Preferred sleep position on the side is associated with carpal tunnel syndrome

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Abstract

Background Although carpal tunnel syndrome is the most common compressive neuropathy, there is no comprehensive theory of its etiology. Because of the prevalence of night symptoms, we are interested in the role of sleep position in the causation of carpal tunnel syndrome.

Methods We performed a case–control study comparing the prevalence of preferred sleep position in 68 cases and 138 controls. Analysis was stratified by age and gender and controlled for body mass index.

Results We found a strong and significant association between a preference for sleeping on the side and the presence of carpal tunnel syndrome in men and in women less than 60 years of age. Body mass index was associated with carpal tunnel syndrome in women but not men.

Conclusions Our findings of a strong association between the presence of carpal tunnel syndrome and preferred sleeping on the side suggest a comprehensive unifying theory of causation.

Keywords Carpal tunnel syndrome · Causation · Sleep position · Case–control study

Introduction

Carpal tunnel syndrome (CTS) is the most common compression neuropathy with an estimated 400,000 procedures performed in the USA per year to release the carpal tunnel [15]. In spite of this huge burden of illness, the etiology of CTS has not been clearly elucidated. There has been a lot of interest in the work attribution of CTS and especially the potential that CTS could be caused by use of a keyboard; however, recent literature revealed significant weakness in the evidence linking CTS to work activity [17]. In fact, Atroshi has found that use of a keyboard may be protective of CTS [2]. While the potential for work causation of CTS has received a lot of interest, there has also been a lot of epidemiologic research investigating the associations of CTS not necessarily related to work. It has been repeatedly shown that CTS is associated with age [5, 22, 26], gender, [1, 22, 26], body mass index (BMI) [4, 7, 23, 24], pregnancy [25, 28], and wrist morphology [8, 12, 21, 27]. At this time, however, there has been no hypothesis that links these associations into a coherent comprehensive understanding of causation of CTS.

Gupta [11], Mackinnon [18], and others have elegantly laid out the ultrastructural and pathologic changes that can occur with nerve compression. It has been shown that wrist deviation increases the pressure in the carpal tunnel [30]. We have been interested in the night-time symptoms of CTS and the possibility that sleep position may be related to wrist deviation and play a role in causation. Most patients with CTS report night-time symptoms [13, 29], and an effective treatment of CTS is night-time splinting. We have performed an extensive literature review and reported our hypothesis that sleeping in a lateral position is an important link in a causal chain of events that ultimately

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can lead to CTS [19]. Testing this hypothesis, we have subsequently found that sleeping in a lateral position (on the side) is more common in women than men, and the proportion of women who report they prefer to sleep on their side increases with increasing age [20]. These are two previously unlinked epidemiologic associations of CTS that support our hypothesis. We found no association between BMI and preference for sleeping in a lateral position, or age and preference for sleeping in a lateral position in men.

Our hypothesis of sleep position as an important causative step in a mechanism of causation of CTS further predicts that CTS will be associated with sleeping in a lateral position. To test this hypothesis, we designed a case–control study.

Methods

We performed a case–control study with patients from a large urban primary care practice. The study was reviewed and received approval from the University IRB. Our general research strategy was to use a control population, selected from the previous cross-sectional survey, as a population to measure the underlying preference for sleeping on the side and other parameters of interest. These primary care patients are from the same study base from which the cases would be selected.

The cases of CTS were patients referred to an urban Hand Surgery specialty office with a chief complaint of numbness or tingling of the hands. Cases were identified by their chief complaint and through the history and physical examination by the hand surgeon. Exclusion criteria were an obvious cause of numbness of the hand that was not CTS, or CTS that was caused by an obvious anatomic factor such as rheumatoid synovitis or malunited distal radius fracture. No information was gathered about sleep position before the diagnosis and patient entry into the study. Each patient diagnosed with carpal tunnel syndrome completed the Katz–Stirrat Hand Diagram [14], the CTS-6 probability instrument that has been reported by Graham [9, 10] and the CTS disease-specific symptom severity score that has been shortened and reported by Atroshi [3]. We used the shortened version of the severity instrument to reduce the burden on the research participants since symptom severity was not a major feature of our study. For clarity, we will refer to the probability instrument as the CTS6P and the severity instrument as the CTS6S. Cases were included in the primary analysis if they had a hand diagram score of “classic” or “probable”.

Controls were chosen from a recent survey population as noted above. Patients presenting for care at the primary care setting were invited to complete a short data collection form that mirrored data collected for the cases. The hypothesis of

the study was not indicated and could not be discerned in the data collection instrument. Patients from the survey population were included as controls if they had no history of waking at night due to numbness of the hand.

All cases and controls completed a data collection form requesting age, gender, height, weight, and preferred sleep position from a choice of “on the back”, “on the front”, “on the left side”, or “on the right side”. Patients indicated if they worked shift work, if they had diabetes, their smoking history, severity of back or neck pain, the cause of any sleep difficulties, and a short insomnia instrument. All data were collected and entered into Excel and transferred to PASW 18 for analysis.

