Current Neurology and Neuroscience Reports (2019) 19: 46
https://doi.org/10.1007/s11910-019-0956-5

HEADACHE (R.B. HALKER SINGH, SECTION EDITOR)

# Cold Stimulus Headache

Amokrane Chebini[1] · Esma Dilli[1]

Published online: 6 June 2019


**Abstract**
**Purpose of Review** To provide an updated review on cold stimulus headache.
**Recent Findings** Age, type of stimulus, comorbidities, and study design but not necessarily gender appear to influence the reported prevalence of cold stimulus headache (CSH). Different cold stimuli appear to provoke different types of CSH. Ice water appears to provoke more frequent and higher pain intensity with a shorter latency compared to CSH provoked by ice cubes.
**Summary** Cold stimulus headache is very common unusual headache with limited literature. The severity, frequency, and latency appear to be influenced by the speed and size of the exposed area.

**Keywords** Cold stimulus headache · Ice cream headache · Brain freeze · Cold stimulus ingestion · Cold stimulus inhalation

## Introduction

Cold stimulus headache is an unusual headache that can be misdiagnosed. It is not associated with any underlying disease. It is a short-lasting headache, and therefore, it is difficult to study. It may be reduced by modifying potential triggers. The prevalence is variable depending on age, comorbidities such as migraine, speed of cold stimulus, and reporting biases.

## Definition

The latest version of the International Classification of Headache Disorder (ICHD-3) defines cold stimulus headache (CSH) as headache brought on by a cold stimulus applied externally to the head or ingested or inhaled [1]. This includes headache following exposure of the unprotected head to a very low environmental temperature. Ice cream headache (ICH), also known as "brain freeze," and headache attributed to ingestion or inhalation of a cold stimulus are also incorporated under this definition. Headache attributed to ingestion or inhalation of cold stimulus is defined as a short-lasting frontal or temporal pain that is possibly intense and is induced in susceptible people by the passage of cold material over the palate and/or posterior pharyngeal wall [1].

The literature specifically on cold stimulus headache is relatively sparse compared to other primary headache disorders. The inclusion of ice cream headache and headache attributed to ingestion or inhalation of cold stimulus adds to our knowledge of this condition.

## Epidemiology

The reported prevalence of cold stimulus headache is quite variable. This variability appears to be due to study design, age, comorbidities, and type of stimulus. Most of these studies used ice, ice water, or ice cream to trigger the cold stimulus headache while the other studies assessed the prevalence of cold stimulus headache using questionnaires [2–7, 8•]. However, as it was mentioned by de Oliveira et al., we cannot compare CSH rates obtained from questionnaires with the experimental provocation of CSH [6].

The lifetime prevalence of cold stimulus headache is reported to be 15% [9]. In the literature, the point prevalence in the adult population ranges between 7.6% in a 2001 Swedish study in females aged 40 and 74 years old, and 93% in a 1976 study of migrainous male and female subjects admitted to a hospital in the USA [2, 3]. In the teenage population, the prevalence ranges from 41 [5] to 79% [4]. The rate of CSH was significantly higher in students aged 10 and

This article is part of the Topical Collection on *Headache*

✉ Esma Dilli
esma.dilli@vch.ca

[1] Division of Neurology, University of British Columbia, 8219-2775, Laurel Street, Vancouver, BC V5Z 1M9, Canada

14 years than their parents and teachers (62% vs 31%) in a self-administered questionnaire [7]. They hypothesized that this could be explained by the fact that adults learn to avoid painful stimuli, that the smaller anatomical structures in children could result in a faster cooling area, and that an increased neuronal stability against cold stimuli developed with age [7].

Cold stimulus headaches appear to be more common in migraineurs compared to tension-type headache (TTH) patients [10]. CSH was reported to be 74% in the episodic migraine patients compared to 32% in the episodic TTH patients [10]. One possible explanation for this difference is the hyperexcitability of the trigeminal pathway in migraineurs and the possibility of triggering a migraine-like attack with the cold stimulus [2]. There is conflicting data regarding whether CSH is more common in the non-headache population compared to migraine population [2, 11]. Raskin and Knittle found the rate of CSH to be 93% and 31% in the migraineurs and control groups, respectively, using an interview in 108 hospitalized patients for non-neurological problems [2], while Bird et al. found a lower rate of CSH in migraineurs than in persons without migraines (27 and 40%, respectively) in 70 patients attending a migraine clinic as well as 50 dental and medical student volunteers [11]. This difference may be due to age and type of stimulus used in the studies.

