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Original article

Dairy products and hypertension: Cross-sectional and prospective associations

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SUMMARY

Background: The association between dairy intake and prevalence or incidence of hypertension remains controversial. We aimed to investigate the association between intake of different dairy products and prevalence and incidence of hypertension in a community-dwelling sample.
Methods: Three cross-sectional studies (2009–12, 2014-17 and 2018–21) and one prospective study (2009-12 to 2018–21) were conducted in Lausanne, Switzerland. Dietary intake was assessed via a validated food frequency questionnaire. Dairy consumption was compared between participants with and without prevalent or incident hypertension.
Results: For the cross-sectional analyses, data from 4437 (2009–12, 54.0% women, 57.7 ± 10.5 years), 2925 (2014–17, 53.4% women, 62.5 ± 10.0 years), and 2144 (2018–21; 53.3% women, 65.5 ± 9.6 years) participants were used. No consistent differences between participants with and without hypertension were found for all dairy products (total dairy, milk, yogurt, cheese, low-fat dairy, and full-fat dairy) although participants with hypertension tended to consume less cheese (51 ± 1 vs. 55 ± 1, p = 0.014, 52 ± 1 vs. 56 ± 1, p = 0.053, and 54 ± 1 vs. 56 ± 1 g/day for 2009–12, 2014-17 and 2018–21, respectively). For the prospective study, data from 2303 participants (60.8% women, 53.9 ± 9.0 years) were used. Irrespective of the dairy product considered, no association was found between quartiles of dairy consumption and development of hypertension. Similar findings were obtained after stratifying on dietary quality.
Conclusion: In this population-based study, no association was found between the consumption of different dairy products and the prevalence or incidence of hypertension.

1. Introduction

Hypertension is a major cardiovascular risk factor, being responsible for over 10 million deaths worldwide [1]. Intake of dairy products has been associated with lower blood pressure levels and to a lower risk of developing hypertension [2]. A cross-sectional study reported that regular consumption of low-fat milk or yogurt was associated with better blood pressure control among hypertensive older patients, while no association was found for cheese [3]. In another cross-sectional study, the negative association between low-fat dairy intake and blood pressure levels was no longer significant after multivariable adjustment [4]. Two prospective studies confirmed the protective effect of milk [5] and yogurt [6] intake regarding the risk of hypertension, while a third prospective study conducted in the UK failed to find such an association [7].

A systematic review found a negative association between low-fat dairy, milk and yogurt and incidence of hypertension, while no association was found with cheese [8]. Another systematic review confirmed the protective effect of low-fat dairy and milk on risk of hypertension, while no effect was found for regular- and high-fat dairy, cheese, yogurt, and fermented dairy intake [9]. A meta-analysis found an inverse association between total dairy, low-fat dairy, milk and fermented dairy intake and risk of hypertension,

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but this association was dependent on sex, geographical region of study, and the stage of hypertension [10]. Another meta-analysis reported a non-linear association with total dairy, and an inverse association with low-fat dairy and milk [11].

Some intervention studies showed a favourable effect on blood pressure levels of increased dairy intake [12,13], while others found no significant effect of yogurt [14] or whole milk and full-fat dairy intake [15]. Finally, a mendelian randomization study found no effect of dairy products on blood pressure levels or incidence of hypertension [16].

Overall, most cross-sectional and prospective studies focused on a limited number of dairy products and lacked confirmation in other settings.

Hence, we aimed to investigate the association between intake of different dairy products and prevalence and incidence of hypertension in a community-dwelling sample.

2. Methods

2.1. Study population

The CoLaus|PsyCoLaus study is a population-based study investigating the epidemiology and genetic determinants of psychiatric and cardiovascular disease in Lausanne, Switzerland [17]. Briefly, a representative sample was collected through a simple, non-stratified random sampling of individuals aged between 35 and 75. The baseline study was conducted between June 2003 and May 2006; the first follow-up was performed between April 2009 and September 2012; the second follow-up was performed between May 2014 and April 2017 and the third follow-up was performed between April 2018 and May 2021.

