calcium intake modifies responsiveness of fat metabolism and blood lipids to a high-fat diet. Br. J. Nutr. Jan 31: 1-10, 2011. [Epub ahead of print].

27. Kris-Etherton, P.M., J.A. Grieger, K.F. Hilpert, et al. Milk products, dietary patterns and blood pressure management. J. Am. Coll. Nutr. 28(suppl. 1): 103s-119s, 2009.

28. Tremblay, A., and J.-A. Gilbert. Human obesity: is insufficient calcium/dairy intake part of the problem? J. Am. Coll. Nutr. 30(suppl.): 449s-453s, 2011.

29. Pal, S., V. Ellis, and S. Dhaliwal. Effects of whey protein isolate on body composition, lipids, insulin and glucose in overweight and obese individuals. Br. J. Nutr. 104: 716-723, 2010.

30. Pal, S., and V. Ellis. The chronic effects of whey proteins on blood pressure, vascular function, and inflammatory markers in overweight individuals. Obesity 18: 1354-1359, 2010.

31. Hulmi, J.J., C.M. Lockwood, and J.R. Stout. Effect of protein/essential amino acids and resistance training on skeletal muscle hypertrophy: a case for whey protein. Nutr. Metab. 7: 51, 2010.

32. Westerterp-Plantenga, M.S., A. Nieuwenhuizen, D. Tome, et al. Dietary protein, weight loss, and weight maintenance. Annu. Rev. Nutr. 29: 21-41, 2009.

33. U.S. Department of Agriculture and US Department of Health and Human Services. *Dietary Guidelines for Americans, 2010.* 7th Edition. Washington, D.C.: U.S. Government Printing Office, December 2010.

34. Dietary Guidelines Advisory Committee 2010. *Report of the Dietary Guidelines Advisory Committee on the Dietary Guidelines for Americans, 2010,* to the Secretary of Agriculture and Secretary of Health and Human Services. U.S. Department of Agriculture, Agricultural Research Service, Washington, D.C.

Dairy Research Institute® *was established under the leadership of America's dairy farmers with a commitment to nutrition, product and sustainability research. The Dairy Research Institute is a 501(c)(3) non-profit organization created to strengthen the dairy industry's access to and investment in the technical research required to drive innovation and demand for dairy products and ingredients globally. The Institute works with and through industry, academic, government and commercial partners to drive pre-competitive research in nutrition, products and sustainability on behalf of the Innovation Center for U.S. Dairy®, National Dairy Council® and other partners. The Dairy Research Institute is primarily funded by the national dairy checkoff program managed by Dairy Management Inc.*

About National Dairy Council
National Dairy Council® (NDC), the non-profit organization funded by the national dairy checkoff program, is committed to nutrition education and research-based communications. NDC provides science-based nutrition information to, and in collaboration with, a variety of stakeholders committed to fostering a healthier nation, including health professionals, educators, school nutrition directors, academia, industry, consumers and media. Established in 1915, NDC comprises a staff of registered dietitians and nutrition research and communications experts across the country. NDC has taken a leadership role in promoting child health and wellness through programs such as Fuel Up to Play 60. Developed by NDC and the National Football League (NFL), Fuel Up to Play 60 encourages youth to consume nutrient-rich foods and achieve at least 60 minutes of physical activity every day. For more information, visit www.NationalDairyCouncil.org.