Review

Milk Consumption Does Not Lead to Mucus Production or Occurrence of Asthma

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There is a belief among some members of the public that the consumption of milk and dairy products increases the production of mucus in the respiratory system. Therefore, some who believe in this effect renounce drinking milk. According to Australian studies, subjects perceived some parameters of mucus production to change after consumption of milk and soy-based beverages, but these effects were not specific to cows' milk because the soy-based milk drink with similar sensory characteristics produced the same changes. In individuals inoculated with the common cold virus, milk intake was not associated with increased nasal secretions, symptoms of cough, nose symptoms or congestion. Nevertheless, individuals who believe in the mucus and milk theory report more respiratory symptoms after drinking milk. In some types of alternative medicine, people with bronchial asthma, a chronic inflammatory disease of the lower respiratory tract, are advised not to eat so-called mucus-forming foods, especially all kinds of dairy products. According to different investigations the consumption of milk does not seem to exacerbate the symptoms of asthma and a relationship between milk consumption and the occurrence of asthma cannot be established. However, there are a few cases documented in which people with a cow's milk allergy presented with asthma-like symptoms.

Key teaching points:

- In alternative medicine, a popular belief is that the consumption of milk and dairy products leads to mucus in upper and lower respiratory tracts.
- Sensations associated with increased mucus production are not specific to cow's milk, but are more likely due to physical characteristics of some beverages.
- In rare cases asthma can occur in patients with confirmed food allergy against cow's milk proteins.
- People with asthma are sometimes advised to abstain from the consumption of dairy products, but research shows that consumption of milk does not significantly change various lung function parameters. In addition, limiting dairy food consumption can lead to low intake of many nutrients, including calcium.

INTRODUCTION

Mucus is a film covering the surface of the mucous membrane of the alimentary and respiratory tracts and protects the organism against a variety of mechanical, thermic and chemical irritations. It is a product of secretory epithelial cells and consists of water, mucins, a mixture of fucose-rich glucosaminoglycans (mucopolysaccharides) and sialic acid-rich glycoproteins, lysozyme, immunoglobulins, different inorganic salts, leucocytes and scaled epithelial cells [1–3]. There is a belief among some members of the public that the consumption of milk and dairy products increases the production of mucus in the upper and lower respiratory tracts - and that, therefore, these foods should be removed from the diet. There is no precise explanation for the mechanism behind this recommendation [4, 5]. The belief can be followed back to the Jewish physician Moses Maimonides, living in the 12th century [6]. Traditional Chinese medicine attributes a humidifying effect in humans to an exaggerated consumption of dairy products - with the exception of butter - as well as chocolate, honey and all other natural sweeteners. It is believed this humidity

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will thicken to mucus with time [7]. Since an excessive mucus production has been documented in people with asthma, it is not surprising that in alternative medicine these patients are advised not to eat so-called mucus-forming foods, especially all kinds of dairy products (milk, cheese, cream, butter) [8]. But individuals excluding milk products from their daily diet lose an important calcium source and a lack of this mineral may lead to nutritional deficiency and to various health disturbances [9].

The aim of this review is to examine the available evidence regarding the question of whether milk consumption leads to increased mucus formation and whether milk is related to the occurrence of asthma.

MUCUS PRODUCTION

Surveys of Dairy Consumption and Mucus

According to some Australian investigations the belief that milk consumption stimulates mucus production is held by approximately 30% of the population and is accordingly associated with a 38% reduction in their liquid milk intake [10, 11]. The authors identified a milk mucus belief [12].

One study was conducted among 345 randomly-selected Australian shoppers. They were asked about general health perceptions of milk and knowledge about the association between milk and disease. Concerning the question of whether consumption of whole, reduced fat and soy beverage increases mucus, 46% of 111 whole milk drinkers, 25% of 121 reduced fat milk drinkers and 11% of 113 soy milk drinkers agreed [13]. In another study conducted in a pediatric pulmonology office, 330 parents received a 9-question anonymous questionnaire regarding the relationship between milk and mucus. Among these parents 58.5% believed and 21.8% did not believe drinking milk increases mucus, and 19.7% were uncertain. Of the 193 believers 58 parents got their information that milk increases mucus from family members, 19 parents heard it from pediatricians, 36 parents had it from other physicians and 5 parents from other healthcare professionals [14].