Median follow-up time was 5.4 (average 5.6, range 4.5–8.8) years for the first follow-up, 10.7 (average 10.9, range 8.8–13.6) years for the second follow-up, and 14.5 (average 14.6, range 13.2–17.3) for the third follow-up. As dietary intake was collected only from the first follow-upon, only data from the follow-ups was considered in this study.

2.2. Inclusion and exclusion criteria

For the cross-sectional analyses, participants were excluded if they 1) had no blood pressure measurements; 2) had no dietary data; 3) had extreme dietary intakes, characterized as a total energy intake <500 or >3500 kcal/day, and 4) missed any covariate. For the prospective analysis, participants were also excluded if they 5) presented with hypertension at baseline, or 6) had no follow-up.

2.3. Blood pressure measurements

Blood pressure (BP) was measured using an Omron® HEM-907 automated oscillometric sphygmomanometer after at least a 10-min rest in a seated position, and the average of the last two measurements was used. Hypertension was defined by a SBP ≥140 mm Hg or a DBP ≥90 mm Hg or presence of antihypertensive drug treatment.

2.4. Dietary intake

Dietary intake was assessed using a self-administered, validated semi-quantitative FFQ [18,19]. Briefly, this FFQ assesses the dietary intake of the previous 4 weeks and consists of 97 different food items that account for more than 90% of the intake of calories, proteins, fat, carbohydrates, alcohol, cholesterol, vitamin D and retinol, and 85% of fibre, carotene, and iron. For each item, consumption frequencies ranging from “less than once during the last 4 weeks” to “2 or more times per day” were provided, and the participants also indicated the average serving size (smaller, equal, or bigger) compared to a reference size.

Both daily frequencies and daily amounts of dairy products were considered. The choice of dairy categories was based on the available literature that assessed the effect on blood pressure or hypertension of total dairy [2], milk [5], yogurt [6], yogurt and cheese [3], and low-fat dairy [4]. Total dairy, total milk, total yogurt, total cheese, low-fat and regular fat dairy were considered in the analyses.

The Alternative Healthy Eating Index (AHEI) was computed as described previously [20]. In our study, the amount of *trans* fat could not be assessed, and we considered all participants taking multivitamins as taking them for a duration ≥5 years. Thus, the modified AHEI score ranged between 2·5 and 77·5, instead of 2·5 and 87·5 for the original AHEI score [20]. Participants were considered to have a healthier diet if their AHEI was equal or above to the median.

2.5. Covariates of interest

In previous studies, we have shown that women, older age, being married or having a high education were associated with a healthier dietary intake, while a higher BMI and smoking status were associated with an unhealthier dietary intake [21]. Similarly, being on a diet (i.e., for dyslipidaemia) was associated with a healthier dietary intake [22]. Hence, we considered those characteristics as potential confounders for the analyses.

Smoking was self-reported and categorized as never, former (irrespective of the time since quitting smoking) and current. Education was categorized into high (university), middle (high school) and low (apprenticeship + mandatory). Marital status was defined as living alone (single, divorced, widowed) or living with a partner. Presence of any self-reported diet (for slimming, for hypertension, diabetes, or other condition) was categorized as yes/no.

Body weight and height were measured with participants barefoot and in light indoor clothes. Body weight was measured in kilograms to the nearest 100 g using a Seca® scale (Hamburg, Germany). Height was measured to the nearest 5 mm using a Seca® (Hamburg, Germany) height gauge. Body mass index (BMI) was computed and categorized as normal (<25 kg/m^2), overweight (≥25 and < 30 kg/m^2) and obesity (≥30 kg/m^2).

Most biological assays were performed by the CHUV Clinical Laboratory on fresh blood samples within 2 h of blood collection. Fasting plasma glucose was assessed by glucose hexokinase. Diabetes mellitus was defined as fasting plasma glucose ≥7.0 mmol/L and/or presence of oral hypoglycaemic or insulin treatment.

