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RESEARCH ARTICLE

Cheese consumption and prevalence of overweight and obesity in a Basque adult population: a cross-sectional study

Iker Alegría-Lertxundi, Ana Rocandio Pablo, and Marta Arroyo-Izaga

Department of Pharmacy and Food Sciences, Faculty of Pharmacy, University of the Basque Country (UPV/EHU), Vitoria, Spain

Abstract

Studies have reported a negative association between dairy product consumption and weight status. However, not as much research has focused on cheese; therefore, the aim of this study was to study the association between cheese intake and overweight and obesity in a representative Basque adult population. A food frequency questionnaire (FFQ) was obtained from a random sample of 1081 adults (530 males and 551 females, 17–96 years old). Cheese consumption data were expressed as g/1000 kcal/day. The prevalence of overweight/obesity was higher in men (55.1%) than in women (35.4%) ($p < 0.001$). Participants with low or moderate intake of fresh and processed cheese demonstrated a higher prevalence of excess weight, compared with those with higher consumption. The confounding variables selected in multivariate analysis were occupational status and age in both genders; and place of residence in men. In conclusion, negative associations were found between consumption of some types of cheese and overweight and obesity in this population.

Keywords

Cheese, food consumption frequency, obesity, overweight

History

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Introduction

The prevalence of obesity in developed countries has increased at an alarming rate with the associated complications placing a substantial burden on healthcare costs (Sicras-Mainar et al., 2012). Obesity, however, is a complex issue and thus a wide range of strategies are required to tackle the problem. The potential for the involvement of particular aspects of the diet in preventing obesity has been considered.

With regard to diet, dairy foods such as cheeses make up a considerable part of the Western diet; nevertheless, the effects of these foods on preventing obesity are not clear. Dairy food represents an important source of saturated fat, which is a risk factor for obesity, cardiovascular disease and type 2 diabetes (Mann, 2002). The common perception that the consumption of dairy foods, particularly of the non-reduced fat options, leads to excessive weight gain has led to a number of recent studies exploring the association between the intake of dairy foods and body weight and/or body mass index (BMI, in kg/m^2). BMI is widely used as an indirect measure of fatness (Center for Disease Control and Prevention, 2009); although its accuracy as an assessment of adiposity has been called into question, correlation between BMI and body fat percentage is good overall (Romero-Corral et al., 2008). Contrary to expectations, it has been suggested that the consumption of dairy foods plays a beneficial role in the regulation of body weight (Zemel, 2004).

Negative associations between consumption of dairy products or calcium and body weight or obesity have been observed in several cross-sectional (Marques-Vidal et al., 2006; Mirmiran et al., 2005; Rosell et al., 2004) and longitudinal studies in adults (Davies et al., 2000; Fumeron et al., 2011; Pereira et al., 2002). Various components of dairy foods, such as calcium (through its effects on intracellular calcium), other minerals (potassium, magnesium), or the insulinotropic effects of whey proteins may be responsible for these potential beneficial effects (McCarty, 2005; Nilsson et al., 2004; Tremblay & Gilbert, 2011).

However, the beneficial effect of dairy consumption is not supported by all studies (Barba & Russo, 2006; Rajpathak et al., 2006) possibly due to differences in study populations, study design and methodology (dietary consumption, including the types of dairy products). Whereas many studies have focused on dairy consumption, fewer have assessed the relationship between cheese intake, taken separately from other dairy products, and weight status (Beydoun et al., 2008; Bradlee et al., 2010; Houston et al., 2008; Shao & Chin, 2011) and their results are confusing. On one hand, some authors have attributed deleterious effects to cheese due to its higher energy density, to its elevated content in saturated fat, and to its higher phosphorus content compared with other dairy products (Beydoun et al., 2008). On the other hand, cheese, as distinct from other dairy products, has been inversely associated with obesity (Bradlee et al., 2010), or not correlated with obesity tendencies (Shao & Chin, 2011). To try to elucidate this relationship, the present study assessed the association between consumption of cheese, in general, and between intake of different types of cheeses and overweight (Ov) and obesity (Ob), in a representative sample of the adult population of the Basque Country.