In another Australian study a questionnaire was sent to people who were convinced that a relationship exists between milk consumption and mucus formation (n = 70, called believers below) and to others who were not convinced of it (n = 99, non-believers). Respondents were recruited from urban areas and from university and hospital campuses. In the first part of this study, the authors used unstructured questions. The subjects were asked to describe exactly what they felt or what happened when they drank milk. The believers mentioned that the most common site where the sensory perception appeared after drinking milk was the throat (94.3%), followed by back of throat (41.4%), nose (37.1%) and mouth (31.4%). The most common symptoms mentioned were clearing of the throat (52.8%), cough (50.0%), swallow (21.4%), spit (21.4%) and catarrh (10.0%). The terms used by the believers to describe this sensory perception were: thick (35.7%), blocked (20.0%), clogged (12.8%), sticky, coating, choked, heavy (each 10.0%) [12].

In another part of the survey, prompted questions were used. Respondents were asked about specific respiratory and gastrointestinal symptoms experienced after drinking milk. Believers and non-believers differed distinctly in the occurrence of symptoms reported. The believers reported more respiratory symptoms such as throat clearing, moist cough, post-nasal drip, blocked nose and other symptoms (Table 1). The majority of believers (63.2%) needed one glass of milk or less to experience the symptoms and most were certain that whole milk (78.6%) and low fat milk (52.9%) caused the effect. The effect among the believers lasted either a few minutes (12.9%), less than an hour (31.4%) or several hours (24.3%). In an additional trial conducted as part of this study 130 individuals completed a "health" questionnaire. The believers (n = 45) reported more respiratory symptoms related to hay fever, bronchitis or asthma than the non-believers (n = 85) [12].

Experimental Studies on Dairy Consumption and Mucus

Pinnock and Arney [15] conducted a randomised, double-blind trial to investigate the relationship between cow's milk consumption and mucus formation, the so called "milk mucus" effect. They divided 125 subjects into a milk (n = 60) or placebo group (n = 65), of which 43 and 29, respectively, believed that cow's milk consumption produces mucus. These subjects received 300 mL of cow's milk or 300 mL of a soy-based drink (placebo). Both drinks were ultra-heat treated and a cocoa-peppermint flavour-combination was found to be

Table 1. Structured Interview: Percentages of Believers and Non-Believers Experiencing Symptoms after Drinking Milk [12]

Symptom	Believers (n = 70)	Non-believers (n = 99)	Significance
Throat clearing	84.3	20.2	**
Moist cough	34.3	4.0	**
Post-nasal drip	32.7	1.2	**
Blocked nose	30.0	1.0	**
Difficulty swallowing	22.9	6.1	**
Runny nose	22.9	0	**
Other	21.4	5.1	**
Difficulty breathing	20.0	1.0	**
Sneezing	12.9	1.0	**
Dry cough	12.9	1.0	**
Watery eyes	11.4	1.0	**
Headache	4.3	0	*
Diarrhoea	4.3	0	ns
Stomach cramps	2.9	0	ns

**= significant at $p < 0.01$

*= significant at $p < 0.05$

ns = non-significant

most effective in disguising both the mouth-feel of milk and the after-taste of the soy drink and were used for a randomized, double-blind trial. The subjects answered a questionnaire before they received a chilled test drink, and repeated the questionnaire five minutes after, four hours after and the following morning. In both groups three out of 14 indicators of a milk and mucus effect (coating over mouth, back of throat; need to swallow a lot; saliva thicker, harder to swallow) showed statistically significant increases, but only immediately following the test drink in both milk and placebo groups (Table 2). These three indicators were analysed with reference to a belief in a relationship between milk drinking and mucus formation as well as to the assumption by the subjects that they were drinking cow's milk. Subjects who believed in a "milk mucus" effect or thought the drink was milk tended to show larger, though not significant, increases in these three indicators: increases in "coating over mouth", "swallow a lot" and "saliva thicker". The authors concluded that it was possible to detect an increase in three "milk mucus" sensations by the believers after drinking both beverages. The effect which was measured was thus not specific to cow's milk and was also produced by the soy-based drink.

