Nutrition, Metabolism & Cardiovascular Diseases (2015) **25**, 3–8

Available online at www.sciencedirect.com

Nutrition, Metabolism & Cardiovascular Diseases

journal homepage: www.elsevier.com/locate/nmcd

REVIEW

Dairy consumption and insulin sensitivity: A systematic review of short- and long-term intervention studies

K.M. Turner, J.B. Keogh, P.M. Clifton*

School of Pharmacy and Medical Sciences, University of South Australia, Adelaide, Australia

Received 5 May 2014; received in revised form 17 July 2014; accepted 29 July 2014
Available online 7 August 2014

KEYWORDS
Dairy;
Whey;
Insulin sensitivity;
Randomised controlled trial

Abstract *Aim:* Evidence from epidemiological studies suggests that higher consumption of dairy products may be inversely associated with risk of type 2 diabetes and other components of the metabolic syndrome, although the evidence is mixed. Intervention studies that increase dairy intake often involve lifestyle changes, including weight loss, which alone will improve insulin sensitivity. The aim of this review was to examine weight stable intervention studies that assess the effect of an increased intake of dairy products or dairy derived supplements on glucose metabolism and insulin sensitivity.
Data synthesis: An electronic search was conducted using MEDLINE, EMBASE, the Cochrane Database and Web of Science for randomised controlled trials altering only dairy intake in humans with no other lifestyle or dietary change, particularly no weight change, and with measurement of glucose or insulin. Healthy participants and those with features of the metabolic syndrome were included. Chronic whey protein supplementation was also included. Ten studies were included in this systematic review.
Conclusions: In adults, four of the dairy interventions showed a positive effect on insulin sensitivity as assessed by Homeostasis Model Assessment (HOMA); one was negative and five had no effect. As the number of weight stable intervention studies is very limited and participant numbers small, these findings need to be confirmed by larger trials in order to conclusively determine any relationship between dairy intake and insulin sensitivity.

Introduction

Diabetes is the seventh leading cause of death in the U.S. and the risk of stroke or heart disease related death is two to four times higher in adults with diabetes [1]. In Australia, those with Type 2 Diabetes Mellitus (T2DM) have more than twice the total and cardiovascular mortality risk of those with normal glucose tolerance, and those with impaired fasting glucose and impaired glucose tolerance have a 50%–60% greater mortality risk than those with normal glucose levels [2].

While ageing, family history and ethnicity play a role, obesity is the most common predictor for the onset of insulin resistance and T2DM [3] and may account for over 77% of the population attributable risk [4]. Improvement in diet and increased physical activity lowers the risk for T2DM, and while energy restriction and weight loss have been proven to improve insulin sensitivity, the role of specific dietary components is uncertain [5].

* Corresponding author. University of South Australia, School of Pharmacy and Medical Sciences, Division of Health Sciences, GPO Box 2471, Adelaide, SA 5000, Australia. Tel.: +61 8 8302 1357; fax: +61 8 8302 2389.
E-mail addresses: peter.clifton@unisa.edu.au, peter.clifton@adelaide.edu.au (P.M. Clifton).

http://dx.doi.org/10.1016/j.numecd.2014.07.013
0939-4753/

Some epidemiological evidence indicates that a diet high in dairy foods may be protective against the onset of T2DM [6,7], but the data is mixed [8,9]. A recent meta-analysis examined 14 cohorts and found a significant inverse linear association between consumption of total dairy products, low-fat dairy, cheese and yoghurt and risk of T2DM [10]. The pooled risk ratios (RRs) were 0.94 (95% CI 0.91–0.97) for 200 g/day total dairy and 0.88 (0.84–0.93) for low-fat dairy. For 30 g/d cheese and 50 g/d yoghurt consumption, the pooled RRs were 0.80 (0.69–0.93) and 0.91 (0.82–1.00), respectively. There was a nonlinear association of low-fat dairy intake and T2DM risk, with most of the risk reduction occurring with intake up to 300 g/day; higher intake (>400 g/day) was not associated with a further decrease in risk. Aune et al. [11] examined 17 cohort studies and found a 9% reduction in the incidence of T2DM per 200 g serving of low-fat dairy and an 8% reduction per 50 g of cheese. In the Women's Health Study [12], the inverse association with T2DM was mainly attributable to low-fat dairy intake; the multivariate relative risks comparing the highest to the lowest quintiles was 0.79 (0.67–0.93; p for trend = 0.002). The inverse relationship between dairy intake and incident T2DM remained unchanged after further adjustment for glycaemic load and for dietary calcium, vitamin D, fat, fibre and magnesium. These associations also did not vary significantly according to BMI status. Similar results were seen in the Health Professionals Follow-up Study [13] where each serving of dairy was associated with a 9% lower risk of diabetes. A recent U.K. study showed a 24% lower risk with 4.5 (125 g) servings of low-fat fermented dairy per week and a 28% lower risk for yoghurt, but total dairy, high-fat dairy, milk, cheese and high-fat fermented dairy showed no association [14].

