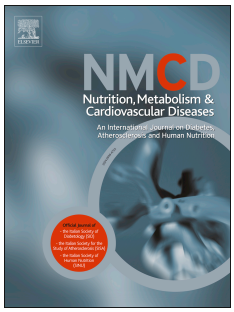
Dairy shows different associations with abdominal and BMI-defined overweight: cross-sectional analyses exploring a variety of dairy products

Brouwer, E. M., Sluik, D., Singh-Povel, C. M., & Feskens, E. J. M.

Accepted Manuscript



Dairy shows different associations with abdominal and BMI-defined overweight: cross-sectional analyses exploring a variety of dairy products

E.M. Brouwer-Brolsma, D. Sluik, C.M. Singh-Povel, E.J.M. Feskens

PII: S0939-4753(18)30025-5

DOI: 10.1016/j.numecd.2018.01.008

Reference: NUMECD 1839

To appear in: *Nutrition, Metabolism and Cardiovascular Diseases*

Received Date: 11 September 2017

Revised Date: 16 January 2018

Accepted Date: 17 January 2018

Please cite this article as: Brouwer-Brolsma E, Sluik D, Singh-Povel C, Feskens E, Dairy shows different associations with abdominal and BMI-defined overweight: cross-sectional analyses exploring a variety of dairy products, *Nutrition, Metabolism and Cardiovascular Diseases* (2018), doi: 10.1016/j.numecd.2018.01.008.

Dairy shows different associations with abdominal and BMI-defined overweight: cross-sectional analyses exploring a variety of dairy products

Brouwer-Brolsma EM[a], Sluik D[a], Singh-Povel CM[b], Feskens EJM[a]

[a]Division of Human Nutrition, Wageningen University, Wageningen, The Netherlands

[b]FrieslandCampina, Amersfoort, The Netherlands.

Corresponding author:

Elske Brouwer-Brolsma, PhD

Wageningen University, Division of Human Nutrition

PO Box 8129, 6700 EV Wageningen, The Netherlands

Tel: +31 (0)317 481287 Fax: +31 (0)317 484987

E-mail: elske.brouwer-brolsma@wur.nl

Word count abstract: 249

Word count text: 3000

Number of references: 35

Number of figures: 0

Number of tables: 4

Abstract

Background and aims

Previous studies suggest weight-regulatory properties for several dairy nutrients, but population-based studies on dairy and body weight are inconclusive. We explored cross-sectional associations between dairy consumption and indicators of overweight.

Methods and results

We included 114 682 Dutch adults, aged ≥18y. Dairy consumption was quantified by a food frequency questionnaire. Abdominal overweight was defined as waist circumference (WC) ≥88 (women) or ≥102 (men) cm (*n*=37 391), overweight as BMI ≥25-30 kg/m^2 (*n*=44 772), and obesity as BMI ≥30 kg/m^2 (*n*=15 339). Associations were quantified by logistic (abdominal overweight, no/yes), multinomial logistic (BMI-defined overweight and obesity) and linear regression analyses (continuous measures of WC and BMI), and adjusted for relevant covariates. Total dairy was positively associated with abdominal overweight (OR Q1^{ref} vs Q5: 1.09; 95% CI: 1.04, 1.14), and BMI-defined overweight (OR^{Q5} 1.13; 95% CI: 1.08, 1.18) and obesity (OR^{Q5} 1.09; 95% CI: 1.02, 1.16). Positive associations were also observed of skimmed, semi-skimmed, and non-fermented dairy with overweight categories. Full-fat dairy was inversely associated with overweight and obesity (OR^{Q5} for obesity: 0.78; 95% CI: 0.73, 0.83). Moreover, inverse associations were observed for yogurt and custard, and positive associations for milk, buttermilk, flavoured yogurt drinks, cheese, and cheese snacks. Fermented dairy, curd cheese and Dutch cheese were not consistently associated with overweight categories.

Conclusions

Total, skimmed, semi-skimmed, and non-fermented dairy, milk, buttermilk, flavoured yogurt drinks, total cheese, and cheese snacks were positively associated with overweight categories, whereas full-fat dairy, custard, and yogurt were inversely associated with overweight categories.

Keywords: dairy; adiposity; overweight; obesity

Introduction

Dietary choices play an important role in body weight regulation, where specific effects have been suggested for particular dairy nutrients. Favourable effects have for instance been proposed for dairy proteins and calcium [1], while less favourable effects are expected for energy-dense dairy products [2]. However, when consuming dairy products, nutrients are consumed as a mixture of food compounds exerting potentially opposing effects. Therefore, gaining insight in the composite impact of dairy consumption on body weight by studying single nutrients is challenging; studying dairy products may provide more insight.

Already several trials [3], cross-sectional studies (*n*=37 up to 37 513) [4-16], and prospective studies (*n*=1124 up to 120 877) [17-22] have been conducted on this topic. A meta-analysis of RCTs indicates that dairy consumption beneficially affects body weight and fat loss in short-term and energy-restricted trials, but not in ad libitum and long-term trials [3]. However, trial duration was often short - i.e. ranging from one month to one year - and most interventions were conducted in participants with overweight or obesity [3]. Evidence from cohort studies is still inconclusive as well [23], which may be because studies largely focussed on total dairy intake or a few dairy subgroups, rather than *detailed* analyses for a variety of dairy subgroups [22].

As analyses on total dairy intake may reflect an offset of specific products with favourable properties with that of products with unfavourable properties, we explored associations between a broad variety of dairy classes (i.e. skimmed, semi-skimmed, full-fat, non-fermented, and fermented dairy; total, skimmed, semi-skimmed, and full-fat milk; total, skimmed, and full-fat yogurt; buttermilk, curd cheese, custard, flavoured yogurt drinks, total cheese, Dutch cheese, and cheese snack) and measured abdominal overweight (waist circumference (WC) ≥102cm for men and ≥88cm for women), and BMI-defined overweight (≥25-30 kg/m^2) and obesity (≥30 kg/m^2) in a unique large population (*n*=114 658) of Dutch adults.

Methods

Study population

Participants were selected from the Lifelines Cohort Study (LCS) [24]. LCS is a multi-disciplinary prospective population-based cohort study examining in a unique three-generation design the health and health-related behaviours of 167 729 persons living in the North of The Netherlands. Participants were recruited between 2006-2013. All participants gave written informed consent. The LCS is conducted according to the principles of the Declaration of Helsinki, in accordance with the research code of the University Medical Centre Groningen (UMCG), and approved by the medical ethical committee of the UMCG, The Netherlands.

Study sample

In total, 144 095 participants completed a baseline Food Frequency Questionnaire (FFQ). Participants with unrealistic dietary data (*n*=29 413) (i.e. <500 kcal for women, <800 kcal for men, or unrealistic as judged by our dietitians based on intake reports of macronutrients and food groups below the possible under/upper limit as well as additional calculations evaluating the reported energy intake in view of basal metabolic rate) and/or missing data on weight or height (*n*=24) were excluded from the analyses. Subsequently, *n*=114 682 participants were included in the crude analyses; fully-adjusted analyses were conducted with *n*=105 302 (abdominal overweight) and *n*=105 280 (BMI-defined overweight and obesity).

