Self-Reported Symptoms of Cold Intolerance in Workers with Injuries of the Hand

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Abstract Cold intolerance is a well-recognized complication of crushing injuries and amputations in the hand. These symptoms are usually thought to resolve within 2 years of injury. The objectives of our study were to determine the prevalence and course over time of self-reported symptoms of cold intolerance in workers with hand injuries. Files from a large worker's compensation carrier were randomly selected from index years 2, 4, 6, and 10 after a claim was made. Cohorts comprising cases with diagnostic codes corresponding to traumatic hand injuries and codes referring to non-trauma diagnoses in the hand were assembled for each of the years under consideration. A questionnaire was mailed to a total of 7,088 asking questions related to the symptom of cold intolerance. Twenty-five percent of the surveys were returned. Over 90% of trauma patients from all 4 years reported symptoms of cold intolerance. The rate of cold intolerance in the non-trauma group was between 59% and 69%. Individuals reporting cold intolerance indicated worsening over time in 50% of cases and improvement in only 9%. The severity of injury did not appear to be a factor in the development of cold intolerance. Symptoms of cold intolerance are highly prevalent in workers with significant hand injuries. Workers with non-trauma hand conditions also report a substantial prevalence of this symptom. The development of cold intolerance is

not related to injury severity. The symptoms remain either static or deteriorate slightly over time. Improvement is experienced by less than 10% of patients.

Keywords Cold intolerance · Disability · Hand injury · Impairment · Injury severity

Introduction

Cold intolerance is a well-recognized complication of crushing injuries and after replantation of amputations in the hand [3, 6, 8, 9, 11, 15, 26, 28]. The etiology of cold intolerance is unknown but is hypothesized to be a result of either vascular insufficiency [7], neurologic injury [10], or a combination of these factors [13, 18]. Patient age has also been considered a possible etiologic factor [24], although cold intolerance is frequently observed in children who undergo replantation of digit amputations [4].

The symptoms of cold intolerance are not usually considered to be serious and have been reported to resolve within 2 years of injury [2, 27]. Although they may be associated with significant impairment [19], in general, symptoms of cold intolerance are not considered in the evaluation of impairment resulting from a traumatic injury [1].

Anecdotal experience at our clinic, a large, tertiary referral center located in a temperate climate, has suggested that the prevalence and severity of cold intolerance after hand injury, and sometimes after elective hand surgery, is substantially greater than that reported in the literature. Equally important has been our observation that symptoms of cold intolerance do not resolve over time.

The objectives of our study were to determine the prevalence and severity of self-reported symptoms of cold

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intolerance in workers treated for injuries of the hand and the course of those symptoms over time.

Method

The study was conducted using the database of the Workplace Safety and Insurance Board (WSIB) in the Province of Ontario. The WSIB is a nonprofit agency, created by an Act of the provincial legislature, which insures about 70% of Ontario workers with work-related injuries and diseases. We hypothesized that if cold intolerance gradually decreases over time, the prevalence within cohorts of patients randomly selected from different years after injury should show a progressive decline.

The study was conducted in 2002 using cohorts with WSIB claims filed in 2000, 1998, 1996, and 1992. The workers in these cohorts established claims for their injuries 2, 4, 6, and 10 years before the study. It was assumed that the claims were made close to the time of injury. Any variation in this regard was assumed to be equal, and randomly distributed, in the four cohorts. Although it would have been desirable to have a cohort of individuals surveyed within a year of injury, access to the administrative database for these newer claims was limited.

A control group was also established for each year. This comprised a second cohort of workers with claims for non-trauma-related hand conditions randomly selected from the same years. Therefore, a total of eight cohorts were assembled, one trauma-related and one containing non-trauma cases, for each of the years under consideration (Fig. 1).