It was hypothesized that cheese consumption, in general, and/or the different types of cheese, especially fresh cheese given its lower energy density and its lower content in fat compared

Correspondence: Dr Marta Arroyo-Izaga, Department of Pharmacy and Food Sciences. Faculty of Pharmacy, University of the Basque Country (UPV/EHU), Paseo de la Universidad, 7. 01006 Vitoria, Spain. Tel: 00 34 945013862. Fax: 00 34 945013014. E-mail: marta.arroyo@ehu.es

with other cheeses, was negatively associated with body weight. To our knowledge, the effect of the consumption of cheese has not been examined in the Basque Country population. The range of consumption of dairy products in general, and in particular the consumption of cheese, is relatively broad in Basque Country (The Agriculture, Fishing and Food Department, Basque Government, 2007); hence, the current study population should be suitable for detecting a possible association between cheese intake and body weight status.

Methods

This cross-sectional study is part of the project LisRisk (NIC 08196), ERANET-Safefoodera (FP7) that aims to analyze the risk of *Listeria monocytogenes* associated with the consumption of cheese in several European countries (Portugal, Iceland, Cyprus and Basque Country – Spain).

Subjects

The target population consisted of 1081 adults aged 17 years old and older, living in the Basque Autonomous Community (a region of Northern Spain). Of the total sample, 530 were males (49.0%) and 551 females (51.0%). The median age was 45.0 years old (17–96), 46.0 (17–93) years old for men and 44.0 (17–96) years old for women. The type of measurements was explained to the participants, who gave their informed verbal consent. Verbal consent was witnessed and formally recorded and obtained before the interview. All data were coded to ensure confidentiality. This study was conducted according to the guidelines laid down in the Declaration of Helsinki.

The sampling design was polietapic and stratified by region, gender and age, drawn randomly from the Basque Country population with the aim of obtaining a representative sample (EUSTAT, 2011). The eligibility criteria for inclusion were established to recruit a healthy population and were as follows: (1) adults aged 17 years old and older; (2) no current reported diseases or conditions (such as being on a diet or doing intense physical activity) that may affect the weight and/or height and not currently on medication related to these diseases; and (3) not related to other participants. The initial sample included 1104 participants. Data exclusion criteria were used to omit participants when they did not report weight and/or height data and/or other studied variables or when BMI was less or greater than 4 SD. Twenty participants were excluded owing to lack of data and three cases were excluded because their BMI was greater than 4 SD of BMI. All data were recorded using structured questionnaires in face-to-face interviews with qualified staff. The response rate of the study was 76%.

Assessment of cheese intake

Dietary intake data were collected using a semi-quantitative FFQ based on recall of diet during the past year. This questionnaire was especially designed and based on a validated FFQ (National Cancer Institute, 2008) and was tested on a pilot study (67 subjects), which indicated that it provides a reasonable estimate of food intake. The food consumption estimated from FFQ correlated well with the consumption reported on 3-day diet records ($r = 0.70$).

In the FFQ, cheese intake referred to the consumption of cheese both on its own and as part of foods and dishes. Cheese-specific questions were structured into three categories: fresh (e.g. Burgos cheese, curd, cottage, mozzarella), mature (e.g. Emmental, Gruyere, Idiazábal) and processed (e.g. portions of slices, cheese spreads). This categorization was made according to the Spanish Food Code taking into account the cheese-making process (Deleuze, 2001), which defines fresh cheese as one resulting from recent manufacture which has not undergone any transformation or fermentation, except for lactic acid fermentation. Fresh cheeses were characterized by a lower energy and fat content than the other kinds of cheese. Mature cheeses, in addition to lactic acid fermentation, undergo other fermentation and changes in their mass, and are characterized by a higher protein and calcium content than the other cheeses. Processed cheeses are defined as products obtained by grinding, mixing and fusing one or more varieties of cheeses using heat treatment, or which contain authorized emulsifying agents or which contain added milk or other products (such as spices, nuts). Idiazábal cheese is a traditional mature cheese from the Basque Country made with raw sheep's milk, as approved by its Denomination of Origin (Official State Gazette, 2002).

When answering FFQ, participants indicated how often, on average, they had consumed the amount of each food item in the past year. The arithmetical mean was used for frequency bands. Portion categories were converted into gram amounts using predefined standard portion sizes for the Spanish population (Centre d'Ensenyament Superior de Nutrició i Dietètica, 2003). The average food intake was calculated by multiplying frequency by portion size. Total energy intake was estimated using a computerized dietary assessment program (Centre d'Ensenyament Superior de Nutrició i Dietètica, 2003). Results of cheese consumption were reported as g/1000 kcal/day and participants were categorized into tertiles.