2.6. Ethical statement

The institutional Ethics Committee of the University of Lausanne, which afterwards became the Ethics Commission of Canton Vaud (www.cer-vd.ch) approved the baseline CoLaus study (reference 16/03). The approval was renewed for the first (reference 33/09), the second (reference 26/14) and the third (reference PB_2018-000408) follow-ups. The approval for the entire CoLaus|PsyCoLaus study was confirmed in 2021 (reference PB_2018-00038, 239/09). The full decisions of the CER-VD can be obtained from the authors upon request. The study was performed in agreement with the Helsinki declaration and its former amendments, and in accordance with the applicable Swiss legislation. All participants gave their signed informed consent before entering the study.

2.7. Statistical analysis

Statistical analyses were conducted using Stata v.18.1 (Stata Corp, College Station, TX, USA). Descriptive results were expressed as number of participants (percentage) for categorical variables and as average ± standard deviation or median [interquartile range] for continuous variables.

Two approaches were considered as performed by others [23]. The first approached consisted of a cross-sectional analysis comparing dairy intake between participants with and without hypertension. The second approach was a prospective analysis of the association between dairy intake at the first follow-up and subsequent incidence of hypertension among participants devoid of the condition. Those approaches allowed comparing our findings with the literature, as some studies used a cross-sectional approach [3,4] and others a prospective one [7,24].

The first approach combined the data from the three follow-ups and applied a mixed model taking into account repeated measures, with a random slope to take into account changes in dietary intake with time for each participant. The bivariate model had only hypertensive status in the fixed part, while the multivariable model also included age (continuous), gender (man, woman), education (low, medium, high), BMI categories (normal, overweight, obese), smoking status (never, former, current), being on a diet (yes, no), diabetes (yes, no), total energy, meat, fish, fruit, and vegetable intake (all continuous) in the fixed part of the model. In both the bivariate and multivariable models, results were expressed as mean ± standard error.

The second approach used logistic regression modelling the likelihood of developing hypertension and categorizing dairy products into quartiles as performed previously [5]. Three models were applied: model 1 adjusted for age, gender, and education; model 2 adjusted for age, gender, education, BMI categories, smoking status, diet, diabetes, and total energy intake; model 3 adjusted for age, gender, education, BMI categories, smoking status, diet, diabetes, total energy intake, meat, fish, fruit, and vegetable intake. Results were expressed as odds ratio (OR) and (95% confidence interval). As included and excluded participants differed, we used inverse probability weighting to consider those differences [25]. Briefly, logistic regression was used to estimate the likelihood of being included for each participant using covariates that were significantly different between included and excluded participants. The inverse of the predicted probability was then used for the analysis by logistic regression.

Sensitivity analyses were conducted splitting the sample according to AHEI levels below or equal and above the median. We considered a two-tailed $P < 0.05$ to be statistically significant.

3. Results

3.1. Study population, cross-sectional studies

Of the 5064 participants in the first follow-up, 627 were excluded, leaving 4437 (87.6%) for analysis. The corresponding values for the second follow-up were 4881 and 2925 (59.9%), and for the third follow-up 3751 and 2144 (57.2%). The reasons for exclusion are summarized in supplementary Fig. 1 and the characteristics of included and excluded participants are indicated in supplementary table 1 for each survey period. Excluded participants were less educated, had a higher BMI, presented more frequently with diabetes, and were less frequently on a diet: excluded participants also tended to be more frequently men and to live alone.

3.2. Association of dairy products and hypertension, cross-sectional analysis

The characteristics of the included participants according to presence or absence of hypertension are indicated in Table 1 for each survey period. The prevalence of hypertension was 40.9%, 45.1% and 50.7% in first, second, and third follow-ups, respectively. Participants with hypertension were older, more frequently men, of lower educational level, more frequently former smokers, with a higher BMI, presented more frequently with diabetes and reported more frequently being on a diet.

The consumption of the different dairy products according to presence or absence of hypertension is indicated in Table 2 On bivariate analysis, no differences were found between participants with and without hypertension. After multivariable adjustment, participants devoid of hypertension had a higher consumption of cheese (both in absolute amounts and frequency) and a lower frequency of milk consumption than participants with hypertension.