Cases for inclusion in the study were randomly selected from a combination of ICD-9 codes and a system of coding for the involved anatomic region used by WSIB to classify claims in their database. Trauma cases were defined by codes relating not only to amputations, avulsions, and crushing injuries, but also to fractures, lacerations, and other closed injuries classified as sprains or strains. This resulted in the inclusion of cases representing a relatively broad spectrum of trauma severity, including a substantial proportion of cases that would not necessarily have been considered to predispose to posttraumatic cold intolerance. The anatomic regions included hand, fingers, thumb, wrist, and forearm. The cases that were selected contained at least one identifier from both the list mechanisms of injury and from the targeted anatomic regions.

Cases representing controls were randomly selected from among those classified under the same system of diagnostic codes. The conditions included common non-trauma-related conditions like carpal tunnel syndrome, tendonitis, and a large proportion of cases classified as unspecified soft tissue injuries, often described as sprains or strains. It was unclear whether these actually represented injuries or were, for the most part, undiagnosed cases of hand and wrist pain. It is likely that some, but not all, of these cases had undergone surgical treatment. This information was not available because the database used for the study was based on diagnostic and not procedure codes. The same anatomic classification was also used. As for the trauma cohorts, the selected cases were identified with codes from both the diagnostic classification and from the anatomic labels.

The database included the patients' name, address, gender, date of birth, anatomical area of involvement, condition classification, claim number, and noneconomic loss (NEL) rating. The NEL is a rating of percentage of impairment, based on the guidelines of the American Medical Association [1], which was used in this study as a surrogate measure of condition severity. It was assumed that the impairment rating would be greater the more severe the extent of injury.

The questionnaire that was sent to the workers in each of the cohorts is shown in Fig. 2. The primary aim of the study was to establish the prevalence of cold tolerance. This was determined on the basis of a simple yes/no answer given in response to question 1 by each respondent. The additional questions were not validated or tested for reliability before use in this study. The data obtained from these questions was used in gaining further information about the nature of cold intolerance but were not used to address the main objective of the study, which was specifically to determine the prevalence of cold intolerance in each of the cohorts.

Some consideration was given to using the questionnaire on cold intolerance developed by McCabe [16], but it was felt that this instrument would not meet the objective of the study, which was to establish the prevalence of cold intolerance in this population because of its focus on symptom severity. The goal in prevalence studies is usually to maximize sensitivity, and the use of a simple yes/no response to the question of the existence of the symptom was thought to be more appropriate. In addition, the McCabe questionnaire focuses on exposure in the workplace. This might exclude workers who had not returned to

Figure 1 Schema showing composition of sample.

Figure 2 Questionnaire sent to workers in each of the eight cohorts.

Questionnaire sent to workers in each of the eight cohorts

1. Do you suffer from symptoms of pain or a sense of severe cold in the injured area of your hand when the hand is exposed to cold temperatures?

yes

no

If you answered “no” to question 1 there are no other questions to answer. If you answered yes to question 1 please answer questions 2, 3 and 4.

2. How often do you experience a sense of severe cold in the injured area of your hand when the hand is exposed to cold temperatures?

rarely

sometimes

frequently

constantly

3. When did these symptoms start in relation to your injury?

within four weeks of injury

between one and three months of injury

between three and six months of injury

between six months and one year of injury

more than one year after injury

4. Compared with the time that the symptoms first started, rate the severity of your problems with cold temperatures now

definitely worse

slightly worse about the same

slightly better

definitely better

work, and it was thought that this would potentially impose an undesirable bias on the results of the study.

Comparisons of the observations made in each of the cohorts were performed using the chi-square. Statistical significance was set at $p < 0.05$.

Results

A total of 7,077 surveys were sent out. This represented an average of about 930 surveys per cohort, except for the trauma cohort from 2000, which included only 563 cases. The smaller number of cases in this cohort was related to

the relatively recent nature of most of the claims. About 40% of the claims in this cohort were incomplete because they were still subject to adjudication.