Dietary assessment

Participants completed a new type of FFQ, the Flower FFQ, which was developed as an alternative for the regular FFQ to reduce the size of the questionnaire. A detailed description of the FFQ can be found elsewhere [25]. In short, the FFQ consists of one basic questionnaire on energy and macronutrient intake, and four complementary questionnaires on micronutrients and eating behaviour. For the current analyses only data of the basic questionnaire was available, comprising 110 food items, including all major food groups. Dairy intake was covered by 28 items and clustered as skimmed, semi-skimmed, full-fat, non-fermented, and fermented dairy; milk, custard, yogurt, buttermilk, curd cheese, flavoured yogurt drinks, total cheese, Dutch cheese, and cheese snacks (**Table 1**). Information on fat content was available for 22 out of 28 dairy products. We specifically

asked for cheese snacks consumption, i.e. “During the previous month, how often did you eat cheese as a snack?”. Questions on frequency were answered by selecting: ‘never’, 1 day/month, 2-3 days/month, 1 day/week, 2-3 days/week, 4-5 days/week, or 6-7 days/week. Portion sizes were estimated using natural portions and commonly used household measures. Average daily nutrient intakes were calculated by multiplying consumption frequency by portion size and nutrient content per gram by means of the Dutch Food Composition table 2011 (NEVO) [26]. Moreover, participants were asked whether they followed a diet during the past month: “none”, “energy-restricted diet”, “fat-restricted diet”, “sodium-restricted diet”, “diet in view of diabetes mellitus”, “diet in view of hypercholesterolemia”, “fibre-rich diet”, or “other”. Researchers are currently working on the validation of the FFQ. Before the dietary variables were entered in the models they were energy adjusted using the residual method [27].

Anthropometric measurements

Physical examinations were conducted by trained research nurses. Height was measured to the nearest 0.1 cm (SECA 222 stadiometer) and weight was measured to the nearest 0.1 kg (SECA 761 scale). WC was measured twice (SECA 200 tape), to the nearest 0.1 cm. Participants did not wear shoes or heavy clothing [28]. BMI was calculated as weight (kilograms)/height (meters)^2. Abdominal overweight was defined as WC ≥102cm (men) or ≥88cm (women). Overweight and obesity were defined as 25-30 kg/m^2 and ≥30 kg/m^2, respectively [29]. Although LCS also collects prospective information on body weight and waist circumference, these data were not available yet at the time of the current study.

Non-dietary covariates

Data on demographics (age, sex), education (primary, secondary, higher, other), smoking including use of cigarettes, cigarillos, cigars and pipe tobacco (current, former, never), physical activity (a physically active lifestyle was based on the question ‘being active for at least half an hour a day’) [30], ethanol consumption (none, 1-9g/d, 10-19g/d, ≥20g/d), self-reported history and prevalence of hypertension, hypercholesterolemia, and type 2 diabetes, and family history of diseases were collected using questionnaires.

Statistical analyses

Participant characteristics are reported as mean with standard deviation (SD), *n* with percentages, or medians with interquartile range (IQR). Associations between dairy and overweight categories were explored using logistic (WC-defined abdominal overweight, no/yes) and multinomial logistic regression analyses (BMI-defined normal weight (reference), overweight, obesity), resulting in Odds Ratios (ORs) with 95% confidence intervals (95%CI). Dairy intakes were categorized in quintiles using the lowest category as the reference group. Multiple linear regression analyses were conducted to assess associations between dairy intakes and continuous measures of body weight (i.e. BMI and WC), reporting β±SEs. Residuals of BMI and WC were normally distributed. All analyses were adjusted for age, sex (model 1) + alcohol, smoking, education, physical activity (model 2) + total energy intake [27], and the intake of energy adjusted bread, pasta, rice, potato, fruit, vegetables, legumes, meat, fish, coffee, tea, soda/fruit juice, other dairy groups [27], and following a weight loss diet (model 3). In addition, analyses were stratified for sex and age. Sensitivity analyses were conducted by excluding all participants reporting an energy intake lower than their basal metabolic rate (BMR), following a weight loss diet, and having a history of diabetes or high cholesterol. Analyses were performed using SPSS, version 22 (IBM SPSS Inc., Chicago, IL, USA). A two-sided p-value≤0.05 was considered statistically significant.

Results

Population characteristics are presented by quintiles of total dairy consumption showing a median total dairy intake of 319 (242) g/d and a mean±SD BMI of 25.7±4.1 kg/m^2 (**Table 2**).

Total dairy consumption

Age-and sex adjusted models showed positive associations between total dairy intake and the overweight categories (OR abdominal overweight Q1^{ref} vs Q5: 1.05; 95% CI: 1.01-1.10), which became stronger after adjustment for lifestyle factors (OR abdominal overweight Q1^{ref} vs Q5: 1.11; 95% CI: 1.06-1.16). Additional adjustment for dietary factors did not substantially alter the strength of the associations between total dairy intake and abdominal overweight (OR Q1^{ref} vs Q5: 1.09; 95% CI: 1.04, 1.14), BMI-defined overweight (OR Q1^{ref} vs Q5: 1.13; 95% CI: 1.08, 1.18) and BMI-defined obesity (Q1^{ref} vs Q5: 1.09; 95% CI: 1.02, 1.16) (**Table 3**).

Dairy subclasses based on fat-content and being fermented or not

Age-and sex adjusted models showed positive associations for semi-skimmed dairy intake and the overweight categories (OR abdominal overweight Q1^{ref} vs. Q5: 1.17; 95% CI: 1.12, 1.22), but not for skimmed dairy intake (OR abdominal overweight Q1^{ref} vs. Q5: 1.00; 95% CI: 0.96, 1.04). After further adjustment, the association for skimmed dairy intake did reach significance and the association for semi-skimmed dairy intake became stronger (ORs semi-skimmed dairy Q1^{ref} vs. Q5: 1.24; 95% CI: 1.19, 1.30 for abdominal overweight, 1.25; 95% CI: 1.20, 1.31 for BMI-defined overweight, and 1.42; 95% CI: 1.33, 1.51 for BMI-defined obesity (model 3)). Full-fat dairy intake was inversely associated with abdominal overweight showing a 16% (Q5, model 1), 18% (Q5, model 2), and 14% (Q5, model 3) lower odds for abdominal overweight. This association was stronger for full-fat fermented dairy intake than for full-fat non-fermented dairy intake. Furthermore, after full-adjustment a 15%, and 22% lower odds for BMI-defined overweight and obesity was observed in the upper quintiles of full-fat dairy intake. Age-and sex adjusted models showed inverse associations for non-fermented dairy intake and overweight categories (OR abdominal overweight Q1^{ref} vs. Q5: 0.97; 95% CI: 0.96, 0.98), which became positive after adjustment for lifestyle factors (OR abdominal overweight Q1^{ref} vs. Q5: 1.11; 95% CI: 1.06, 1.16). Fully-adjusted models remained statistically significant, showing 11%, 10% and 19% higher odds of abdominal overweight, and BMI-defined overweight and obesity in the upper quintiles of non-fermented dairy intake. No consistent associations were observed between fermented

dairy intake and abdominal overweight (OR $Q1^{ref}$ vs. Q5: 1.02; 95% CI: 0.97, 1.07), BMI-defined overweight (OR $Q1^{ref}$ vs. Q5: 1.11; 95% CI: 1.06, 1.16) and obesity (OR $Q1^{ref}$ vs. Q5: 0.98; 95% CI: 0.92, 1.05) (model 3). Linear regression data supported the results of the logistic regression analyses (**Table 4**). Moreover, associations were generally in the same direction for men and women and different age-categories, but the strength of the effect estimates was variable. For instance, trends for fermented dairy products with BMI-defined overweight and obesity were stronger in women than in men. Trends for total, skimmed, full-fat, and non-fermented dairy intake with abdominal overweight were stronger in women as well. Hence, most of the interaction terms were statistically significant (**Supplemental Tables 1-4**).