There appears to be inconclusive data regarding gender differences in CSH. A 2012 observational study of 414 healthy university student volunteers and their family members found that the prevalence of CSH was actually similar between the genders in migraineurs [6], and in an experimental study, the prevalence of CSH was also similar between the genders in tension-type headache patients [10]. Also, a 2016 cross-sectional epidemiological study that distributed a self-administered questionnaire to students between 10 and 14 years as well as their parents and teachers found no gender difference in the student, but the CSH rate was higher in the adult female than in the adult male groups [7]. In addition, a self-administered questionnaire to students aged 13 to 15 found that CSH was significantly more common in boys than in girls [5].

Family history may play a role in CSH. The risk of CSH was higher for children whose father (odds ratio [OR] 8.4) or mother (odds ratio [OR] 10.7) had CSH.

## Diagnostic Criteria

In the 2018 ICHD-3 classification, "headache attributed to external application of a cold stimulus" and "headache attributed to ingestion or inhalation of a cold stimulus" are classified under "cold stimulus headache" in the "other primary headache disorders" section and their diagnostic criteria include:

Headache attributed to external application of a cold stimulus: Data from (2018) Headache Classification Committee of the International Headache Society (IHS). The international classification of headache disorders, 3rd edition. Cephalalgia, Vol. 38(1)1–211. Reprinted with permission from SAGE Publications, Ltd.

A. At least two acute headache episodes fulfilling criteria B and C
B. Brought on by and occurring only during application of an external cold stimulus to the head
C. Resolving within 30 min after removal of the cold stimulus
D. Not better accounted for by another ICHD-3 diagnosis.

Headache attributed to ingestion or inhalation of a cold stimulus: Data from (2018) Headache Classification Committee of the International Headache Society (IHS). The international classification of headache disorders, 3rd edition. Cephalalgia, Vol. 38(1)1–211. Reprinted with permission from SAGE Publications, Ltd.

A. At least two episodes of acute frontal or temporal headache fulfilling criteria B and C
B. Brought on by and occurring immediately after a cold stimulus to the palate and/or posterior pharyngeal wall from ingestion of cold food or drink or inhalation of cold air
C. Resolving within 10 min after removal of the cold stimulus
D. Not better accounted for by another ICHD-3 diagnosis.

The ICHD-3 also include a codable subform described as "Headache probably attributed to ingestion or inhalation of a cold stimulus" under "probable cold-stimulus headache" defined as: Data from (2018) Headache Classification Committee of the International Headache Society (IHS). The international classification of headache disorders, 3rd edition. Cephalalgia, Vol.38(1)1–211. Reprinted with permission from SAGE Publications, Ltd.

A. A single headache episode fulfilling criteria B and C
B. Brought on by and occurring only during or immediately after a cold stimulus applied externally to the head or ingested or inhaled
C. Resolving within 10 min after removal of the cold stimulus
D. Not fulfilling ICHD-3 criteria for any other headache disorder
E. Not better accounted for by another ICHD-3 diagnosis.

## Clinical Features

Cold stimulus headache is triggered by the passage of cold material (solid, liquid, or gas) over the palate and/or posterior

pharyngeal wall. The location of the headache triggered by the cold stimulus is typically bilateral frontal or temporal. The type of stimulus is typically stabbing [12]; however, pressure, throbbing, and achy pain has also been reported [8•, 10]. This difference may be due to the type of stimulus and the presence of other comorbid headache conditions. Patients with migraine tend to report a throbbing pain and typically have the CSH on the same side of their migraine [10, 11].

As stipulated in the diagnostic criteria, the duration of CSH is short-lasting, ranging from a few seconds to a few minutes. Two large cross-sectional surveys found that 72% and 77% of participants reported that the headache lasted less than 30 s [5, 7]. However, headaches > 5 min have been reported in 9% and 11% of patients who participated in a questionnaire and experimental study, respectively [5, 6].