After two sets of mailings, 1,777 responses (25%) were completed. The response rate among members of the trauma cohorts was consistently higher than among those in the non-trauma groups. Overall, the response rate of trauma patients was double that of the non-trauma patients (34% vs. 17%), and this difference was statistically significant ($p < 0.001$; Table 1).

Symptoms of cold intolerance were reported by between 92% and 95% of patients in the four trauma cohorts (Table 2). There was no statistically significant difference

Table 1 Percent response rate to mailed survey by cohort after two mailings.

Year	Trauma	Non-trauma	TOTAL
1992	28	17	22
1996	34	21	28
1998	36	18	27
2000	37	14	23
Total	34*	17	25

* $p<0.001$

between the prevalence of cold intolerance reported by any of the trauma cohorts. Cold intolerance was also reported in 59% to 69% of individuals in the non-trauma cohorts. The difference in the prevalence of cold intolerance reported for the trauma and non-trauma cohorts was statistically significant for all four years surveyed. The responses of the individuals in the trauma cohorts were considered reliable (Kuder-Richardson=0.97 or 0.98 for each cohort).

Among the members of the trauma cohorts, symptoms of cold intolerance began within 6 months after injury in 81% of cases and were present in 96% of individuals reporting the problem by 1 year. Thirty-five percent of cases reported the onset of symptoms within 1 month of injury. Cold intolerance did not begin until 1 year after injury in 10% of individuals in the trauma cohorts. Over 85% of the trauma cohort members reporting cold intolerance indicated that they felt their symptoms either frequently (32%) or constantly (54%). The proportion reporting constant symptoms was significantly greater than the percentage of patients from the non-trauma cohorts who experienced cold intolerance constantly (40%, $p<0.01$). The responses for frequency were considered reliable (Cronbach's $\alpha=0.71$ –0.82).

Fifty-two percent of the trauma patients affected by cold intolerance reported either slight or definite worsening of their symptoms since onset (Table 3). In 39% of cases, the symptoms were unchanged since onset. Only 9% of these workers reported improvement of their symptoms. The rate of worsening among non-trauma patients was slightly higher at 55% ($p<0.05$). The percentage of non-trauma patients reporting improvement was also slightly higher at 11%.

Table 2 Percentage of respondents reporting symptoms of intolerance.

Parameter	1992	1996	1998	2000
Non-trauma	59	63	69	62
Trauma	95*	92*	92*	93*

* $p<0.05$ **Table 3** Percentage of respondents reporting either improvement or worsening since onset.

Parameter	Slight or definite worsening	Slight or definite improvement
Trauma	52	9
Non-trauma	55*	11

* $p<0.05$

As expected, the impairment rating for individuals in the trauma cohorts was consistently higher than for workers in the non-trauma cohorts. The difference in NEL rating between trauma and non-trauma patients was statistically significant for each cohort. However, there was no difference between the impairment rating given to patients who reported cold intolerance and those who did not in each of the four cohorts (Table 4).

Discussion

Our data shows that the prevalence of self-reported symptoms of cold intolerance in patients who have sustained hand trauma is approximately the same in samples taken 2, 4, 6, and 10 years after injury. It is impossible to make definite conclusions about the evolution of these symptoms in individuals based on cross-sectional data; however, because the samples were all randomly assembled, it seems a reasonable assumption that the prevalence of cold intolerance should have decreased in each of the cohorts as a function of time from injury if the natural history was one of improvement over time as has been previously reported. The absence of any statistically significant differences in the proportion of patients reporting cold intolerance among any of the four trauma cohorts suggests that the symptoms probably do not decrease in individual cases through time. This conclusion is supported by the observation that in the majority of patients in all four trauma cohorts, symptoms of cold intolerance were reported to either remain static or deteriorate. Fewer than 10% of respondents indicated that the symptoms improved.

Table 4 Overall percentage impairment by cohort rating.