Specific dairy product groups

Significant fully-adjusted inverse associations were shown of yogurt and custard, and positive associations of milk, buttermilk, flavoured yogurt drinks, and cheese, with the overweight categories. Sex-stratified analyses suggested differences for some fermented products, which were most prominent for cheese, curd cheese, and flavoured yogurt drinks (**Supplemental Tables 1-3**).

Sensitivity analyses

Excluding potential underreporters (**Supplemental Table 5)**, those following a weight loss diet (**Supplemental Table 6**), having a history of diabetes or high cholesterol (data not shown) generated results that were comparable to the results of the total population.

Discussion

In our study, intakes of total, skimmed, semi-skimmed, and non-fermented dairy, and milk were positively associated with overweight categories. Moreover, full-fat dairy and custard were inversely associated with overweight categories. While fermented dairy intake and overweight categories were not associated, an inverse association was observed for yogurt and positive associations for buttermilk, flavoured yogurt drinks, total cheese, and cheese snacks.

Several other studies investigated the link between dairy intake and overweight as well [3-22]. So far, randomized controlled trials (RCTs) have not provided convincing evidence on the role of dairy consumption in reducing overweight [3]. However, modest effects of dairy consumption on body weight and fat loss have been observed in short-term RCTs and energy-restricted RCTs [3]. In a review of observational studies, 11 out of 16 studies showed inverse associations between dairy fat and/or high-fat dairy intakes and body weight or weight gain, where no associations were observed in 5 other studies [23]. In addition, low-fat dairy intakes were positively associated with weight gain in 4 studies, while none of the studies showed inverse associations for low-fat dairy. Thus, our finding that full-fat dairy is inversely associated with overweight categories - and vice versa for skimmed and semi-skimmed dairy - is in line with previous studies. Although these associations may be true linkages, they may also reflect reverse causation. To further investigate this issue, we excluded potential underreporters, and stratified the data according to BMI categories. However, this did not substantially alter the associations and hence did not confirm our hypothesis on reverse causation. The positive association between skimmed dairy intakes and overweight categories may be explained by a relatively large contribution of flavoured yogurt drinks (45%) - i.e. yogurt-based dairy beverages (0.2g fat) with e.g. raspberry flavour - to the total skimmed dairy intake. Literature suggests that the association between higher full-fat dairy intakes and lower odds of overweight categories may be explained by potential benefits of specific dairy fats, such as *cis* and *trans* palmitoleic acid (by affecting lipogenesis and fat oxidation), butyric acid (by effects on energy expenditure and gut health), and phytanic acid (by stimulating adipogenesis and energy homeostasis) [23]. Though, comparing low and high-fat dairy intake has its challenges. For instance, each specific dairy product has its own cut-off point for being skimmed, semi-skimmed or full-fat. As such, full-fat milk, yogurt, and cheese are all categorized as full-fat dairy, while the actual fat content of regular-fat cheese is much higher than the fat content of full-fat milk and yogurt. Moreover, specific dairy products classified in a specific fat-

category probably also exert effects independent of their fat content. These aspects highlight why additional studies on the impact of individual dairy products in relation to various health outcomes, including overweight, are warranted.

Up to now, a limited number of studies conducted detailed analyses on specific dairy subgroups, including milk, yogurt, and cheese [23]. Cross-sectional studies on milk intake and overweight showed no [14] or inverse associations [10, 13, 16]. Moreover, no association between milk consumption and change in body weight variables was observed among 1 124 Dutch adults over 6.4-years [21], while milk was associated with 6-y changes in weight (Q1 vs Q4: 2.47±0.32 vs 0.98±0.40, *P* for trend 0.02) and WC (Q1 vs Q4: 1.85±0.39 vs -0.08±0.48, *P* for trend 0.02) among 2 267 middle-aged French overweight men participating in SU.VI.MAX [22]. In contrast, we observed a positive association between milk consumption - predominantly semi-skimmed milk - and overweight categories. We do not have a clear-cut explanation for this finding.

Concerning fermented products, we observed a significant inverse association between yogurt consumption and overweight categories. In agreement, the Korean KNHANES study observed an inverse association between yogurt consumption and obesity, OR $^{\text{none [ref] vs. ≥1 time/day}}$: 0.77; 95% CI 0.59, 1.00, *P* for trend 0.01 [16]. Yogurt consumption was also inversely associated with weight gain among 120 877 U.S. adults, specifically -0.37 kg per serving/day, P<0.001 [17]. In line, yogurt was prospectively associated with weight change in French normal-weight women, Q1 vs. Q4: 1.34±0.25 vs. 2.05±0.27kg, P=0.04 [22]. Conversely, yogurt was not cross-sectionally or prospectively associated with BMI or WC among Dutch older adults in the Hoorn Study [14, 21]. A recent meta-analyses concluded that each serving increase in yogurt is associated with a decrease in body weight (β -41 gram/year; 95% CI: -48,-34) [31]. Mechanistically, this decrease in body weight has been related to various body processes. Yogurt consumption has been shown to affect colonic microbiota [32], where recent studies observed differences in composition and gut microbiota metabolic activity of lean and obese participants [33, 34]. Furthermore, the high protein and calcium content - as well as the texture - of yogurt may regulate appetite and satiety and hence prevent weight gain [34, 35]. Moreover, higher intakes of yogurt may prevent the intake of less healthy snacks [34].

For fermented dairy products, we also observed a positive association of total cheese and cheese snack consumption with overweight categories. The Hoorn study showed a positive association

between cheese and BMI (β 0.15±0.08, P=0.04), but not WC (0.14±0.21, P=0.50) [14]. However, this association could not be confirmed in prospective analyses within this population [21]. Also no association between cheese and weight-change was observed among French adults [22]. Cheese was inversely associated with weight gain among almost 20 000 Swedish women participating in the Swedish Mammography Cohort having a constant intake of ≥1 serving/day, OR 0.70 (95% CI: 0.59, 0.84) [20]. Conversely, a recent meta-analyses shows an increase in body weight for each serving increase of cheese (β -11 gram/year; 95% CI: 3,19) [31], which is in line with our observation for total cheese. Dutch inhabitants predominately eat cheese on bread. Nevertheless, cheese is also a frequently consumed snack. We showed that the associations observed for total cheese were predominantly driven by cheese consumed as a snack. Our data also showed that men had higher rates of overweight categories and obesity with higher cheese intakes, while no such associations were observed in women. As the average cheese snack consumption was about equal in men and women, the underlying reason for this difference remains to be elucidated.

Thus, we examined associations between a much broader range of dairy products and measured body weight than most other observational studies conducted to date. Moreover, the exceptionally large sample size provided the opportunity to include many potential (dietary) covariates and to conduct well-powered stratified analyses. The most important drawback of our study is its cross-sectional design. It also has to be mentioned that the FFQ is not validated for dairy product consumption. Moreover, we did not have information on the consumption of whole grains and refined grains and therefore it was not possible to adjust for total fibre intake.