The type of stimulus may influence the characteristic of the headache [8•]. CSH triggered by ice water was reported to have a shorter latency, different pain character, and higher pain intensity compared to CSH triggered by ice cubes [8•]. In the study by Mages et al., ice water triggered a stabbing more than a pressing pain quality while ice cubes triggered predominately a pressing pain quality [8•]. This may be due to the fact that the ice cube stimulation study group had to press the ice cube against the hard palate while the ice-water stimulation group drank the water [8•].

## Triggers

Factors that appear to influence both the development of cold stimulus headache and the latency of onset are the location of the stimulation, speed of ingestion, and size of the exposed area to the stimulus. Temperature does influence both the development of cold stimulus headache; however, a further reduction of temperature below 0 °C does not appear to significantly increase the frequency of developing CSH [4, 8•, 10]. Ice cream, icy water, and ice cubes are common triggers studied in the literature [2–7, 8•]. However, headache attributed to external application of a cold stimulus during surfing, ice skating, and scuba diving as well as cryotherapy has been described as being similar to cold-induced headache [13–16].

Mages et al. compared in a study ice cubes applied to the palate to fast ingestion of 200 mL of icy water. In this study, they found that drinking icy water provoked CSH significantly more often than applying ice cubes to the palate (51% vs 12%) [8•]. Also, a faster ingestion appeared to cause a more intense headache with a shorter latency and duration [8•]. The association with speed of ingestion could potentially be explained by the fact that the ice cube cools down over a much smaller palate and tongue area compared to ice water. In addition, swallowing of ice water could stimulate not only the trigeminal nerve but also the glossopharyngeal and vagus nerve. The latency difference could be associated with the melting process of the ice cube [8•]. Furthermore, Kaczorowski and Kaczorowski found that an accelerated ice cream ingestion of less than 5 s doubles the risk of developing ice cream headache when compared to a cautious ingestion of ice cream over more than 30 s [4].

## Proposed Mechanism

The exact mechanism of CSH remains unknown. Local and cerebral vascular changes and direct stimulation of cold receptors are two theories.

### Vascular

When the palate and/or the posterior pharyngeal wall is exposed to a cold substance, this substance may trigger rapid constriction and dilation of vessels with activation of nociceptors of the vessel wall [17]. This seems to be similar to when hand pain is triggered by exposing an icy cold hand to hot water. Wolf and Hardy found that cold-induced pain of the hand is associated with reduced arterial pulses in the hand followed by hand erythema which is associated with vasodilation [18]. This relates to a local vascular effect; however, changes to cerebral blood flow appear to occur in CSH [19••]. Reduction in mean cerebral blood flow velocities of middle cerebral arteries on transcranial Doppler ultrasonography has been reported in patients who following cold stimulus developed a headache and not in those without a headache [19••].

### Sensory Receptor Activation

The perceived sensitivity of the thermal responses differs between sites [20]. The difference in CSH may be related to which cranial nerves are activated. CSH triggered by direct stimulation to the palate (innervated by the trigeminal nerve) may differ from the additional stimulation from the pharynx and esophagus (innervated by the glossopharyngeal and vagus nerve) when swallowing. Mages et al. pointed out that lacrimation occurring during CSH indicates that the trigeminal-autonomic reflex is involved in CSH [8•].

## Treatment

There is no specific treatment for cold stimulus headache other than avoiding the triggering factors such as ice cream, ice water, and icy food. Slow ingestion of cold or icy substances with attempts to minimize rapid exposure of the cold substance to the posterior aspect of the palate should be sufficient to avoid triggering CSH [17].

Alternatively, curling the tongue and pressing the underside against the roof of the mouth has been a method to prevent the cold stimulus headache in some people. This appears to correspond with a report by Burkhart who suggested massaging the face in the distribution of the trigeminal nerve for 1 min prior to cryotherapy for actinic keratosis reduces incidence and severity of the headaches [16]. He hypothesized that rubbing the nerves and vessels prior to cryotherapy reduces their hyperexcitability and therefore reduces the pain.

## Conclusion

Age, type of stimulus, comorbidities, and study design but not necessarily gender appear to influence the reported prevalence of cold stimulus headache. Different cold stimuli appear to provoke different types of cold stimulus headache. Ice water appears to provoke more frequent and severe headaches with a shorter latency compared to cold stimulus headache provoked by ice cubes.