Anthropometric data

BMI was calculated using self-reported weight and height and was classified as underweight, normal weight, Ov and Ob according to the World Health Organization criteria (WHO, 2000). Underweight and normal weight participants were regrouped as non-overweight/obese (non-Ov/Ob).

Socio-demographic and economic data

The questionnaire was based on a validated socio-demographic and economic questionnaire (NIAID AIDS Clinical Trials Group). The questions of this instrument assessed: household (from living alone to four or more people living together), educational attainment (from no education to professional education and/or university), occupational status (from working to in school), income for year (from less than €5000 to more than €150 000) and place of residence (rural or urban). The assignment of either rural or urban place of residence was based on the rural/urban classification of the Spanish Statistic Institute which considers that rural areas have less than 10 000 people (National Statistics Institute, 2001).

For simplicity and descriptive purposes, socio-demographic and economic variables were re-grouped. The sample was re-grouped according to age into the following three categories: 17–35, 36–55 and ≥56 years old. Household composition was re-grouped into the following four categories: living alone; living with other people; three people living together; and four or more people living together. Educational attainment was regrouped according to the criteria of the Spanish Classification of Education (Real Decreto 269/2000) into three groups: without studies (illiterate people or people who spent less than 5 years at the school); primary studies and secondary education; and professional education and/or university. The occupational status was regrouped into: working; unemployed, disabled or retired and not working; and currently in school. Income data were re-grouped into the following categories: less than €20 000 a year; more than €20 000 a year; and ''does not know'' or ''does not answer''.

Statistical methods

Data were analyzed using SPSS vs 20.0. (SPSS Inc., Chicago, IL) and reported as median (range) and frequency. The normality of continuous variables was checked using the Kolmogorov–Smirnov–Lilliefors test. Non-parametric tests were used when the test of normality was significant ($p < 0.05$), which is the case for the variables: BMI, age and cheese consumption. The difference between means was estimated by the Mann–Whitney U test for two independent samples and by the Kruskal–Wallis H test for several independent samples. Significant differences in frequencies were calculated by means of χ^2. The association between quantitative variables (BMI and cheese consumption) was estimated by Spearman's ρ and linear regression.

Multinomial logistic regression models with the calculations of corresponding adjusted odds ratios (ORs) and 95% confidence intervals (CIs) were used to examine possible differences between those with Ov, Ob and non-Ov/Ob. Univariate analysis was first carried out for all of the variables (cheese consumption and socio-demographic and economic factors), which could be associated with the frequency of Ov and Ob. Any factor that was significantly associated was considered as a candidate for the multivariate model. Multivariate regression analyses were used to simultaneously examine the effect of different variables on the prevalence of Ov and Ob. Level of significance for acceptance was $p < 0.05$. Analyses were carried out separately for men and women, because of the differences in dietary intake (Touvier et al., 2011) and prevalence of Ov and Ob by gender (Perez et al., 2010).

Results

Characteristics of study sample and cheese consumption

Characteristics of the cohort studied and intakes for total cheese and for different cheeses are shown in Table 1. The percent of ''non-cheese consumers'' was 7.6% (9.1% of males and 6.2% of females) and their socio-demographic profile was characterized by three or more people living in the household, being in work and residing in urban area ($p < 0.05$). High consumers were characterized only by residence in an urban area ($p < 0.001$).

The prevalence of overweight/obesity was 55.1% for men and 35.4% for women ($p < 0.001$). BMI was significantly different by gender (men: 25.4 kg/m^2 (18.3–39.9); women: 23.5 kg/m^2 (15.2–38.0); $p < 0.001$) and results indicated a higher prevalence of Ov/Ob and a lower prevalence of underweight in men than

Table 1. Characteristics of the sample population and cheese consumption.