Concluding, data of the Lifelines Cohort Study show significant inverse and positive associations between dairy intake and overweight categories. Future large scale prospective studies are warranted to verify these findings.

Acknowledgements

The authors acknowledge the services of the LCS, contributing research centres, and all study participants.

Competing interest statement: CSP is an employee of FrieslandCampina. The other authors declared no conflict of interest.

Funding: This work was supported by a grant from FrieslandCampina.

References

[1] Astrup A, Chaput JP, Gilbert JA, Lorenzen JK. Dairy beverages and energy balance. Physiol Behav. 2010;100:67-75.

[2] Romaguera D, Angquist L, Du H, Jakobsen MU, Forouhi NG, Halkjaer J, et al. Dietary determinants of changes in waist circumference adjusted for body mass index - a proxy measure of visceral adiposity. PLoS One. 2010;5:e11588.

[3] Chen M, Pan A, Malik VS, Hu FB. Effects of dairy intake on body weight and fat: a meta-analysis of randomized controlled trials. Am J Clin Nutr. 2012;96:735-47.

[4] Azadbakht L, Esmaillzadeh A. Dietary and non-dietary determinants of central adiposity among Tehrani women. Public Health Nutr. 2008;11:528-34.

[5] Azadbakht L, Mirmiran P, Esmaillzadeh A, Azizi F. Dairy consumption is inversely associated with the prevalence of the metabolic syndrome in Tehranian adults. Am J Clin Nutr. 2005;82:523-30.

[6] Brooks BM, Rajeshwari R, Nicklas TA, Yang SJ, Berenson GS. Association of calcium intake, dairy product consumption with overweight status in young adults (1995-1996): the Bogalusa Heart Study. J Am Coll Nutr. 2006;25:523-32.

[7] Dicker D, Belnic Y, Goldsmith R, Kaluski DN. Relationship between dietary calcium intake, body mass index, and waist circumference in MABAT--the Israeli National Health and Nutrition Study. Isr Med Assoc J. 2008;10:512-5.

[8] Heiss CJ, Shaw SE, Carothers L. Association of calcium intake and adiposity in postmenopausal women. J Am Coll Nutr. 2008;27:260-6.

[9] Lawlor DA, Ebrahim S, Timpson N, Davey Smith G. Avoiding milk is associated with a reduced risk of insulin resistance and the metabolic syndrome: findings from the British Women's Heart and Health Study. Diabet Med. 2005;22:808-11.

[10] Marques-Vidal P, Goncalves A, Dias CM. Milk intake is inversely related to obesity in men and in young women: data from the Portuguese Health Interview Survey 1998-1999. Int J Obes (Lond). 2006;30:88-93.

[11] Mirmiran P, Esmaillzadeh A, Azizi F. Dairy consumption and body mass index: an inverse relationship. Int J Obes (Lond). 2005;29:115-21.

[12] Murakami K, Okubo H, Sasaki S. No relation between intakes of calcium and dairy products and body mass index in Japanese women aged 18 to 20 y. Nutrition. 2006;22:490-5.

[13] Satija A, Taylor FC, Khurana S, Tripathy V, Khandpur N, Bowen L, et al. Differences in consumption of food items between obese and normal-weight people in India. Natl Med J India. 2012;25:10-3.

[14] Snijder MB, van der Heijden AA, van Dam RM, Stehouwer CD, Hiddink GJ, Nijpels G, et al. Is higher dairy consumption associated with lower body weight and fewer metabolic disturbances? The Hoorn Study. Am J Clin Nutr. 2007;85:989-95.

[15] Varenna M, Binelli L, Casari S, Zucchi F, Sinigaglia L. Effects of dietary calcium intake on body weight and prevalence of osteoporosis in early postmenopausal women. Am J Clin Nutr. 2007;86:639-44.

[16] Lee HJ, Cho JI, Lee HS, Kim CI, Cho E. Intakes of dairy products and calcium and obesity in Korean adults: Korean National Health and Nutrition Examination Surveys (KNHANES) 2007-2009. PLoS One. 2014;9:e99085.

[17] Mozaffarian D, Hao T, Rimm EB, Willett WC, Hu FB. Changes in diet and lifestyle and long-term weight gain in women and men. N Engl J Med. 2011;364:2392-404.

[18] Pereira MA, Jacobs DR, Jr., Van Horn L, Slattery ML, Kartashov AI, Ludwig DS. Dairy consumption, obesity, and the insulin resistance syndrome in young adults: the CARDIA Study. JAMA. 2002;287:2081-9.

[19] Rajpathak SN, Rimm EB, Rosner B, Willett WC, Hu FB. Calcium and dairy intakes in relation to long-term weight gain in US men. Am J Clin Nutr. 2006;83:559-66.

[20] Rosell M, Hakansson NN, Wolk A. Association between dairy food consumption and weight change over 9 y in 19,352 perimenopausal women. Am J Clin Nutr. 2006;84:1481-8.

[21] Snijder MB, van Dam RM, Stehouwer CD, Hiddink GJ, Heine RJ, Dekker JM. A prospective study of dairy consumption in relation to changes in metabolic risk factors: the Hoorn Study. Obesity. 2008;16:706-9.

[22] Vergnaud AC, Peneau S, Chat-Yung S, Kesse E, Czernichow S, Galan P, et al. Dairy consumption and 6-y changes in body weight and waist circumference in middle-aged French adults. Am J Clin Nutr. 2008;88:1248-55.

[23] Kratz M, Baars T, Guyenet S. The relationship between high-fat dairy consumption and obesity, cardiovascular, and metabolic disease. Eur J Nutr. 2013;52:1-24.

[24] Scholtens S, Smidt N, Swertz MA, Bakker SJ, Dotinga A, Vonk JM, et al. Cohort Profile: LifeLines, a three-generation cohort study and biobank. Int J Epidemiol. 2014.

[25] Brouwer-Brolsma E, Streppel M, van Lee L, Geelen A, Sluik D, van de Wiel A, et al. A National Dietary Assessment Reference Database (NDARD) for the Dutch Population: Rationale behind the Design. Nutrients. 2017;9:1136.

[26] NEVO. NEVO-tabel: Nederlands Voedingsstoffenbestand 2011. Den Haag: Voedingscentrum; 2011.

[27] Willett WC, Howe GR, Kushi LH. Adjustment for total energy intake in epidemiologic studies. Am J Clin Nutr. 1997;65:1220S-8S; discussion 9S-31S.

[28] Klaver EI, van Loon HC, Stienstra R, Links TP, Keers JC, Kema IP, et al. Thyroid hormone status and health-related quality of life in the LifeLines Cohort Study. Thyroid. 2013;23:1066-73.

[29] WHO. BMI classification. World Health Organization; 2018.

[30] Wendel-Vos GC, Schuit AJ, Saris WH, Kromhout D. Reproducibility and relative validity of the short questionnaire to assess health-enhancing physical activity. J Clin Epidemiol. 2003;56:1163-9.

[31] Schwingshackl L, Hoffmann G, Schwedhelm C, Kalle-Uhlmann T, Missbach B, Knuppel S, et al. Consumption of Dairy Products in Relation to Changes in Anthropometric Variables in Adult Populations: A Systematic Review and Meta-Analysis of Cohort Studies. PLoS One. 2016;11:e0157461.