### Compliance with Ethical Standards

**Conflict of Interest** Esma Dilli reports honoraria from Allergen and royalties from Lippincott. Amokrane Chebini declares that there are no conflicts of interest.

**Human and Animal Rights and Informed Consent** This article does not contain any studies with human or animal subjects performed by any of the authors.

## References

Papers of particular interest, published recently, have been highlighted as:
- • Of importance
- •• Of major importance


1. Society HCCotIH. Headache Classification Committee of the International Headache Society (IHS) the international classification of headache disorders, 3rd edition. Cephalalgia. 2018;38(1):1–211.
2. Raskin NH, Knittle SC. Ice cream headache and orthostatic symptoms in patients with migraine. Headache. 1976;16(5):222–5.
3. Mattsson P. Headache caused by drinking cold water is common and related to active migraine. Cephalalgia. 2001;21(3):230–5.
4. Kaczorowski M, Kaczorowski J. Ice cream evoked headaches (ICE-H) study: randomised trial of accelerated versus cautious ice cream eating regimen. BMJ (Clinical research ed). 2002;325(7378):1445–6.
5. Fuh JL, Wang SJ, Lu SR, Juang KD. Ice-cream headache–a large survey of 8359 adolescents. Cephalalgia. 2003;23(10):977–81.
6. de Oliveira DA, Valenca MM. The characteristics of head pain in response to an experimental cold stimulus to the palate: an observational study of 414 volunteers. Cephalalgia. 2012;32(15):1123–30.
7. Zierz AM, Mehl T, Kraya T, Wienke A, Zierz S. Ice cream headache in students and family history of headache: a cross-sectional epidemiological study. J Neurol. 2016;263(6):1106–10.
8. • Mages S, Hensel O, Zierz AM, Kraya T, Zierz S. Experimental provocation of 'ice-cream headache' by ice cubes and ice water. Cephalalgia. 2017;37(5):464–9 **Updated experiment that describes different characteristics of the cold stimulus headache based on the type of cold stimulus**.
9. Rasmussen BK, Olesen J. Symptomatic and nonsymptomatic headaches in a general population. Neurology. 1992;42(6):1225–31.
10. Selekler HM, Erdogan MS, Budak F. Prevalence and clinical characteristics of an experimental model of 'ice-cream headache' in migraine and episodic tension-type headache patients. Cephalalgia. 2004;24(4):293–7.
11. Bird N, MacGregor EA, Wilkinson MI. Ice cream headache–site, duration, and relationship to migraine. Headache. 1992;32(1):35–8.
12. Hulihan J. Ice cream headache. BMJ **(Clinical research ed)**. 1997;314(7091):1364.
13. Harries M. Ice cream headache. Ice cream headache occurred during surfing in winter. BMJ (Clin Res ed). 1997;315(7108):609.
14. Cheshire WP Jr, Ott MC. Headache in divers. Headache. 2001;41(3):235–47.
15. Jankelowitz SK, Zagami AS. Cold-stimulus headache. Cephalalgia. 2001;21(10):1002.
16. Burkhart CG, Burkhart CN. Ice cream headaches with cryotherapy of actinic keratoses. Int J Dermatol. 2006;45(9):1116–7.
17. Starling AJ. Unusual headache disorders. Continuum (Minneapolis, Minn). Headache. 2018;24(4):1192–208.
18. Wolf S, Hardy JD. Studies on pain. Observation on pain due to local cooling and on factors involved in the "cold pressor" effect. J Clin Invest. 1941;20(5):521–33.
19. •• Hensel O, Mages S, Kraya T, Zierz S. FV 3 Functional transcranial Doppler (fTCD) during cold-induced pain in the oral cavity and ice cream headache. Clin Neurophysiol. 2017;128(10):e306–e7 **Cerebral vascular changes documented on transcranial doppler in this study in patients given a cold stimulus and reporting a cold stimulus headache but not those without the headache.**
20. Naganawa T, Baad-Hansen L, Iida T, Ando T, Svensson P. Assessment of human intraoral thermal sensitivity with simple devices in the clinic: implications for orofacial pain conditions. J Oral Facial Pain Headache. 2015;29(1):83–90.