	Total ($n = 1081$)	Men ($n = 530$)	Women ($n = 551$)	p[a]
Age, %				
17–35 y	33.9	33.2	34.5	0.46
36–55 y	33.5	33.0	33.9	0.53
≥56 y	32.7	33.8	31.6	0.79
BMI, %				
Underweight	2.8	0.2	5.3	<0.001
Normal weight	52.2	44.7	59.3	<0.001
Overweight	33.4	40.8	26.3	<0.001
Obesity	11.7	14.3	9.1	0.02
Household composition, %				
Living alone	8.7	8.7	8.7	0.84
2	28.8	30.6	27.0	0.46
3	29.5	26.2	32.7	0.02
4 or more	33.0	34.5	31.6	0.63
Educational level, %				
None	0.5	0.4	0.5	0.66
Primary/secondary	51.9	47.2	56.4	0.01
Professional education/university	47.6	52.5	43.0	0.07
Occupational status, %				
Currently in school	13.6	14.0	13.2	0.93
Unemployed, disabled or retired or not working	39.5	36.6	42.3	0.06
Working	46.9	49.4	44.5	0.45
Income, %				
<20 000 €/year	35.0	35.8	34.1	0.92
≥20 000 €/year	30.3	35.1	25.8	0.02
''Does not know'' or ''does not answer''	34.7	29.1	40.1	<0.001
Place of residence, %				
Urban	80.4	80.2	80.6	0.52
Rural	19.6	19.8	19.4	0.89
Cheese consumption, g/day, median(range)				
Total	1.8 (0–13.5)	1.8 (0–13.5)	1.8 (0–13.5)	0.01
Fresh	2.5 (0–74.2)	2.5 (0–74.2)	6.2 (0–74.2)	<0.001
Mature	5.3 (0–39.5)	5.3 (0–39.5)	5.3 (0–39.5)	0.53
Idiazábal	1.0 (0–30.0)	1.0 (0–30.0)	1.0 (0–30.0)	0.85
Processed	1.5 (0–44.5)	1.5 (0–44.5)	1.5 (0–44.5)	<0.001
Cheese consumption, g/1,000 kcal/day, median(range)				
Total	0.7 (0–7,1)	0.7 (0–5.9)	0.8 (0–7.1)	<0.001
Fresh	1.1 (0–39.4)	0.9 (0–32.5)	2.5 (0–39.4)	<0.001
Mature	1.9 (0–20.8)	1.9 (0–17.3)	2.1 (0–20.8)	0.12
Idiazábal	0.4 (0–15.7)	0.4 (0–13.2)	0.5 (0–15.7)	0.01
Processed	0.7 (0–20.6)	0.5 (0–19.5)	0.8 (0–20.6)	<0.001

BMI, body mass index.
[a]Tested by χ^2 test for categorical variables and tested by Mann–Whitney U test for continuous non-parametric variables.

in women ($p<0.001$). Table 2 shows the age and gender distribution of non-Ov/Ob, Ov and Ob. As far as cheese consumption by gender was concerned, significant differences were found for total cheese, fresh and processed cheese consumption, this being higher in women than in men ($p<0.05$).

Association between cheese consumption and BMI and other variables

In the total sample, non-Ov/Ob participants consumed more cheese (total and different type of cheeses) than subjects classified as Ov or Ob (Table 3). In the categories of Ov and Ob, total cheese, fresh and processed cheese consumption was significantly higher in women than in men ($p<0.05$). In men classified as Ov/Ob the consumption of fresh and mature cheese was higher than the intake of processed cheese ($p<0.001$); nevertheless, in women classified as Ov/Ob the consumption of fresh cheese was higher than the intake of the other types of cheeses ($p<0.01$).

The study of the association between cheese consumption and BMI, when obese participants were eliminated, indicated a decrease in total and processed cheese consumption with increasing BMI in both genders ($p<0.05$) (Table 4). The results of linear regression, including non-obese participants, showed that only processed cheese consumption has significance impact on BMI in the total sample (B −0.10; SE 0.02; $p<0.001$) and in men (B −0.15; SE 0.03; $p<0.001$).

The univariate analysis with cheese consumption and socio-demographic and economic variables showed that the prevalence of excess weight was associated with fresh and processed cheeses, age, occupational status and place of residence in men; and with consumption of processed cheese, age and occupational status in women. Therefore, these factors were entered in the multivariate analysis because they were considered possible confounders.

The proportion of men with Ov was higher among individuals who reported moderate consumption of fresh cheese (second tertile) compared with those with high intake (third tertile) (Table 5). This association remained significant after controlling for age, occupational status and place of residence. Nevertheless, the relationship between processed cheese intake and obesity in men did not remain significant after adjusting for confounders. Women in the second tertile of processed cheese consumption had a significantly higher prevalence of Ov and Ob, compared with women in the third tertile, after adjustment for confounding variables (Table 6).