[32] He T, Priebe MG, Zhong Y, Huang C, Harmsen HJ, Raangs GC, et al. Effects of yogurt and bifidobacteria supplementation on the colonic microbiota in lactose-intolerant subjects. J Appl Microbiol. 2008;104:595-604.
[33] Conterno L, Fava F, Viola R, Tuohy KM. Obesity and the gut microbiota: does up-regulating colonic fermentation protect against obesity and metabolic disease? Genes Nutr. 2011;6:241-60.
[34] Tremblay A, Doyon C, Sanchez M. Impact of yogurt on appetite control, energy balance, and body composition. Nutr Rev. 2015;73 Suppl 1:23-7.
[35] Hogenkamp PS, Stafleu A, Mars M, Brunstrom JM, de Graaf C. Texture, not flavor, determines expected satiation of dairy products. Appetite. 2011;57:635-41.

Table 1 Dairy product group classification

Dairy product group	*Included dairy products*
Total dairy	All dairy products except butter: skimmed (24%), semi-skimmed (24%), full-fat (25%). For 27% of the dairy products data was not specific enough to classify according to fat content.
Skimmed dairy	All types skimmed milk (4%) and yogurt (27%), buttermilk (24%), and flavoured yogurt drinks (45%).
Semi-skimmed dairy	All types semi-skimmed milk (74%) and low-fat cheeses (26%).
Full-fat dairy	All types of full-fat milk (23%), yogurt (7%), regular-fat cheese (43%), cream (3%), milk-based ice cream (12%), chocolate milk (12%).
Fermented dairy	All types of yogurt (22%), curd cheese/quark (10%), buttermilk (15%), cheese (34%), and flavoured yogurt drinks (19%).
Non-fermented dairy	All types of milk (73%), custard (9%), porridge (3%), milk-based ice cream (11%), and cream (4%).
Full-fat fermented dairy	All types of full-fat yogurt and regular-fat cheese.
Full-fat non-fermented dairy	All types of full-fat milk, cream, and milk-based ice-cream.
Milk	All types of milk, including plain milk (63%), coffee milk (25%), and chocolate milk (12%).
Yogurt	All types of yogurt.
Buttermilk	All types of buttermilk.
Curd cheese/quark	All types of curd cheese/quark.
Flavoured yogurt drinks	All types of flavoured yogurt drinks.
Custard	All types of custard.
Cheese	All types of cheese, including Dutch cheeses (soft and hard cheeses) (68%) and other cheeses (i.e. cream cheese, foreign cheeses, cheese snack) (32%).
Dutch cheese	All types of Dutch (yellow) cheeses.

The percentage (%) in the second column refers to the contribution of the specific dairy product in the associated category

Table 2. Baseline characteristics of 114 682 men and women ≥18 years, displayed across quintiles of total dairy consumption.

	n	Total population	**Q1** <197	**Q2** 197-282	**Q3** 283-367	**Q4** 368-479	**Q5** >480	*P*
n		114 682						
Total dairy intake, g/day	114 682	319 (242)	137 (95)	223 (84)	312 (76)	409 (97)	582 (192)	<0.0001
Age, years	114 682	45±13	42±12	44±13	46±13	46±13	47 ±13	<0.0001
Men, %	114 682	41	53	41	39	36	38	<0.0001
Smoking, %	114 417							<0.0001
Never		32	30	33	33	33	32	
Former		47	41	45	48	50	52	
Current		21	29	22	19	17	16	
Education, %	114 223							<0.0001
Primary		2	2	2	2	3	2	
Secondary		57	56	54	56	57	60	
Higher		39	40	42	40	38	36	
Other		2	2	2	2	2	2	
Moderate intensity physical activity, days/week	106 563	5 (7)	4 (6)	5 (6)	5 (7)	5 (7)	6 (8)	<0.0001
Alcohol intake, %	114 682							<0.0001
0 g/day		2	2	2	2	3	3	
1-9 g/day		71	61	69	73	75	77	
10-19 g/day		19	23	21	19	17	15	
≥20 g/day		8	14	8	6	5	5	
BMI, kg/m^2	114 658	25.7±4.1	25.5±4.2	25.6±4.0	25.7±4.0	25.8±4 .0	26.0±4.1	<0.0001
Waist circumference	114 658	89±12	89±12	89±12	89±12	89±12	90±12	<0.0001
Hypertension, %	114 518	21	18	20	22	23	23	<0.0001
Hypercholesterolemia, %	114 520	13	12	13	13	14	14	<0.0001
Type 2 diabetes, %	114 682	2	1	2	2	2	2	<0.0001
Fasting plasma glucose, mmol/L	111 844	5.0±0.8	5.0±0.8	5.0±0.8	5.0±0. 8	5.0±0.8	5.0±0.9	<0 .0001
%HbA1c	113 432	5.5±0.4	5.5±0.4	5.5±0.4	5.6±0.4	5.6±0.4	5.6±0.5	<0. 0001
Creatinine, μmol/L	114 124	73±13	75±13	73±14	73±13	73±14	73±13	<0.0001
Total cholesterol, mmol/L	114 123	5.1±1.0	5.1±1.0	5.1±1.0	5.1±1.0	5.1±1.0	5.1±1.0	<0.0001
LDL-cholesterol	114 115	3.2±0.9	3.2±0.9	3.2±0.9	3.2 ±0.9	3.2±0.9	3.2±0.9	0.01
HDL-cholesterol, mmol/L	114 123	1.5±0.4	1.5±0.4	1.5±0.4	1.5±0.4	1.5±0.4	1.5±0.4	<0.0001
Triglycerides, mmol/L	114 123	1.0 (0.7)	1.0 (0.7)	1.0 (0.7)	1.0 (0.6)	1.0 (0.7)	1.0 (0.7)	<0.0001
Energy intake, kcal/day	114 682	2139±549	2277±596	2074±527	2070±505	2088±515	2189±566	<0.0001
Total fat, En%	114 682	36±5	37±5	36±5	36±5	35±5	34± 5	<0.0001
Protein, En%	114 682	15±2	13±2	14±2	15±2	15±2	16±2	<0.0001
Carbohydrates, En%	114 682	45±5	45±6	45±6	45±5	45±5	45±5	<0.0001
Fruits, g/day	114 682	110 (178)	85 (186)	110 (178)	110 (178)	127 (144)	152 (144)	<0.0001
Vegetables, g/day	114 682	108 (75)	108 (87)	108 (51)	108 (50)	109 (74)	109 (75)	<0.0001
Legumes, g/day	114 682	12 (29)	13 (34)	11 (29)	12 (29)	12 (29)	13 (29)	<0.0001
Bread, g/day	114 682	136 (73)	147 (90)	136 (72)	134 (69)	134 (67)	133 (69)	<0.0001
Meat, g/day	114 682	78 (40)	85 (46)	77 (39)	77 (38)	76 (38)	75 (41)	<0.0001
Pasta, g/day	114 682	19 (20)	19 (19)	19 (19)	19 (20)	19 (19)	19 (20)	<0.0001
Rice, g/day	114 682	16 (22)	20 (22)	16 (22)	16 (17)	16 (16)	16 (16)	<0.0001
Potatoes, g/day	114 682	93 (63)	89 (71)	88 (61)	91 (59)	93 (60)	93 (61)	<0.0001
Fish, g/day	114 682	11 (12)	11 (13)	11 (12)	11 (12)	11 (12)	11 (12)	0.05
Coffee, g/day	114 682	465 (348)	402 (420)	465 (348)	465 (348)	465 (348)	465 (348)	<0.0001
Tea, g/day	114 682	232 (304)	161 (326)	232 (304)	232 (268)	232 (268)	232 (304)	<0.0001
Soda and fruit juice, g/day	114 682	95 (180)	132 (246)	96 (177)	83 (166)	74 (156)	74 (160)	<0.0001
Current weight loss diet, %	113 982	5	3	4	5	5	6	<0.0001

Differences between groups BMI categories are investigated using ANOVA in case of normally distributed continuous variables, Kruskal-Wallis in case of skewed continuous variables, and chi-square tests in case of categorical variables. Values are expressed as mean±SD, median (IQR), or %.