Serum phospholipid *trans*-palmitoleic acid (*trans*-16:1n-7), a marker of dairy fat consumption, has been associated with a lower incidence of insulin resistance [15]. This was confirmed in an observational study of 17 individuals with non-alcoholic fatty liver disease and 15 BMI- and age-matched controls [16]. Higher consumption of dairy fat, measured by *trans*-16:1n-7, free fatty acid (FFA) 15:0 and FFA 17:0 was inversely associated with fasting plasma glucose, and positively associated with lower glucose levels in an oral glucose tolerance test (OGTT) and higher systemic and hepatic insulin sensitivity. In another cohort of overweight and insulin resistant individuals there was no relationship between *trans*-16:1n-7 and insulin sensitivity [17], although other indicators of dairy consumption, including lysophosphatidylcholine, lyso-platelet-activating factor and phospholipid FFA 17:0, were associated with insulin sensitivity as measured by the Matsuda Index [18].

It appears that regular dairy consumers have a 10% lower risk of diabetes per extra serving of dairy but the benefit may be as high as a 28% lower risk with yoghurt consumption. Whether this is due to the dairy itself or some other aspect of dairy consumers' lifestyle is not clear, although in prospective studies all the usual predictors of diabetes such as weight, smoking, family history and fibre intake are taken into account. A meta-analysis of 29 randomised controlled trials evaluating dairy intake and body weight and fat mass did not find a beneficial effect of increasing dairy consumption [19], suggesting the effect of dairy is not via control of body weight, although in prospective cohort studies increases in dairy are associated with less body weight gain [20]. The aim of this review was to assess weight stable randomised controlled studies that altered dairy intake and assessed glucose and/or insulin levels.

Methods

An electronic search was conducted using MEDLINE, EMBASE, Web of Science and the Cochrane database for randomised controlled trials that contrasted at least two levels of dairy intake and measured glucose and/or insulin and were longer than one week in duration. Trials less than four weeks were designated as short term trials, and greater than 4 weeks as long term. Acute feeding studies were not included. Whey protein supplementation was included. Key search terms were: "randomised controlled trial" plus "dairy, glucose" or "whey, glucose". Reference lists of retrieved articles were also searched for relevant articles. Two hundred and forty five references were retrieved and the title examined.

Eligibility criteria

To be included in this review a published study had to meet the following criteria: (1) original article; (2) randomised controlled trial of at least one week duration for each treatment; (3) weight stable human population; (4) total dairy intake or one of the dairy products (milk, yoghurt, cheese) as the only independent variable; and (5) glucose or insulin measured as one of the endpoints. All participants, healthy or with disease, were included. Information on study design, participant characteristics, and study variables was extracted independently by two reviewers (KMT and PMC). Discrepancies were resolved by discussion. A total of ten randomized controlled trials, nine whole dairy and one whey supplementation trial were included in this systematic review. Participant numbers and the time frame for each study are referenced in Table 1.

Short term (1–4 week) dairy interventions in healthy participants

In a one-week intervention study in Denmark in healthy 8-year old boys, one group (n = 12) consumed 250 g of lean red meat each day and the other (n = 12) consumed 1.5 L of skim milk, both of which provided approximately 53 g protein daily, otherwise the diets were not controlled. No significant difference in fasting insulin was found in those on the meat diet, but the milk diet doubled fasting insulin concentrations from baseline, with no change in fasting glucose [21]. However tests of statistical difference