With regard to confounding variables in men, subjects currently in school, unemployed, disabled or retired or who did not work seemed to be protected against excess weight compared with those who worked. Furthermore, men resident in rural areas had a higher prevalence of Ov than those living in urban areas. Moreover, 17-to-35-year-old subjects seemed to be protected against overweight compared with those who were 56 or over. The multivariate model in men revealed the following ORs (95%CIs) and significance level for: occupation variable (currently in school, unemployed, disabled or retired or not working: OR <1, $p<0.05$; Working: ref.); place of residence (Rural: OR >1; $p<0.05$; Urban: ref.); and age (17–35 years: OR <1, $p<0.001$; ≥56 years: ref.).

Moreover, 17- to 35-year old women seemed to be protected against overweight and obesity compared with those aged 56 or over (OR <1, $p<0.05$). Unemployed, disabled or retired and not working women seemed to be protected against excess weight compared with those who worked (OR <1, $p<0.05$). None of the other variables considered in this study (household

Table 2. Age and gender distribution of non-overweight/obesity, overweight and obesity.

%	Non-Ov/Ob	Ov	Ob	p[a]
Men, age	$n=238$	$n=216$	$n=76$	
17–35 y	52.9	17.6	15.8	<0.001
36–55 y	24.4	42.1	34.2	<0.001
≥56 y	22.7	40.3	50.0	<0.001
p	<0.001	<0.001	<0.01	
Women, age	n=356	n=145	n=50	
17–35 y	45.2	15.2	14.0	<0.001
36–55 y	33.7	35.9	30.0	<0.001
≥56 y	21.1	49.0	56.0	<0.001
p	<0.001	<0.001	<0.01	

Non-Ov/Ob, non-overweight/obesity; Ov, overweight; Ob, obesity.
[a]Tested by χ^2 test.

Table 3. Cheese consumption by BMI.

Cheese (g/1000 kcal/day)	Gender	Median (range) Non-Ov/Ob	Ov	Ob	p[a]
Total	Total	0.8 (0–7.1)	0.7 (0–6.2)	0.7 (0–5.4)	<0.001
	Men	0.8 (0–5.9)	0.7 (0–5.9)	0.5 (0–5.0)	<0.01
	Women	0.8 (0–7.1)	0.7 (0–6.2)	0.7 (0–5.4)	<0.01
	p[b]	<0.001	0.02	<0.01	
Fresh	Total	1.1 (0–39.4)	1.0 (0–34.3)	2.3 (0–29.7)	0.03
	Men	1.0 (0–32.5)	0.9 (0–32.5)	0.9 (0–27.7)	0.50
	Women	2.8 (0–39.4)	1.1 (0–34.3)	4.0 (0–29.7)	0.42
	p[b]	<0.001	<0.001	0.02	
Mature	Total	2.2 (0–20.8)	1.9 (0–18.3)	1.3 (0–15.8)	<0.01
	Men	2.2 (0–17.3)	1.9 (0–17.3)	1.5 (0–14.7)	0.36
	Women	2.4 (0–20.8)	1.3 (0–18.3)	1.3 (0–15.8)	0.02
	p[b]	0.02	0.49	0.81	
Idiazábal	Total	0.4 (0–15.7)	0.4 (0–13.9)	0.4 (0–12.0)	0.04
	Men	0.4 (0–13.2)	0.4 (0–13.2)	0.4 (0–11.1)	0.76
	Women	0.5 (0–15.7)	0.4 (0–13.9)	0.4 (0–12.0)	0.04
	p[b]	<0.001	0.33	0.86	
Processed	Total	1.6 (0–20.6)	0.6 (0–20.6)	0.5 (0–17.8)	<0.001
	Men	1.5 (0–19.5)	0 (0–19.5)	0 (0–16.5)	<0.001
	Women	1.7 (0–20.6)	0.6 (0–20.6)	1.5 (0–17.8)	<0.01
	p[b]	<0.01	<0.01	<0.001	

BMI, body mass index; Non-Ov/Ob, non-overweight/obesity; Ov, overweight; Ob, obesity.
[a]Tested by Kruskal–Wallis H test; [b]Tested by Mann–Whitney U test.

Table 4. Correlations between cheese consumption and BMI for non-obese participants.