Cold intolerance	Trauma		Non-trauma	
	Present	Absent	Present	Absent
1992	9.0	9.0	1.5	1.4
1996	9.5	9.5	1.6	1.4
1998	10.1	10.1	1.2	1.2
2000	8.0	8.0	0.2	0.2

These findings confirm the earlier reports of a number of small series that have found that symptoms of cold intolerance persist through time [17, 20]. Our finding that only 9% of individuals experiencing cold intolerance after hand trauma note improvement conflicts with the finding of Backman et al. [2] who reported improvement in symptoms of cold intolerance in 60% of a series of 19 patients followed from between 1 and 8 years after replantation. Irwin et al. [10] have reported improvement in 21% of patients after an average follow-up of 4 years. They also found deterioration in 18% of cases over the same period of follow-up, a substantially smaller percentage than the 52% of trauma patients who reported worsening in our series.

Craig et al. [5] reported some improvement in the extent of cold sensitivity in a cohort of 123 individuals who had sustained hand trauma. At an evaluation between 1 and 3 months after injury, 85% of the patients reported symptoms of cold sensitivity. In 60% of these individuals, the symptoms were at least “moderate” by their rating scale. In a subgroup of the most severely affected individuals, there was a reduction in the average severity of the symptoms from “severe” or “extreme” to “moderate” at 3 years follow-up. In the group in whom the symptoms were initially ranked as moderate, there was no statistically significant change between the evaluation at 11 months and at 3 years after injury. These findings are consistent with our results in indicating both a very high prevalence of cold sensitivity after hand trauma and little change in this condition over time.

The prevalence of cold intolerance symptoms was also surprisingly high in the control group for each cohort. There are relatively a few papers describing the prevalence of cold intolerance in patients other than those who have undergone replantation. Zyluk et al. [28] reported that cold intolerance was noted in 44% of patients with upper extremity symptoms of reflex sympathetic dystrophy. Rayan and Coray [21] found cold intolerance in 23% of patients with chronic inflammatory tendinopathy of the lateral epicondyle. There have also been a number of papers describing cold intolerance following significant surgical procedures on a non-traumatized limb like the harvesting of a radial forearm flap [14, 22]. The prevalence of cold intolerance after these procedures has generally been low, usually less than 10%. Stern and Fulton [25] have reported that only 3% of patients requiring arthrodesis of the distal interphalangeal joint, for a variety of indications, developed symptoms of cold intolerance.

The prevalence of cold intolerance in our non-trauma cohorts was much higher than that reported in the literature. This might be an effect of self-reporting in a worker’s compensation population; however it is also possible that mild inflammatory conditions and compressive neuropathies, which comprised the majority of the control group

cases, may also lead to symptoms of cold intolerance. It was not possible to determine from our data whether or not non-trauma cases had undergone surgical treatment. As a result, the independent effects of these various conditions and any surgery carried out as treatment, on the development of cold intolerance, could not be established. In any case, all four cohorts showed a statistically significant difference between the trauma and non-trauma groups in the prevalence of cold intolerance. This indicates that there is an important effect of trauma on the development of these symptoms over and above the possible effect of self-reporting in a worker’s compensation population.