Table 3. Odds Ratios for dairy consumption, abdominal overweight[1,2], overweight[3], and obesity[3] in the Lifelines study[4].

		Abdominal overweight (n=105 302)			BMI ≥25 kg/m^2 (n=105 280)			BMI ≥30 kg/m^2 (n=105 280)		
Gram/day		Cases, n (%)	OR	*95%CI*	Cases, n (%)	OR	*95%CI*	Cases, n (%)	OR	*95%CI*
Total dairy										
Q1	<197	5963 (28)	1	(ref)	7877 (37)	1	(ref)	2752 (13)	1	(ref)
Q2	197-282	6586 (31)	1.02	0.97-1.06	8173 (39)	1.06	1.01-1.11	2672 (13)	0.99	0.93-1.06
Q3	283-367	6910 (33)	0.99	0.94-1.04	8223 (39)	1.03	0.98-1.08	2674 (13)	0.93	0.87-0.99
Q4	368-479	7349 (35)	1.03	0.99-1.08	8314 (39)	1.08	1.03-1.13	2842 (14)	0.99	0.93-1.06
Q5	≥480	7543 (36)	1.09	1.04-1.14	8370 (40)	1.13	1.08-1.18	3030 (15)	1.09	1.02-1.16
P for trend				<0.0001			<0.0001			0.004
Skimmed dairy										
Q1	<4	6188 (30)	1	(ref)	8244 (40)	1	(ref)	2783 (13)	1	(ref)
Q2	4-31	6717 (32)	1.04	0.99-1.08	7772 (37)	1.06	1.02-1.11	2720 (13)	1.08	1.01-1.15
Q3	32-79	7017 (33)	1.11	1.06-1.17	8113 (38)	1.14	1.09-1.19	2894 (14)	1.16	1.09-1.24
Q4	80-150	7041 (33)	1.07	1.02-1.12	8375 (40)	1.16	1.11-1.21	2758 (13)	1.10	1.03-1.17
Q5	≥151	7388 (35)	1.09	1.04-1.14	8453 (40)	1.16	1.11-1.21	2815 (13)	1.09	1.03-1.17
P for trend				0.005			<0.0001			0.13
Semi-skimmed dairy										
Q1	<9	5856 (28)	1	(ref)	7889 (38)	1	(ref)	2599 (13)	1	(ref)
Q2	9-31	7056 (33)	1.08	1.03-1.14	8121 (38)	1.15	1.10-1.20	2580 (12)	1.10	1.02-1.18
Q3	32-79	7183 (34)	1.09	1.04-1.15	8242 (39)	1.18	1.13-1.24	2761 (13)	1.17	1.09-1.25
Q4	80-163	7078 (34)	1.15	1.10-1.20	8364 (40)	1.19	1.14-1.25	2877 (14)	1.24	1.16-1.32
Q5	≥164	7178 (34)	1.24	1.19-1.30	8341 (40)	1.25	1.20-1.31	3153 (15)	1.42	1.33-1.51
P for trend				<0.0001			<0.0001			<0.0001
Full-fat dairy										
Q1	<30	6012 (29)	1	(ref)	8275 (40)	1	(ref)	2887 (14)	1	(ref)
Q2	30-49	7032 (33)	1.00	0.95-1.04	8219 (39)	1.03	0.98-1.08	2904 (14)	1.01	0.95-1.08
Q3	50-69	7183 (34)	0.95	0.91-0.99	8308 (39)	0.99	0.94-1.03	2741 (13)	0.90	0.85-0.97
Q4	70-104	7409 (35)	0.94	0.90-0.99	8284 (39)	0.94	0.90-0.98	2786 (13)	0.87	0.81-0.93
Q5	≥105	6715 (32)	0.86	0.82-0.90	7871 (38)	0.85	0.81-0.89	2652 (13)	0.78	0.73-0.83
P for trend				<0.0001			<0.0001			<0.0001
Fermented dairy										
Q1	<53	6088 (29)	1	(ref)	8076 (38)	1	(ref)	1	(ref)	1
Q2	53-96	6683 (32)	1.06	1.02-1.11	8140 (39)	1.10	1.05-1.15	2852 (14)	1.10	1.03-1.17
Q3	97-149	6870 (33)	1.04	0.99-1.09	8154 (39)	1.09	1.04-1.14	2710 (13)	1.01	0.95-1.08
Q4	150-228	7251 (34)	1.03	0.99-1.08	8216 (39)	1.09	1.04-1.14	2836 (13)	1.03	0.97-1.10
Q5	≥228	7459 (36)	1.02	0.97-1.07	8371 (40)	1.11	1.06-1.16	2767 (13)	0.98	0.92-1.05
P for trend				0.80			0.001			0.08
Non-fermented dairy										
Q1	<49	6276 (30)	1	(ref)	8139 (39)	1	(ref)	2700 (13)	1	(ref)
Q2	49-96	6838 (32)	0.94	0.90-0.99	8064 (38)	0.99	0.95-1.04	2598 (12)	0.94	0.88-1.00
Q3	97-160	6970 (33)	1.02	0.97-1.06	8176 (39)	1.02	0.98-1.07	2734 (13)	1.01	0.95-1.08
Q4	161-260	7152 (34)	1.03	0.99-1.08	8321 (40)	1.05	1.00-1.09	2874 (14)	1.05	0.99-1.13
Q5	≥261	7115 (34)	1.11	1.06-1.16	8257 (40)	1.10	1.05-1.15	3064 (15)	1.19	1.11-1.27
P for trend				<0.0001			<0.0001			<0.0001
Full-fat fermented dairy										
Q1	<5	6221 (30)	1	(ref)	8499 (41)	1	(ref)	3009 (14)	1	(ref)
Q2	5-11	7542 (36)	1.05	1.01-1.11	8511 (40)	1.11	1.06-1.16	3037 (14)	1.07	1.00-1.14
Q3	12-21	7242 (34)	1.00	0.95-1.04	8102 (38)	0.99	0.95-1.04	2809 (13)	0.96	0.90-1.02
Q4	22-41	6950 (33)	0.92	0.88-0.97	8085 (38)	0.91	0.87-0.95	2723 (13)	0.87	0.82-0.93
Q5	≥42	6396 (31)	0.81	0.78-0.85	7760 (37)	0.80	0.76-0.83	2392 (12)	0.70	0.65-0.74
P for trend				<0.0001			<0.0001			<0.0001
Full-fat non-fermented dairy										
Q1	<3	5934 (29)	1	(ref)	8040 (39)	1	(ref)	2976 (14)	1	(ref)
Q2	4-12	7045 (33)	1.02	0.97-1.07	8072 (38)	1.07	1.02-1.12	2944 (13)	0.77	0.72-0.82
Q3	13-22	7054 (33)	0.90	0.86-0.95	7973 (38)	0.99	0.94-1.04	2536 (12)	0.70	0.66-0.75
Q4	23-42	7070 (33)	0.85	0.81-0.89	8516 (40)	0.96	0.91-1.00	2589 (12)	0.77	0.72-0.82
Q5	≥43	7248 (35)	0.89	0.85-0.94	8356 (40)	0.91	0.86-0.95	2925 (14)	1.01	0.94-1.08
P for trend				<0.0001			<0.0001			<0.0001
Milk										
Q1	<32	6147 (29)	1	(ref)	8177 (39)	1	(ref)	2644 (13)	1	(ref)
Q2	32-73	6959 (33)	1.00	0.96-1.05	8048 (38)	1.01	0.96-1.05	2631 (12)	1.00	0.94-1.07
Q3	74-136	6933 (33)	1.07	1.02-1.12	8218 (39)	1.06	1.01-1.11	2709 (13)	1.07	1.00-1.15
Q4	137-235	7195 (34)	1.10	1.05-1.15	8312 (39)	1.08	1.03-1.13	2884 (14)	1.14	1.07-1.21
Q5	≥236	7117 (34)	1.18	1.13-1.24	8202 (39)	1.14	1.08-1.19	3102 (15)	1.31	1.22-1.39
P for trend				<0.0001			<0.0001			<0.0001
Yogurt										
Q1	0	13691 (31)	1	(ref)	17013 (39)	1	(ref)	5760 (13)	1	(ref)