3.3. Association of dairy products and hypertension, prospective analysis

Of the initial 5064 participants in the first follow-up, 2303 (45.5%) were included in the prospective study. The characteristics of the included and excluded participants are indicated in supplementary table 2. Excluded participants were older, more frequently men, of a lower educational level, more frequently former smokers, had a higher BMI, presented more frequently with obesity and diabetes, and were more frequently on a diet.

The association between quartiles of dairy consumption and incidence of hypertension is indicated in Table 3. Irrespective of the dairy product, no significant association was found regarding development of hypertension, and similar findings were obtained after inverse probability weighting (supplementary table 3).

3.4. Sensitivity analyses

The results of the multivariable analyses stratified according to AHEI categories are summarized in supplementary table 4 for the cross-sectional and in supplementary table 5 for the prospective study. Overall, and irrespective of the AHEI category, participants with hypertension consumed less cheese than participants without hypertension (supplementary table 4), while no significant association was found regarding dairy products and development of hypertension (supplementary table 5).

4. Discussion

4.1. Main findings

In this study, we used data from a population-based study to assess the cross-sectional and prospective associations between consumption of dairy products and prevalence or incidence of hypertension. In the cross-sectional analysis, participants with hypertension consumed less cheese than participants without hypertension, while no difference was found for milk, yogurt, low-fat or full-fat dairy. In the prospective analysis, consumption of dairy products was categorized into quartiles as performed previously [5], and no association was found between all dairy products and incident hypertension. Similar findings were obtained when participants were categorized according to the dietary quality using the AHEI.

Table 1
Characteristics of participants according to hypertension status, CoLaus|PsyCoLaus study, Lausanne, Switzerland.

	Follow-up 1			Follow-up 2			Follow-up 3		
	No HTN	HTN	*P*-value	No HTN	HTN	*P*-value	No HTN	HTN	*P*-value
N	2621	1816		1605	1320		1056	1088	
Age (years)	54.0 ± 9.1	62.9 ± 10.1	<0.001	59.2 ± 8.9	66.6 ± 9.7	<0.001	62.1 ± 8.4	68.8 ± 9.5	<0.001
Women (%)	1571 (59.9)	823 (45.3)	<0.001	933 (58.1)	629 (47.7)	<0.001	640 (60.6)	502 (46.1)	<0.001
Educational level (%)			<0.001			<0.001			<0.001
High	684 (26.1)	297 (16.4)		423 (26.4)	234 (17.7)		279 (26.4)	202 (18.6)	
Middle	730 (27.9)	451 (24.8)		464 (28.9)	340 (25.8)		323 (30.6)	299 (27.5)	
Low	1207 (46.1)	1068 (58.8)		718 (44.7)	746 (56.5)		454 (43.0)	587 (54.0)	
Living in couple (%)	1500 (57.2)	1070 (58.9)	0.262	1072 (66.8)	856 (64.9)	0.270	673 (63.7)	680 (62.5)	0.555
Smoking status (%)			<0.001			<0.001			<0.001
Never	1097 (41.9)	723 (39.8)		714 (44.5)	517 (39.2)		466 (44.1)	473 (43.5)	
Former	897 (34.2)	797 (43.9)		582 (36.3)	598 (45.3)		397 (37.6)	483 (44.4)	
Current	627 (23.9)	296 (16.3)		309 (19.3)	205 (15.5)		193 (18.3)	132 (12.1)	
Body mass index (kg/m^2)	24.9 ± 4.0	27.7 ± 4.7	<0.001	25.1 ± 4.0	27.7 ± 4.7	<0.001	24.9 ± 4.0	27.4 ± 4.5	<0.001
BMI categories (%)			<0.001			<0.001			<0.001
Normal	1450 (55.3)	527 (29.0)		857 (53.4)	387 (29.3)		580 (54.9)	337 (31.0)	
Overweight	923 (35.2)	806 (44.4)		591 (36.8)	584 (44.2)		364 (34.5)	484 (44.5)	
Obese	248 (9.5)	483 (26.6)		157 (9.8)	349 (26.4)		112 (10.6)	267 (24.5)	
Diabetes (%)	107 (4.1)	325 (17.9)	<0.001	61 (3.8)	200 (15.2)	<0.001	39 (3.7)	149 (13.8)	<0.001
On a diet (%)	688 (26.3)	724 (39.9)	<0.001	335 (20.9)	344 (26.1)	0.001	262 (24.8)	356 (32.7)	<0.001

HTN, hypertension. Results are expressed as number of participants (percentage) for categorical variables and as average ± standard deviation for continuous variables. Between group comparisons performed using chi-square for categorical variables and student's t-test for continuous variables.