The severity of injury in the individuals comprising each trauma cohort could not be determined from the claims data. Instead, the non-economic loss percentage, a rating of impairment based on the AMA guidelines, was used as a surrogate measure of injury severity. We assumed that, in general, final impairment is linked to the extent of injury, although this may not necessarily hold for individual cases. As expected, the average non-economic loss percentage was much higher in the trauma groups than in the controls for each cohort. The difference between the NEL rating for trauma and non-trauma patients was statistically significant for each cohort. This suggests that this measure was effective at distinguishing large differences in the extent of the problem affecting the hand. The difference in the NEL ratings between the trauma and non-trauma cohorts also suggests that the samples were clearly different from one another. This is an important finding because errors in coding may have resulted in patients with relatively minor hand trauma being classified together with much more severely injured cases. There were no statistically significant differences in the impairment ratings within each cohort between workers reporting cold intolerance and those who did not have these symptoms in any of the trauma or non-trauma groups. This appears to indicate that the severity of hand trauma, at least as reflected by the final impairment rating, does not affect the development of symptoms of cold intolerance. It is possible that the final impairment rating may not be a sufficiently sensitive measure to allow subtle differences in hand injury severity thus explaining the apparent lack of importance of this factor as a potential predictor of cold intolerance. However, the prevalence of cold intolerance was so high in all of the trauma cohorts that it appears more likely that the severity of hand injury is not an important variable. The fact that cold intolerance was also highly prevalent among the non-trauma cohorts, though less so than in the trauma groups, suggests that even in the absence of a traumatic injury, cold intolerance may be experienced by patients who have less severe hand conditions like minor fractures, inflammatory tendinopathies, and compressive neuropathies. This observation supports the conclusion that the severity of hand

trauma may not predict the development of symptoms of cold intolerance. At the least, trauma severity may be only one factor in the causation of cold intolerance.

It is impossible to quantify the effect of “symptom magnification” that may have played a role in the high prevalence of cold intolerance that was observed in all of the groups. Like pain, cold intolerance is a subjective experience that is not easily or necessarily reliably measured. Nonetheless discomfort, whether on the basis of pain or cold intolerance will contribute, to some extent, to disability, in some cases beyond the degree of impairment that might be objectively evaluated. In the absence of reliable and valid instruments for assessment of this component of disability, self-reporting remains the only means of determining the presence of these important symptoms.

The finding that there was no difference between the impairment rating given to individuals who reported cold intolerance and those who did not, may also suggest that the presence of this symptom does not have a measurable impact on the extent of impairment attributed to the injury. The AMA guidelines [1] are specifically aimed at measuring impairment and do not necessarily reflect disability. A failure to consider symptoms that cannot be easily measured, such as cold intolerance, may lead to a substantial error in the determination of disability. This may particularly disadvantage individuals who work in refrigerated environments or outdoors in cold or temperate climates. Koman et al. [12] have shown that symptoms of cold intolerance have a negative impact on quality of life.

The response rate for workers with traumatic injuries was 34%, slightly below average for surveys of this nature [23]. The characteristics of the nonresponders was not analyzed, so it is unknown whether this group was systematically different from those who did respond; however, this is a possibility. The response rate among the trauma cohorts was double that of the non-trauma cohorts. Although there may have been several reasons for this observation, the most likely is that the survey gave the respondents an opportunity to bring attention to a symptom that may previously have received little or no consideration. This may have motivated many workers to respond and might have led to a reporting bias if those most likely to respond were those with cold intolerance. However, even if it were assumed that all nonrespondents did not experience cold intolerance, the rate of this symptom in the trauma cohorts would have been 31% and 11% in the non-trauma cohorts. The statistically significant difference in the prevalence of cold intolerance between the trauma and non-trauma cohorts would remain unchanged. More importantly, the observation that the prevalence of cold intolerance does not change through time would also be unchanged.

On the basis of our data, we conclude:

1. Symptoms of cold intolerance are highly prevalent in workers with significant injuries of the hand and among workers affected by any of a number of minor injuries, compressive neuropathies, or mild inflammatory conditions affecting the hand.
2. Cold intolerance is more likely to be observed among workers with significant hand injuries than in workers with minor injuries or conditions affecting the hand.
3. Among patients who sustain hand trauma, the development of symptoms of cold intolerance is not related to the severity of injury as reflected by a final rating of impairment.
4. In the overwhelming majority of individual patients, symptoms of cold intolerance remain either static or deteriorate slightly over time. Less than 10% of patients experience improvement in these symptoms once they have become established.
5. The natural history of cold intolerance is one of persistence of the symptoms between 2 and 10 years after onset.

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