	BMI					
	Total ($n = 955$)		Men ($n = 454$)		Women ($n = 501$)	
Cheese (g/1000 kcal/day)	ρ	p	ρ	p	ρ	p
Total	−0.15	<0.001	−0.11	0.02	−0.10	0.03
Fresh	−0.07	0.03	0.01	0.87	−0.03	0.45
Mature	−0.06	0.09	−0.06	0.22	−0.03	0.53
Idiazábal	−0.05	0.12	−0.02	0.62	−0.03	0.58
Processed	−0.23	<0.001	−0.23	<0.001	−0.18	<0.001

BMI, body mass index.

Table 5. Multivariate-adjusted ORs and 95%CIs for overweight and obese men across tertile categories of cheese consumption[a].

	Tertile categories of cheese consumption[b]		
OR(95%CI)	First	Second	Third
Overweight			
Total cheese	0.85 (0.43–1.69)	1.30 (0.73–2.31)	ref.
Fresh cheese	1.25 (0.78–2.00)	2.90 (1.66–5.05)§	ref.
Mature cheese	1.33 (0.70–2.58)	1.23 (0.68–2.25)	ref.
Processed cheese	1.41 (0.84–2.38)	1.33 (0.64–2.75)	ref.
Obesity			
Total cheese	1.19 (0.45–3.15)	1.72 (0.77–3.84)	ref.
Fresh cheese	0.89 (0.47–1.67)	1.96 (0.94–4.09)	ref.
Mature cheese	1.32 (0.52–3.31)	0.98 (0.42–2.31)	ref.
Processed cheese	2.29 (1.07–4.89)‡	3.18 (1.25–8.08)‡	ref.

[a]Multinomial logistic regression: Odds ratios (OR) and 95% confidence intervals (CI) for being overweight or obese compared to non-overweight/obese. The present ORs are adjusted for age, household composition, educational level, occupational status, income and place of residence.

[b]Tertile categories of total cheese (1st, <0.5; 2nd, 0.5–2.3; 3rd, >2.3), of fresh cheese (1st, 0.0; 2nd, 0.0–2.6; 3rd, >2.6), of mature cheese (1st, <0.6; 2nd, 0.6–3.9; 3rd, >3.9) and of processed cheese (1st, <0.0; 2nd, 0.0–1.6; 3rd, >1.6); ‡P < 0.05; ¶P < 0.01; §P < 0.001 compared to third tertile.

Table 6. Multivariate-adjusted ORs and 95%CIs for overweight and obese women across tertile categories of cheese consumption[a].

	Tertile categories of cheese consumption§		
OR (95%CI)	First	Second	Third
Overweight			
Total cheese	1.21 (0.56–2.60)	1.35 (0.73–2.48)	ref.
Fresh cheese	3.20 (1.91–5.37)§	1.99 (1.15–3.42)‡	ref.
Mature cheese	1.33 (0.68–2.60)	0.81 (0.43–1.53)	ref.
Processed cheese	1.75 (0.99–3.06)	4.41 (2.53–7.67)§	ref.
Obesity			
Total cheese	0.66 (0.22–2.00)	1.36 (0.58–3.21)	ref.
Fresh cheese	1.96 (0.95–4.05)	1.06 (0.47–2.39)	ref.
Mature cheese	2.24 (0.86–5.79)	0.79 (0.30–2.05)	ref.
Processed cheese	1.25 (0.52–3.02)	4.92 (2.18–11.14)§	ref.

[a]Multinomial logistic regression: Odds ratios (OR) and 95% confidence intervals (CI) for being overweight or obese compared to non-overweight/obese. The present ORs are adjusted for age, household composition, educational level, occupational status, income and place of residence.

† Tertile categories of fresh cheese (1st, <1.0; 2nd, 1.0–4.5; 3rd, >4.5), of mature cheese (1st, <0.6; 2nd, 0.6–2.8; 3rd, >2.8) and of processed cheese (1st, <0.0; 2nd, 0.0–2.7; 3rd, >2.7); ‡$p < 0.05$; ¶$p < 0.01$; §$p < 0.001$ compared to third tertile.

composition, educational level and income) was significantly associated with Ov or Ob, either in men or in women.

Discussion

In this representative Basque adult population, cheese consumption, in general, was negatively associated with BMI in both genders; and particularly the low or moderate intake of fresh and processed cheese was associated with higher prevalence of excess weight (Ov and/or Ob).