In an earlier study by the same researcher, 60 volunteers aged 18 to 35 were inoculated with the common cold virus (rhinovirus-2). Daily respiratory symptoms and milk intake were recorded over a 10-day period. Fifty one people, who had a cold and from whom satisfactory records of milk intake were received, recorded nasal secretion weights and respiratory symptoms (510 person-days of observation). Symptoms of congestion (nasal discharge, blocked nose, loose cough, post-nasal drip) occurred on 245 person-days. Mean weight of nasal secretion did not increase with increasing milk intake (0–1.9, 2–3.9, >4 glasses). Milk intake was not associated with symptoms of cough, nose symptoms or congestion after infection with the rhinovirus (Table 3). Considering the symptoms by belief, "milk mucus" believers were more likely to report symptoms. For example, believers reported dry cough on 22% of observation days but non-believers on only 12% of observation days. This observation was not accompanied by a parallel increase in the more objective measure of mucus weights. The authors summarized that in healthy adult volunteers challenged with the common cold virus, milk intake was not associated with an increase in symptoms of congestion or nasal secretion weight [10].

Earlier, Blumberger *et al.* [16] showed that drinking hot and cold milk or hot and cold water increased the speed of saliva

Table 2. Mean Milk-Mucus Indicator Scores[1,2] (Upper Part) and Significant Increases of These Scores (Lower Part) in Milk and Placebo Groups at Baseline and after Test Drink [15]

Indicator/Symptom	Milk group (n = 60)				Placebo group (n = 65)			
Time[3]	0	1	2	3	0	1	2	3
Feeling in general	78	74	79	70	83	77	80	76
Coating over mouth	32	43	18	27	28	43	20	22
Mucousy/claggy back of throat	35	38	26	27	34	42	24	29
Cough	25	25	16	17	19	21	16	16
Clear throat	31	38	25	29	30	38	26	25
Swallow a lot	30	45	23	21	30	43	22	25
Mucus dropping down throat	22	25	20	19	23	25	16	20
Saliva thicker	13	31	12	14	11	30	13	16
Spit phlegm	22	23	17	20	15	22	17	21
Chest heavy	10	11	8	11	8	10	9	12
Nose breathing difficult	11	10	17	19	15	16	16	18
Mouth breathing difficult	4	5	4	4	5	9	6	5
Coating over mouth, back of throat		++	−	−		++	−	−
Need to swallow a lot		++	−	−		++	−	−
Saliva thicker, harder to swallow		++	−	−		++	−	−
Want to cough/spit up phlegm/mucus*		−	−	−		+	−	+
Mouth breathing difficult		−	−	−		+	−	−
Need to clear throat		−	−	−		+	−	−
Mucousy/claggy at back of throat		−	−	−		+	−	−
Nose breathing difficult*		+	−	−		−	−	−

[1]not all indicators are shown

[2]for the milk-mucus score a hedonic scaling method was used: 0 = not at all, 100 = very much

[3]time 0, 1, 2, 3: the first questionnaire was completed for baseline measurement before milk consumption (time 0), the second after 5 min (time 1), the third after 4 h (time 2) and the fourth before breakfast on the following day (time 3)

++= significant at $p < 0.01$

+= significant at $p < 0.05$

−= non significant

*= Difference between milk and placebo groups significant at $p < 0.05$

Table 3. Mean Nasal Secretion Weight and Percentages of Symptoms of Cough, Nose or Congestion by Milk Intake [10]

Milk intake glasses	Mucus weight[1] g	Loose cough %	Loose cough/ Total cough	Nose[2] %	congested[3] %
0–1.9	1.32	15.5	0.58	36.9	46.0
2–3.9	0.86	18.6	0.63	37.6	52.4
> 4	1.15	15.0	0.74	37.2	43.4
Significance	ns	ns	ns	ns	ns

[1]Nasal secretion weight
[2]runny/stopped-up nose
[3]one or more of runny, blocked nose, postnasal drip, or loose cough
ns = non significant

secretion by as much as twice the initial value. However, the concentration of neuraminic acid and hexosamine, and therefore also the concentration of the mucopolysaccharides responsible for the viscosity, decreased during drinking. In no case could they show a clear increase in the mucus content of the saliva after milk consumption.