Table 2
Bivariate and multivariable analysis of the association between dairy consumption and hypertension status, CoLaus|PsyCoLaus study, Lausanne, Switzerland.

	Bivariate			Multivariable		
	No HTN	HTN	*P*-value	No HTN	HTN	*P*-value
Daily frequency						
Total dairy	1.33 ± 0.02	1.33 ± 0.02	0.990	1.34 ± 0.02	1.33 ± 0.02	0.437
Milk, all	0.23 ± 0.01	0.24 ± 0.01	0.653	0.22 ± 0.01	0.25 ± 0.01	0.032
Yogurt, all	0.55 ± 0.01	0.55 ± 0.01	0.832	0.56 ± 0.01	0.54 ± 0.01	0.367
Cheese, all	0.60 ± 0.01	0.58 ± 0.01	0.153	0.61 ± 0.01	0.58 ± 0.01	0.035
Low-fat dairy	0.18 ± 0.01	0.17 ± 0.01	0.427	0.17 ± 0.01	0.17 ± 0.01	0.858
Full-fat dairy	1.20 ± 0.01	1.20 ± 0.02	0.975	1.21 ± 0.01	1.20 ± 0.02	0.635
Daily amount						
Total dairy	188 ± 3	186 ± 3	0.476	189 ± 3	186 ± 3	0.466
Milk, all	38 ± 1	38 ± 2	0.936	36 ± 1	40 ± 2	0.088
Yogurt, all	96 ± 2	95 ± 2	0.735	97 ± 2	94 ± 2	0.364
Cheese, all	54 ± 1	53 ± 1	0.225	56 ± 1	52 ± 1	0.002
Low-fat dairy	27 ± 1	26 ± 1	0.422	27 ± 1	27 ± 1	0.939
Full-fat dairy	160 ± 2	160 ± 3	0.980	162 ± 2	159 ± 2	0.500

HTN, hypertension. Results are expressed as average ± standard error. Bivariate analyses performed using a mixed model for repeated measures, with a random slope to take into account changes in dietary intake with time for each participant. Multivariable analyses performed using the same model as previously, adjusting for age (continuous), gender, education (low, medium, high), BMI categories (normal, overweight, obese), smoking status (never, former, current), being on a diet (yes, no), diabetes (yes, no), total energy, meat, fish, fruit, and vegetable intake (continuous).

4.2. Association of dairy products and hypertension, cross-sectional analysis

No associations were found between consumption of most dairy products and prevalent hypertension, except for a lower consumption of cheese by participants with hypertension. Our results agree with those observed in Chile [4] and Iran [26] which found limited evidence that the type of dairy products consumed was associated with hypertension. Conversely, they do not replicate another study conducted in Spain [3], where dairy consumption was associated with lower levels of DBP; still, the decreases in BP were small (1.7 mm Hg) and might not be clinically relevant. The trend regarding the lower consumption of cheese by participants with hypertension is likely because most cheeses are rich in salt [27]; hence, participants with hypertension might have been recommended to avoid them.

No differences were found regarding the consumption of low-fat or full-fat dairy between participants with and without hypertension. Our results do not agree with a randomized study that showed that a consumption of 5–6 servings per day of low-fat dairy would reduce BP [13]. Still, the intake of dairy products in this study corresponds to five times the daily consumption observed in our group, which is not very applicable in practice. Our findings also do not confirm those of a study conducted in 21 countries, where whole fat, but not low fat, were associated with lower BP levels [28]. Conversely, our results agree with those of another randomized study that found no effect of full-fat dairy products on BP [15], and of another randomized study that found no effect of both full- and low-fat dairy products [29]. Our results also agree with those of another cross-sectional study, which failed to find a relationship between dairy products and elevated BP or hypertension [26]. Overall, our cross-sectional results suggest that consumption of dairy products, either full-fat or low-fat, is not associated with hypertension. It would also be important to assess whether the fat content of dairy products intervenes in the association between dairy products and hypertension.