The prevalence of overweight/obesity was 55.1% of men and 35.4% of women. Other studies have also found a higher prevalence of Ov/Ob among men than among women in the Basque Country (Perez et al., 2010) and in Spain (Gutiérrez-Fisac et al., 2012; National Statistics Institute, 2010). Differences in lifestyle and socio-demographic variables, as well as other genetic or behavioural factors could explain these gender difference (Gao et al., 2011).

Regarding cheese consumption in the sample studied, expressed as g/1000 kcal, total cheese intake and intake by different types of cheeses (fresh and processed, specifically) were higher in women than in men. Nonetheless, in the Italian population cheese consumption did not differ by gender (Donfrancesco et al., 2008) and other authors, unlike our results, obtained higher intakes in men than in women (Touvier et al., 2011). Advertising campaigns to promote dairy foods consumption which target women in order to prevent osteoporosis may influence cheese intake in the Basque Country population. What is more, our outcomes from fresh cheese, that is to say the higher consumption of fresh cheese in women than in men, are consistent with those of other studies (Touvier et al., 2011) and suggest that women are concerned about their diet and follow a healthier dietary pattern than men (Beydoun et al., 2008).

Our study confirmed some previous findings regarding the negative association between cheese intakes and excess weight (Bradlee et al., 2010); since negative correlations for non-obese participants were found between BMI and total cheese consumption and intake of processed cheese, in both genders. Additionally, multivariate multinomial logistic regression analysis revealed negative associations between overweight and fresh cheese intake in men and women, and between excess weight (Ov and Ob) and processed cheese consumption in women. Participants with low or moderate intakes of these types of cheese had a higher prevalence of Ov and/or Ob, compared with those with high consumption. These results agree with previous cross-sectional studies that have shown a negative association between dairy consumption and body weight in adults (Brooks et al., 2006; Mirmiran et al., 2005; Rosell et al., 2004) and support the starting hypothesis of the current study. Nevertheless, other studies have found both a positive association between cheese consumption frequency and BMI (Beydoun et al., 2008; Houston et al., 2008) as well as no relationship (Shao & Chin, 2011).

At the beginning of the present study, it was hypothesized that fresh cheese consumption would be negatively associated with excess weight due to its lower energy density and its lower content in fat compared with other cheeses. Nevertheless, processed cheese intake was also negatively associated with Ov and Ob, surprisingly. Possible components of cheeses that could explain these relationships are calcium, lipid and bioactive peptide content and interactions with human gut-microbiota. It has been suggested that dietary calcium may play a key role in the regulation of energy metabolism by down-regulating the concentrations of circulating parathyroid hormone and calcitriol. This increases the uptake of calcium in adipocytes, which in turn stimulates lipolysis and inhibits fatty acid synthesis (Zemel et al., 2004). Dietary calcium may also affect energy regulation by

increasing fecal fat and, hence, the excretion of this energy-rich nutrient (Jacobsen et al., 2005). Lipids of cheeses such as short- and medium-length fatty acids, and conjugated linoleic acid (CLA) have shown some beneficial effects on adiposity (Holmberg & Thelin, 2013; Silveira et al., 2007), as have bioactive components of cheeses (e.g. calcium, leucine and peptides which inhibit angiotensin-converting enzyme) (Zemel, 2005). On the other hand, dairy products such as cheese seem to benefit gut microbiota that have been related to health conditions including obesity (Tuohy et al., 2009).

The different amounts and types of cheese consumed by men and women, mentioned above, may have resulted in dissimilar prevalences of Ov and Ob and different confounding variables selected in multivariate analysis. Regarding the confounding variable *occupational status*, men with high intakes of fresh cheese and non-workers (currently in school, unemployed, disabled or retired or who did not work) seemed to be protected against overweight compared with those in work. Other authors, however, have found negative associations between occupational status and Ov/Ob in men (Vernay et al., 2009). Along similar lines, women with high intakes of processed cheese and unemployed, disabled, retired or not working are more likely to be Ob compared with those in work, in the present study.