The possibility that milk consumption increases the viscosity or "thickness" of mucus could be explained by the fact that consumption of an emulsion such as milk can lead to droplet floculation after mixing with saliva. This aggregation affects the mouth feel and other sensory aspects [17] and the sensation may be mistaken for mucus.

ASTHMA

Bronchial asthma is a chronic inflammatory disease of the lower respiratory tract (bronchi) and includes swelling, bronchoconstriction, and excess mucus production. For a long time, the consumption of milk and dairy products has been implicated in the exacerbation of asthma. The origin of this view dates back to at least the twelfth century [18, 19]. An explanation for this could be the assumption that the consumption of milk stimulates mucus production in the respiratory tract and that increased mucus formation can result in increased airway resistance, which in turn aggravates asthma symptoms [19]. An association between aspiration of milk into the respiratory tract and exacerbation and/or development of asthma has been suggested [20] and in a murine model recurrent milk aspiration leads to alterations in airway function, lung eosinophilia, and goblet cell hyperplasia [21]. Also in a world-famous book about baby and child care it is suggested that children should avoid milk during respiratory illness [22]. There is a widespread view that people with asthma should limit the intake of milk and dairy products [23, 24]. However, scientific evidence does not support an association between asthma and dairy consumption.

Food Allergy and Asthma

Food allergy is due to immune mechanisms specific to the food in question. In the best-established mechanism in food allergy, food allergies are due to the presence of IgE antibodies against the offending food, respectively to the responsible epitope(s). Food allergens are defined as the antigenic molecules giving rise to the immunological response. Non-IgE-mediated food allergy involves food-IgG-immune complexes or T cell-mediated reactions.

In the fourth quarter of the last century, the prevalence of asthma worldwide increased dramatically [25]. Although there are documented cases of asthma-like symptoms resulting from consumption of or exposure to dairy foods in the literature [26–32], such cases are rare. For example Bernaola *et al.* [28] reported a chocolate confectionery worker who had occupational asthma with lactalbumin as the pathogenic agent. A 24 year-old man who had suffered from severe asthma, urticaria and generalized pruritus since the age of 14 after eating milk and dairy products, presented 15 minutes after consumption of feta cheese with conjunctivitis and a running nose, followed by edema and a severe asthma attack [29]. Blötzer and Wüthrich [33] found among 87 patients with confirmed food allergy one male adolescent with perennial asthma, who was sensitized in the skin and RAST (IgE) test to casein, milk protein (alpha-lactalbumin and beta-lactoglobulin) and various sorts of cheese. A case report describes a 16-year-old boy who showed a moderate degree of bronchial hyperreactivity (cough, bronchial obstruction) two to three minutes after a drop of whey from a sandwich containing fresh cheese fell onto his skin [34]. Among 34 previous non atopic adult patients (aged from 16 to 56 years; 31 females) having an IgE-mediated cow's milk allergy (main allergens were caseins followed by whey proteins), an asthma attack was observed in two patients, one after inhalation of baby powder containing hydrolyzed casein and one after inhalation of cow's milk protein-containing vapors during cooking [35]. In a cross-sectional epidemiologic study, 4 of 1141 randomly selected young adults had a positive skin prick test to cow's milk. One subject showed a probable IgE-mediated food allergy to milk, but a relationship to current asthma, asthma and doctor-diagnosed asthma was not detected [36].

In a study with 19 asthma sufferers and 38 control children (average age: 9.4 years, range 1.8–16 years), poorly controlled asthma and food allergy was found to be significant risk factors for life-threatening asthma. Ten of the cases had a food allergy whereof one was to milk. It was suggested that food allergy

Table 4. Relationship Between Consumption of Dairy Products and Prevalence of Asthma and Wheeze in Pre-School Children (Adjusted Model) [43]

	"Ever asthma" (n = 195)	Recent asthma (n = 145)	Recent wheeze (n = 442)
Full cream milk daily	0.54[a]	0.53[a]	0.81
Full cream milk regularly	0.83	0.73	0.87
Butter daily	0.42	0.25[a]	0.49[a]
Butter regularly	0.97	0.73	1.12
Milk products daily	0.74	0.82	0.68[b]
Semi-skimmed milk daily	0.83	0.75	0.99
Semi-skimmed milk regularly	1.07	0.72	1.05
Margarine daily	0.94	0.82	0.96
Margarine regularly	1.03	0.87	0.96
Breast-fed > 8 weeks	0.69[a]	0.63[a]	0.62[b]