Table 3
Incidence of hypertension according to quartiles of dairy intake, CoLaus|PsyCoLaus study, Lausanne, Switzerland.

	Quartile 1	Quartile 2	Quartile 3	Quartile 4	*P* for trend
Total dairy					
Model 1	1 (ref)	0.99 (0.77–1.29)	0.94 (0.73–1.22)	0.96 (0.74–1.24)	0.676
Model 2	1 (ref)	1.02 (0.78–1.33)	0.97 (0.74–1.27)	0.99 (0.74–1.32)	0.862
Model 3	1 (ref)	1.03 (0.79–1.35)	0.99 (0.76–1.30)	1.02 (0.77–1.36)	0.955
Milk, all					
Model 1	1 (ref)	–	1.09 (0.85–1.40)	0.90 (0.72–1.12)	0.481
Model 2	1 (ref)	–	1.08 (0.84–1.39)	0.91 (0.72–1.15)	0.588
Model 3	1 (ref)	–	1.08 (0.84–1.39)	0.92 (0.73–1.16)	0.629
Yogurt, all					
Model 1	1 (ref)	1.11 (0.86–1.44)	1.15 (0.89–1.49)	0.92 (0.71–1.20)	0.606
Model 2	1 (ref)	1.15 (0.88–1.50)	1.18 (0.91–1.53)	0.92 (0.70–1.22)	0.631
Model 3	1 (ref)	1.16 (0.89–1.51)	1.18 (0.90–1.54)	0.95 (0.72–1.25)	0.744
Cheese, all					
Model 1	1 (ref)	1.07 (0.82–1.39)	1.13 (0.87–1.47)	1.11 (0.85–1.44)	0.381
Model 2	1 (ref)	1.06 (0.81–1.38)	1.16 (0.88–1.52)	1.18 (0.89–1.57)	0.206
Model 3	1 (ref)	1.07 (0.82–1.40)	1.17 (0.89–1.54)	1.21 (0.90–1.61)	0.162
Low-fat dairy					
Model 1	1 (ref)	–	1.06 (0.80–1.40)	1.15 (0.93–1.44)	0.208
Model 2	1 (ref)	–	1.00 (0.76–1.33)	1.05 (0.83–1.32)	0.725
Model 3	1 (ref)	–	1.00 (0.76–1.33)	1.05 (0.83–1.32)	0.724
Full-fat dairy					
Model 1	1 (ref)	0.87 (0.67–1.13)	0.95 (0.74–1.23)	0.83 (0.64–1.08)	0.274
Model 2	1 (ref)	0.90 (0.69–1.18)	1.00 (0.77–1.31)	0.88 (0.66–1.17)	0.549
Model 3	1 (ref)	0.91 (0.70–1.19)	1.03 (0.78–1.34)	0.91 (0.68–1.22)	0.748

Results are expressed as odds ratio and (95% confidence interval). Statistical analysis performed using logistic regression. Model 1: adjusted for age, gender, and education; Model 2: adjusted for age, gender, education, BMI categories, smoking status, being on a diet, diabetes, and total energy intake; Model 3: adjusted for age, gender, education, BMI categories, smoking status, being on a diet, diabetes, total energy intake, meat, fish, fruit, and vegetable intake.