Furthermore, our findings, in agreement with other studies (Neovius & Rasmussen, 2008; Padez, 2006), suggest that the confounding variable *place of residence* influences the prevalence of Ov and Ob; men with high intakes of fresh cheese and resident in rural areas had a higher prevalence of overweight than those who lived in urban areas. Moreover, in multivariate analysis men with high consumption of fresh cheese and women with high intakes of fresh and processed cheese and between 17 and 35 years old seemed to be protected against excess weight (Ov and/or Ob) compared with those who are $\geq$56 years. These results could be partially explained by decreasing basal metabolic rates and reducing degrees of physical activity with age (Martínez-Ros et al., 2001; Norman et al., 2002); nevertheless, the lack of physical activity data did not allow a confirmation of this explanation in the current study.

Several limitations should be considered when examining the results of the current study. Cross-sectional data were used to identify the association of cheese consumption with weight status, whereas future studies that use longitudinal data will provide stronger evidence of this association. However, it must be taken into account that appropriate analysis of cross-sectional data represents a valuable initial step in identifying relations between diet and disease. Although an adjustment for a wide range of potential variables was attempted, lack of control for nutrient intake such as saturated and unsaturated lipids and for lifestyles such as physical activity might have confounded the findings. Moreover, the validity of self-reported weight and height for measuring prevalence of obesity has been questioned (Nyholm et al., 2007; Romero-Corral et al., 2008). To our knowledge, there are no studies concerning the validity of self-reported height and weight in the Basque adult population, so it was not possible to apply correction factors to these anthropometric data. Nevertheless, some authors have suggested that these data could be sufficiently precise and appropriate for epidemiological studies (Basterra-Gortari et al., 2007; Spencer et al., 2002). Other limitations of this study are the absence of other anthropometric indices relating to obesity and the lack of corrections of potential over- or underestimation of dietary intake.

The current study has several strengths, including the use of a population sample that is representative of the Basque Country, the use of logistic regression models and simultaneous adjustment of socio-demographic and economic confounding variables in the association of cheese consumption with Ov and Ob, and the finding of cross-sectional associations between intake of different types of cheese and excess weight.

Conclusions

In summary, the current study demonstrates a negative association between consumption of different types of cheese (fresh and processed cheese) and excess weight. In addition to cheese intake, socio-demographic and economic factors such as gender, age, occupational status and place of residence were associated with excess weight. In spite of the aforementioned limitations, these results represent a contribution to the in-depth study of relationships between cheese consumption and excess weight and could be useful in designing strategies to prevent and/or treat overweight/obesity. It is suggested that future studies assess this issue further by addressing those components of cheese and the related mechanisms of action which are responsible for this effect.

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Declaration of interest

The authors declare no conflicts of interest. The authors alone are responsible for the content and writing of this article. This work was financially supported by ERA-NET SAFEFOODERA (7PM, EU Framework Programme; LisRisk 08196).

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Proof Corrections

- Second author's name is Ana and surname Rocandio Pablo.

- Page 1, line 29: "in multivariate analysis were: occupational status…".

- Page 2, line 254: "Educational attainment was re-grouped…" and line 260: "… was re-grouped into: working…".

- **Q1**: page 4, lines 489-491: "Moreover, 17-to-35-year-old subjects of both genders seemed to be protected against overweight compared with those who were 56 or over (OR<1, p<0.05)". Lines 497-499: "Moreover, ~~17 to 35 year old women seemed to be protected against overweight and obesity compared with those aged 56 or over (OR <1, p<0.05).~~ unemployed, disabled or …".

- Page 4, lines 494-495: "…; working: ref.); place of residence (rural: OR>1, p <0.05; urban: ref.); and age …".

- **Q2**: page 5, lines 567-568:

  "2nd, 0.0-1.6; 3rd, >1.6).

  ‡P<0.05; ¶P<0.01; §P<0.001 compared to third tertile"

- **Q2**: page 5, lines 592-593:

  "… 3rd, >2.7).
  ‡P<0.05; ¶P<0.01; §P<0.001 compared to third tertile"

- Page 5, line 653: "…these relationships are: calcium, lipid and bioactive peptide…".

- **Q3**: page 6, lines 777-778: "Center for Disease Control and Prevention. 2009. Defining childhood overweight and obesity. Atlanta, GA: Center for Disease Control and Prevention."

- **Q4**: These references are electronic versions and they have not last page number.

- **Q5:** page 7, lines 912-913: "~~Zemel MB. (2005). The role of dairy foods in weight management. J Am Coll Nutr 24(6 suppl):537S–46S.~~"