Values are presented as odds ratio
[a]$p < 0.05$ [b]$p < 0.01$

might be a marker for severe asthma. Since most allergies, particularly to egg and milk, are outgrown before the age of 5, the persistence of food allergy suggests an increased atopic state [37]. In a community-based cross-sectional study, 1601 young adults with and without asthma were interviewed and tested. Of the 47 analyzed foods, whole milk was negatively ($p < 0.05$) associated with current asthma, doctor-diagnosed asthma and bronchial hyperreactivity, and butter was negatively associated with doctor-diagnosed asthma and bronchial hyperreactivity. However, ricotta, low-fat cheese and soy beverage showed a partially increased risk of current asthma, doctor-diagnosed asthma and bronchial hyperreactivity. The authors stress that their results do not indicate cause and effect [38]. The occurrence of food allergy-induced asthma reaction was established in a further double-blind study. Of 300 patients with asthma, one patient had a positive response to the milk challenge, but developed no asthma symptoms [39].

The findings above show that cases of asthma from dairy are relatively rare.

Survey on Dairy Consumption and Asthma

Based on the belief that mucus formation aggravates asthma symptoms, and milk consumption increases mucus production, asthma patients are commonly advised to reduce milk consumption. However, because the data do not support this recommendation many people may be limiting their dairy food intake unnecessarily, putting themselves at risk for shortages of calcium and other essential nutrients. In a survey of 135 adult asthma patients, 12% indicated that they avoid consumption of dairy products, 16% had renounced them in the past and 36% blamed the consumption of dairy products for having induced asthma symptoms. Among these 135 patients answering a "food and asthma" questionnaire, 54% declared that they received dietary restriction advice from a "Doctor/Specialist" and 21% from a "Doctor/Specialist and a Dietetian". The most common restriction was dairy foods [24]. It has been shown that calcium deficiency can occur in children who have limited their intake of foods containing calcium because of suspected food allergy [40–42].

In the above-mentioned study among 345 Australian shoppers, 20% of whole milk drinkers, 8% of reduced fat milk drinkers and 5% of soy milk drinkers indicated that consumption of the whole, reduced fat and soy beverage caused asthma whereas 20, 26 and 18% respectively gave the answer "don't know" [13]. In a prospective birth cohort study (natural history study in which no intervention took place; the so-called PIAMA [Prevention and Incidence of Asthma and Mite Allergy] study), 2978 children (age: 3 years) showed a lower prevalence of recent asthma symptoms when they consumed full cream milk and butter daily at the age of 3 than those who did not. The results of this study are summarized in Table 4 [43]. In Saudi Arabia, children (age: 12 years) with a history of asthma and wheezing consumed significantly less milk than controls [44]. In addition, there are some indications that milk drinking may possibly protect the respiratory epithelium [45].

Experimental Studies on Dairy Consumption and Asthma

In 1991 Haas *et al.* [19] could not find any indication in the scientific literature that milk consumption aggravated the symptoms of patients with asthma. Hence, they gave 11 asthmatic subjects (23 to 58 years) and 11 non-asthmatic subjects (22 to 50 years) each approximately 450 mL of whole milk, skim milk or water. The forced expiratory volume in 1 second (FEV_1)* and the

*Different parameters of the lung function are measured with a spirometer: vital capacity = maximum volume expelled after maximum inspiration. Forced expiratory volume in 1 second (FEV_1) = volume of air that can be forced out in one second after taking a deep breath, also given as percentage of forced vital capacity. Forced vital capacity (FVC) = maximum volume of air which can be expired as quickly and forcibly as possible after maximum inspiration.