4.3. Association of dairy products and hypertension, prospective analysis

No association was found between dairy consumption and incidence of hypertension, and this lack of association was observed for all dairy products considered. Our results agree with those of other prospective studies conducted in Europe, such as in France [30], Great Britain [7] and the Netherlands [31]. However, our results were not consistent with those of a study conducted among Singaporean Chinese [5], whose daily consumption of dairy products, particularly milk, was associated with a reduced risk of hypertension. This may be due to the selection of dairy products (including butter for spread, malted drinks and ice-cream), a lower frequency of dairy consumption (67% of the Singaporean Chinese participants drank milk less than once per month), or other variables that differ between studies. Our results also do not confirm those of two meta-analyses conducted in 2012 [8,24], where the consumption of low-fat dairy, but not of cheese, would be associated to a lower risk of hypertension. Still, according to another meta-analysis [11], both total dairy and milk, but not low-fat dairy, were associated with a lower risk of hypertension, the association between total dairy and hypertension being non-linear and plateauing at a daily consumption of 400 g/day. Finally, another meta-analysis concluded that total dairy and milk were negatively associated with high BP, while no association was found for cheese [32]. Overall, the current literature does not provide a clear picture of which dairy product is associated with a lower risk of hypertension. Interestingly, based on the data presented in the most recent meta-analyses [11,32], our results for milk fall within the confidence intervals provided by the authors, suggesting that the association might have been missed due to a small sample size. Further, and according to one of the meta-analyses [24] a reduction of 3% in the risk of hypertension would require doubling the current average dairy consumption, which might not be achievable in practice. Overall, our results suggest that the current consumption of dairy products does not influence the risk of developing hypertension, although the effect of milk should be further explored.

4.4. Importance for clinical practice

Dairy products provide proteins of high nutritional value and a significant amount of calcium, necessary for adequate nutrition. Further, fermented dairy products such as yogurt have been suggested to prevent cardiovascular disease [33] and type 2 diabetes [34]. Thus, dairy products should be part of a balanced diet, but should not be promoted as a blood pressure decreasing food.

4.5. Strengths and limitations

Our study combines three cross-sectional studies with a prospective study, based on a population sample and using the same methodology to assess dairy consumption and hypertension. Further, the results are generally consistent between the different studies.

Our study also has some limitations. Firstly, it was conducted among urban residents of Lausanne, and therefore cannot necessarily be extrapolated to other countries or even to whole Switzerland [35]. Still, our results are consistent with those obtained in other European countries [7,30]. Secondly, dietary intake of the last four weeks was assessed, and this might be a too long period to observe an association between diet and BP. Still, a randomized study concluded that there was no association between short-term consumption of dairy products and BP [29]. Finally, for the cross-sectional analyses, although we adjusted for a large array of confounding factors, we cannot exclude the hypothesis of residual confounding due to unmeasured factors. Still, this might not the case for the prospective study, the results of which are like those of the cross-sectional studies.

4.6. Conclusion

In this population-based study, no association was found between the consumption of different dairy products and the prevalence or incidence of hypertension. The effect of milk should be further explored.

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Author contribution statement

Vanessa Oliveira Farinha: investigation, analysis, writing – original draft. **Julien Vaucher**: conceptualization, writing – review & editing. **Pedro-Marques Vidal**: conceptualization, methodology, resources, data curation, writing – review & editing, supervision. PMV had full access to the data and is the guarantor of the study.

Data availability statement

The data of CoLaus|PsyCoLaus study used in this article cannot be fully shared as they contain potentially sensitive personal information on participants. According to the Ethics Committee for Research of the Canton of Vaud, sharing these data would be a violation of the Swiss legislation with respect to privacy protection. However, coded individual-level data that do not allow researchers to identify participants are available upon request to researchers who meet the criteria for data sharing of the CoLaus|PsyCoLaus Datacenter (CHUV, Lausanne, Switzerland). Any researcher affiliated to a public or private research institution who complies with the CoLaus|PsyCoLaus standards can submit a research application to research.colaus@chuv.ch or research.psycolaus@chuv.ch. Proposals requiring baseline data only, will be evaluated by the baseline (local) Scientific Committee (SC) of the CoLaus and PsyCoLaus studies. Proposals requiring follow-up data will be evaluated by the follow-up (multicentric) SC of the CoLaus|PsyCoLaus cohort study. Detailed instructions for gaining access to the CoLaus|PsyCoLaus data used in this study are available at www.colaus-psycolaus.ch/professionals/how-to-collaborate/.

Declaration of competing interest

The authors report no conflict of interest.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.clnesp.2024.07.020.

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