Q2	1-31	6575 (34)	1.14	1.09-1.18	7551 (39)	1.12	1.07-1.16	2824 (14)	1.21	1.14-1.28
Q3	32-64	7082 (34)	1.02	0.98-1.06	8293 (39)	1.06	1.02-1.10	2849 (14)	1.03	0.97-1.09
Q4	≥65	7003 (33)	0.94	0.90-0.98	8100 (38)	0.94	0.91-0.98	2537 (12)	0.83	0.79-0.88
Q5	-	-	-	-	-	-	-	-	-	-
P for trend				<0.0001			0.001			<0.0001
Buttermilk										
Q1	0	5410 (26)	1	(ref)	8265 (40)	1	(ref)	2736 (13)	1	(ref)
Q2	1	6658 (31)	1.12	1.06-1.18	8162 (39)	1.10	1.04-1.15	2926 (14)	1.26	1.17-1.35
Q3	2	7573 (36)	1.16	1.10-1.24	8027 (38)	1.20	1.13-1.27	2895 (14)	1.31	1.21-1.43
Q4	3-64	7143 (34)	1.04	0.98-1.10	8045 (38)	1.10	1.04-1.17	2610 (12)	1.09	1.01-1.18
Q5	≥65	7567 (36)	1.07	1.01-1.12	8458 (40)	1.10	1.04-1.15	2803 (13)	1.12	1.04-1.21
P for trend				0.28			0.83			0.10
Curd cheese										
Q1	0	5724 (28)	1	(ref)	8491 (41)	1	(ref)	2802 (14)	1	(ref)
Q2	1	7052 (33)	1.07	1.02-1.13	8454 (40)	1.05	1.00-1.10	2934 (14)	1.13	1.05-1.21
Q3	2-7	7528 (35)	0.99	0.94-1.05	7731 (36)	0.98	0.93-1.04	2696 (13)	0.96	0.89-1.04
Q4	8-27	7020 (33)	1.06	1.01-1.11	8234 (39)	1.11	1.06-1.16	2885 (14)	1.11	1.04-1.19
Q5	≥28	7027 (33)	0.96	0.91-1.01	8047 (38)	0.99	0.94-1.03	2653 (13)	0.92	0.86-0.98
P for trend				0.008			0.92			0.001
Custard										
Q1	0	9009 (30)	1	(ref)	12094 (40)	1	(ref)	4263 (14)	1	(ref)
Q2	1	4022 (34)	1.02	0.97-1.08	4502 (38)	1.01	0.96-1.07	1708 (15)	1.06	0.99-1.14
Q3	2-4	7756 (37)	1.01	0.96-1.06	8289 (39)	1.09	1.04-1.15	2910 (14)	1.01	0.94-1.08
Q4	5-26	8492 (34)	0.88	0.84-0.92	9409 (37)	0.96	0.92-1.00	3102 (12)	0.80	0.75-0.86
Q5	≥27	5072 (30)	0.85	0.81-0.89	6663 (39)	0.89	0.85-0.93	1987 (12)	0.73	0.68-0.78
P for trend				<0.0001			<0.0001			<0.0001
Flavoured yogurt drinks										
Q1	0	6432 (29)	1	(ref)	9070 (41)	1	(ref)	2974 (13)	1	(ref)
Q2	1-4	6855 (35)	1.09	1.04-1.14	7858 (40)	1.08	1.03-1.13	2802 (14)	1.19	1.12-1.28
Q3	5-11	7554 (36)	1.01	0.96-1.06	8052 (38)	1.08	1.03-1.14	2679 (13)	1.04	0.96-1.12
Q4	12-52	6478 (31)	1.09	1.03-1.14	7822 (37)	1.20	1.14-1.25	2682 (13)	1.21	1.13-1.30
Q5	≥53	7032 (34)	1.13	1.07-1.18	8155 (39)	1.24	1.18-1.30	2833 (14)	1.21	1.13-1.29
P for trend				<0.0001			<0.0001			<0.0001
Total cheese										
Q1	<12	5569 (27)	1	(ref)	7844 (38)	1	(ref)	2584 (12)	1	(ref)
Q2	12-20	6618 (31)	1.06	1.01-1.11	8047 (38)	1.08	1.03-1.13	2667 (13)	1.09	1.02-1.17
Q3	21-31	7260 (34)	1.10	1.05-1.15	8182 (39)	1.07	1.03-1.12	2844 (13)	1.15	1.07-1.22
Q4	32-46	7479 (35)	1.12	1.07-1.17	8381 (40)	1.08	1.03-1.13	2945 (14)	1.18	1.11-1.26
Q5	≥47	7425 (36)	1.08	1.03-1.14	8503 (41)	1.10	1.05-1.15	2930 (14)	1.16	1.08-1.23
P for trend				0.002			0.001			<0.0001
Dutch cheese										
Q1	<7	5677 (27)	1	(ref)	7907 (38)	1	(ref)	2599 (12)	1	(ref)
Q2	7-13	6693 (32)	1.04	1.00-1.10	7847 (37)	1.03	0.99-1.08	2727 (13)	1.09	1.02-1.17
Q3	14-21	7355 (34)	1.05	1.00-1.09	8417 (39)	1.05	1.01-1.10	2866 (13)	1.10	1.03-1.17
Q4	22-35	7124 (34)	1.04	1.00-1.10	8123 (39)	1.02	0.97-1.06	2782 (13)	1.07	1.00-1.14
Q5	≥36	7502 (36)	1.04	0.99-1.09	8663 (42)	1.06	1.01-1.11	2996 (14)	1.10	1.03-1.17
P for trend				0.21			0.06			0.08
Cheese snack										
Q1	<1	5246 (25)	1	(ref)	7854 (38)	1	(ref)	2497 (12)	1	(ref)
Q2	1-3	6466 (31)	1.03	0.98-1.08	7686 (36)	1.04	0.99-1.09	2457 (12)	1.01	0.95-1.09
Q3	3	6847 (32)	1.07	1.02-1.13	8124 (38)	1.11	1.06-1.16	2642 (13)	1.11	1.04-1.19
Q4	4-7	7587 (36)	1.21	1.15-1.27	8437 (40)	1.22	1.17-1.28	2994 (14)	1.35	1.26-1.44
Q5	≥7	8205 (39)	1.32	1.26-1.39	8856 (42)	1.30	1.24-1.36	3380 (16)	1.55	1.45-1.65
P for trend				<0.0001			<0.0001			<0.0001