Table 5. Baseline Values and Mean Changes in Forced Expiratory Volume in 1 Second (FEV_1) and FEV_1/Forced Vital Capacity (FVC) in a Double-Blind, Placebo-Controlled Study of Reaction to Cow's Milk in Non-Cow's-Milk-Sensitive Asthmatic Patients [46]

Challenge type		0 h x	sx	30 min.	%	1 h	%	7 h	%
FEV_1	L								
Cow's milk		2.86	0.71	−0.09	3.3*	−0.05	1.8	0.04	1.8
Placebo		2.85	0.69	−0.02	0.8	−0.07	2.8	−0.01	0.6
FEV_1/FVC	%								
Cow's milk		81.4	6.6	−2.32	2.7*	−0.68	0.7	0.12	0.3
Placebo		81.8	7.0	−1.44	1.7	−1.44	1.7	−0.68	0.7

* = statistically significant in comparison to baseline value (0 h)

On each challenge day, spirometry was done at baseline (0 h) (effective values), 30 min, 1 h and 7 h after challenge (indicated as effective and percent changes against the initial values)

airflow at 50% of vital capacity were not significantly changed in either group after consumption of whole milk, skim milk and water. However, in the asthmatic group, the pulmonary diffusing capacity was reduced by 21.0 ± 3.2% three hours after consumption of whole milk whereas a statistically non-significant reduction of 9.6 ± 2.4% was reached after skim milk consumption and of 10.0 ± 4.0% after water intake. In non-asthmatic subjects the maximum reductions amounted to 9.0 ± 2.7 (whole milk), 8.9 ± 5.3 (skim milk) and 6.6 ± 4.0% (water). According to these authors [19], the differences can be explained by the highly speculative mechanism that milk lipids may alter pulmonary gas exchange in asthmatic persons mediated by prostaglandins.

In a prospective, randomized, double-blind, placebo-controlled crossover study, 25 asthma patients who were neither allergic to cows' milk nor lactose intolerant were randomly assigned to ingest milk (10 g of whole milk powder dissolved in 60 mL placebo) or placebo (60 mL of strawberry-flavoured mocha mix). Some changes in the parameters FEV_1 or FEV_1/FVC were measured 30 minutes, 60 minutes and 7 hours after consumption (Table 5). However, no clinically significant decrease occurred. This author defined a clinically significant decrease as a decrease in FEV_1 or FEV_1/FVC of ≥ 20% [46]. Further investigations were conducted by Woods *et al.* [47] in a randomized, cross-over, double-blind, placebo-controlled trial on 20 asthmatic adults (aged 18 to 65 years) with no positive skin prick test to cows' milk. Ten of them reported that their asthma worsened after the consumption of dairy products. All subjects received either 300 mL of cows' milk or of a placebo (rice milk) (both products were ultra-heat treated and supplemented with sugar, decaffeinated coffee, citric acid and the placebo with rice syrup). The mean group data of FEV_1 and peak expiratory flow (PEF) were not statistically significant between the dairy challenge and the placebo (treatment effects), between the sequence of administration (period or order effects), or between positive and negative perceivers (perception effects). None of the subjects reported an increase in cough or sputum production after the dairy challenge. No significant treatment effects were found for the group as a whole. On an individual basis, nine subjects had a decline in ventilatory function greater than 15% from baseline after one or both challenges, which is defined as a "likely positive" challenge (Table 6). The authors concluded that they were unable to demonstrate convincingly that the consumption of milk induced a bronchoconstrictor effect in a group of adult subjects with asthma.

Influence of a Change of Dairy Nutrition on Asthma

In a double-blind crossover design, 15 adult patients with moderate asthma received twice daily 225 g yogurt with or without *Lactobacillus acidophilus.* The study tested the hypothesis that the consumption of yoghurt containing living lactic acid bacteria leads to some clinical benefits such as improved immune and clinical responses. The experiment was conducted over two 1 month-phases. Among the immune and clinical parameters measured, interferon gamma increased, but the mean daily peak flow did not show any difference and the spirometric values did not change [48].

In a single blind prospective study, 22 children with asthma (13 in the experimental and 9 in the control group; age between 3 and 14 years) received an egg- and milk-free diet for eight weeks. After this period the children of the experimental group exhibited distinctly decreased IgG-antibody-concentrations toward ovalbumin and β-lactoglobulin. In 5 children of the experimental group the PEF rate was notedly increased compared to the findings in 5 children on the control group. Based on these results lung function in asthmatic children seem improvable by eliminating egg and milk from the diet [49]. However, the findings have to be confirmed in a trial with more subjects before such a diet restriction can be recommended for the management of asthma in children.