[1,2] Abdominal overweight was defined as having waist ≥102cm for men and ≥88cm for women. The analyses on abdominal overweight were conducted using logistic regression analyses, where those who had no abdominal overweight served as the reference group. [3] The groups overweight and obesity are analysed using multinomial logistic regression analyses, where those with normal weight (BMI <25kg/m^2) served as the reference group. [4] Table shows fully adjusted models (i.e. adjusted for age (years, continuous), sex (men/women), alcohol (0, 1-9, 10-19, and ≥19 g/d), smoking (never, former, current), education (primary, secondary, higher, other), physical activity (moderate intensity exercise, days/week), total energy intake (kcal/day, continuous), and the intake of energy adjusted bread, pasta, rice, potato, fruit, vegetables, legumes, meat, fish, coffee, tea, soda/fruit juice, other dairy groups (g/day, continuous), and currently being on a weight loss diet).

Table 4. Associations between total dairy consumption (per 100 gram) and markers of body weight

	Model 1 (*n*=114 658)			Model 2 (*n*=105 906)			Model 3 (*n*=105 280)		
	β	SE	*P*	β	SE	*P*	β	SE	*P*
Waist circumference (cm)									
Total dairy	0.10	0.02	<0.0001	0.15	0.02	<0.0001	0.11	0.02	<0.0001
Skimmed dairy	0.01	0.03	0.78	0.12	0.03	<0.0001	0.09	0.03	0.001
Semi-skimmed dairy	0.42	0.03	<0.0001	0.44	0.03	<0.0001	0.38	0.03	<0.0001
Full-fat dairy	-0.39	0.04	<0.0001	-0.46	0.05	<0.0001	-0.40	0.05	<0.0001
Fermented dairy	-0.11	0.03	<0.0001	0.01	0.03	0.79	-0.01	0.03	0.70
Non-fermented dairy	0.26	0.02	<0.0001	0.26	0.02	<0.0001	0.22	0.02	<0.0001
Full-fat fermented dairy	-2.34	0.10	<0.0001	-2.20	0.10	<0.0001	-1.71	0.10	<0.0001
Full-fat non-fermented dairy	-0.20	0.06	0.001	-0.39	0.06	<0.0001	-0.44	0.06	<0.0001
Milk	0.29	0.02	<0.0001	0.29	0.02	<0.0001	0.26	0.02	<0.0001
Yogurt	-0.69	0.07	<0.0001	-0.43	0.07	<0.0001	-0.46	0.07	<0.0001
Buttermilk	-0.27	0.04	<0.0001	-0.08	0.04	0.06	0.01	0.04	0.74
Curd cheese	-0.74	0.12	<0.0001	-0.35	0.13	0.006	-0.60	0.12	<0.0001
Custard	-0.82	0.13	<0.0001	-1.00	0.13	<0.0001	-1.03	0.13	<0.0001
Flavoured yogurt drinks	0.42	0.05	<0.0001	0.34	0.05	<0.0001	0.25	0.05	<0.0001
Total cheese[1]	0.00	0.03	0.99	0.08	0.03	0.02	0.12	0.03	<0.0001
Dutch cheese[1]	-0.02	0.04	0.61	0.00	0.04	0.99	0.01	0.04	0.73
Cheese snack[1]	2.07	0.12	<0.0001	2.10	0.13	<0.0001	1.66	0.13	<0.0001
BMI, kg/m^2									
Total dairy	0.05	0.01	<0.0001	0.06	0.01	<0.0001	0.05	0.01	<0.0001
Skimmed dairy	0.04	0.01	0.001	0.06	0.01	<0.0001	0.05	0.01	<0.0001
Semi-skimmed dairy	0.17	0.01	<0.0001	0.17	0.01	<0.0001	0.15	0.01	<0.0001
Full-fat dairy	-0.23	0.02	<0.0001	-0.25	0.02	<0.0001	-0.19	0.02	<0.0001
Fermented dairy	-0.02	0.01	0.12	0.02	0.01	0.09	0.01	0.01	0.27
Non-fermented dairy	0.10	0.01	<0.0001	0.09	0.01	<0.0001	0.09	0.01	<0.0001
Full-fat fermented dairy	-1.00	0.04	<0.0001	-0.95	0.04	<0.0001	-0.72	0.04	<0.0001
Full-fat non-fermented dairy	-0.15	0.02	<0.0001	-0.22	0.02	<0.0001	-0.21	0.02	<0.0001
Milk	0.12	0.01	<0.0001	0.11	0.01	<0.0001	0.11	0.01	<0.0001
Yogurt	-0.22	0.03	<0.0001	-0.15	0.03	<0.0001	-0.18	0.03	<0.0001
Buttermilk	-0.08	0.02	<0.0001	-0.03	0.02	0.11	0.01	0.02	0.58
Curd cheese	-0.10	0.05	0.04	0.00	0.05	0.98	-0.12	0.05	0.007
Custard	-0.49	0.05	<0.0001	-0.60	0.05	<0.0001	-0.54	0.05	<0.0001
Flavoured yogurt drinks	0.17	0.02	<0.0001	0.14	0.02	<0.0001	0.11	0.02	<0.0001
Total cheese[1]	0.00	0.01	0.81	0.04	0.01	0.002	0.06	0.01	<0.0001
Dutch cheese[1]	0.00	0.01	0.80	0.01	0.01	0.48	0.02	0.01	0.24
Cheese snack[1]	0.68	0.05	<0.0001	0.77	0.05	<0.0001	0.63	0.05	<0.0001

[1]Note: for cheese the analyses are conducted per 25 gram intake. Model 1 was adjusted for age (years, continuous), and sex (men/women). Model 2 was adjusted for age (years, continuous), sex (men/women), alcohol (0, 1-9, 10-19, ≥19 g/d), smoking (never, former, current), education (primary, secondary, higher, other), and physical activity (moderate intensity exercise, days/week). Model 3 was adjusted for age (years, continuous), sex (men/women), alcohol (0, 1-9, 10-19, ≥19 g/d), smoking (never, former, current), education (primary, secondary, higher, other), physical activity (moderate intensity exercise, days/week), total energy intake (kcal/day, continuous), and the intake of energy adjusted bread, pasta, rice, potato, fruit, vegetables, legumes, meat, fish, coffee, tea, soda/fruit juice, other dairy groups (g/day, continuous), and currently being on a weight loss diet (no/yes).

Highlights

- Total, skimmed, and semi-skimmed dairy were positively associated with overweight.
- Non-fermented dairy was positively associated with overweight.
- Full-fat dairy, yogurt, and custard were inversely associated with overweight.
- Milk, buttermilk, yogurt drinks, and cheese positively associated with overweight.
- No associations were shown for fermented dairy, curd cheese, or Dutch cheese.