Table 6. Individual Challenge Results of Subjects with Asthma after Consumption of an Equivalent of 300 mL of Skim Milk or 300 mL of Placebo [47]

Subj. No.	Gender	Perception[1]	Baseline % predicted FEV_1 and (PEF)	Maximum % decrease in FEV_1 and (PEF)		Symptom scores Day-/ Night-time	
				Skim milk	Placebo	Skim milk	Placebo
1	m	−	67 (71)	11.4 (12.9)	−5.0 (6.3)	0/0	0/0
2	m	−	84 (70)	8.4 (12.9)	11.4 (19.8)	0/0	2/0
3	f	−	90 (72)	27.1[a] (27.6[a])	23.4[a] (24.7[a])	2/2	2/0
7	m	−	106 (103)	1.8 (15.2[a])	2.9 (7.8)	0/1	1/0
8	m	−	73 (63)	9.0 (3.3)	18.1[a] (15.3[a])	0/0	0/0
14	f	−	70 (66)	20.6[a] (16.8[a])	22.6[a] (16.8[a])	2/1	2/0
16	f	−	101 (116)	6.9 (5.2)	4.7 (7.0)	0/0	0/0
17	f	−	133 (102)	9.3 (5.7)	14.7 (10.4)	2/1	2/1
18	m	−	129 (115)	2.8 (1.6)	4.8 (4.0)	0/0	0/0
20	m	−	110 (116)	1.3 (4.9)	3.3 (9.1)	1/2	2/2
4	f	+	107 (99)	9.3 (11.9)	5.1 (8.8)	1/0	0/0
5	f	+	90 (98)	3.3 (5.7)	14.6 (13.9)	0/0	1/1
6	f	+	76 (73)	6.0 (3.6)	4.2 (6.6)	0/0	0/0
9	f	+	94 (102)	19.1[a] (23.9[a])	26.2[a] (36.7[a])	3/0	3/0
10	f	+	116 (109)	4.7 (0.4)	9.4 (10.2)	0/0	1/0
11	m	+	122 (120)	6.5 (6.9)	7.4 (9.2)	1/0	1/0
12	F	+	107 (71)	7.5 (19.5[a])	6.0 (−1.2)	2/0	0/0
13	F	+	113 (124)	9.2 (14.4)	4.3 (8.2)	1/0	0/0
15	f	+	82 (90)	14.8 (18.5[a])	16.4[a] (18.5[a])	3/0	2/0
19	f	+	102 (88)	37.0[a] (40.5[a])	3.4 (0.3)	5/2	1/1

FEV_1 = forced expiratory volume in 1 second; PEF = peak expiratory flow

[1]perception means reported be the subjects

[a]change in spirometry of more than 15%. Score: 0 (day- and night-time) = no symptoms; 5 (daytime) = symptoms so severe that normal tasks could not be performed; 4 (night-time) = did not sleep at all. Perception: the subjects were asked to describe the perceived effect on their asthma after they ingested dairy products. Positive = one glass of milk was sufficient to induce asthma symptoms between 5 minutes and 2 hours after consumption.

CONCLUSION

The belief that milk consumption leads to an increased mucus production is present among some members of the public. The following conclusions can be drawn from the results of the different investigations: People who believe that milk increases mucus formation are more likely to report changes in sensory perceptions related to mucus after drinking milk than those who do not hold the same belief. In a double blind trial, symptoms of increased mucus formation were detected by healthy adults after consumption of both cow's milk and a non-milk beverage with similar sensory properties. Furthermore, persons who were convinced of mucus formation due to milk consumption showed more respiratory symptoms. It is possible that aggregation after mixing of an emulsion such as milk with saliva can partly explain this sensation.

Recommendations to abstain from dairy products due to the belief that they induce symptoms of asthma are not supported by the body of research evidence on the relationship between dairy consumption and occurrence of asthma. Furthermore, in general, there is no evidence to explain an underlying mechanism linking dairy and asthma. Therefore, people with asthma do not need to avoid the consumption of dairy products to control symptoms. There have been a few documented cases in which humans with an IgE-mediated cow's milk allergy presented with asthma symptoms, but these do not apply to most people with asthma. Milk and milk products are the main source of calcium in the diet, and they contain eight additional essential nutrients. Needless avoidance of dairy products can lead to limited intakes of these essential nutrients.

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