Initially, descriptive statistics were performed to describe the sample population. Continuous demographics are reported as means and standard deviations, while categorical variables are expressed as percentages. To evaluate if the odds an individual sleeps on their side could be predicted by CTS, logistic regression models were developed in which sleep position was made a function of CTS, adjusting for BMI. Analysis was stratified by gender and age. In women, we initially stratified age into three groups: 0–29, 30–59, and >60; however, there were only two women with CTS less than 30 years old so the younger two groups were combined. In men, because of the smaller sample size we did not stratify by age.

Results

Cases Data were collected from 68 consecutive cases of CTS. This included three patients classified by the hand diagram as “unlikely” and two as “possible” who were excluded from the primary analysis. Twenty six cases were classified as “probable” and 36 as “classic” by the diagram yielding 62 cases of CTS, 16 men (mean age 51.1, SD 15.6) and 46 women (mean age 54.1, SD 12.0), for the analysis. One patient did not complete the diagram.

Controls One hundred and thirty eight primary care patients from the survey population, 103 women (mean age 45.1, SD 18.1) and 35 men (mean age 43.7, SD 14.1), were included as the control population. These patients had no symptoms of night waking due to numbness. As the survey required voluntary participation of the primary care patients to create the control group, it is likely that older women are over-represented in the control population. For this reason, and because age and gender are known associations with CTS and with sleeping on the side, the analysis is stratified by both gender and age.

All men (100%) with CTS reported their preferred sleep position was on their side. This represented a significant

difference when compared to the control population (28.6%; $p<0.001$). In men, there was no association between the presence of CTS and BMI (Fig. 1).

In women under the age of 60 years, the odds a woman sleeps on her side is significantly higher in patients with CTS compared to those without CTS (OR=8.7, 95% CI 1.9–39.4, $p=0.05$). When adjusted for BMI, the association between CTS and sleeping on the side in women less than 60 years old was still significant (OR=8.0, 95% CI 1.7–37.7, $p=0.016$). In addition, BMI was also significantly associated with the presence of CTS in women under the age of 60 years ($p<0.001$; Fig. 2). The relationship between CTS and sleeping on the side remained significant when the cutoff age for women was changed to 63 years and less.

In women aged 60 years and older, there was a significant association between the presence of CTS and BMI (28.1 vs. 32.8, OR 1.11, 95% CI 1.001–1.23, $p=0.048$). In addition, nine of 14 (64.3%) women of age 60 years and older with CTS stated a preference for sleeping in a position on their side compared to 25 of 27 without CTS (OR=0.12, 95% CI 0.02–0.79, $p<0.05$). In women 60 years and older, there was a significant association between CTS and neck pain ($p=0.016$).

In the survey population with no waking at night due to numbness, 59.7% (83/139) of patients preferred to sleep on their side. In the survey population, 107 patients complained of night waking with numbness of their hands. Eighty one (75.7%) of those patients reported a preference for sleeping on the side. In patients diagnosed by the hand

Fig. 1 Box plot shows no difference in body mass index in cases and controls at any age in men

Fig. 2 Box plot showing the relationship between age in decades and body mass index for women with carpal tunnel syndrome and those without. Younger women with carpal tunnel syndrome have a higher body mass index than those without carpal tunnel syndrome

surgeon as CTS with a hand diagram rated as “unlikely” or “possible”, four of five or 80% preferred to sleep on their side. This preference rate for sleeping on the side was 55 of 62 or 88.7% of the CTS patients rated as “classic” or “probable” on the hand diagram (Table 1). We report the results of the CTS6P, CTS6S, and the insomnia data in another manuscript.

Discussion

We found a strong association between sleeping in a lateral position and the presence of CTS (Fig. 3). This was most apparent in men. All men with CTS reported they preferred to sleep on their side. In women less than 60 years of age, there was a strong association between sleeping on the side and CTS. There was also an association between increased BMI and CTS in women less than 60 years of age and to a lesser degree in those women age 60 years and above.

There appears to be a complex relationship between gender, age, BMI, sleep position, and the development of CTS. It is not possible to prove with this study design if sleeping on the side is a causative factor in the development of CTS. In our opinion, however, given the findings of our study and considering the biology of CTS, we believe sleeping on the side is an important causal step in the development of CTS. Through our results, we have linked

Fig. 3 Bar graph showing the proportion of all participants in each decade of age who stated a preference for sleeping on the side

the previously seemingly unconnected known associations of CTS into a plausible causative mechanism.

In men, all patients with CTS stated a preference for sleeping on their side. In this patient population of men, there was no association between BMI and the development of CTS. Based on our hypothesis, we believe that sleeping on the side increases the probability of wrist deviation, increasing the pressure in the carpal tunnel and compressing the median nerve. Since fewer men than women prefer to sleep on their side, the decreased risk for the development of CTS in men compared to women may be based on the decreased preference for sleeping on the side in men. It is interesting that although a lower proportion of men than women prefer to sleep on their side, all men with CTS did prefer that position.

In men, we did not find an association between BMI and the presence of CTS. Similar to many previously published studies, however, we have a small population of men so it is possible that an association between CTS and BMI in men might not be detected in our study. Other studies have found a significant association between BMI and CTS in men and women [7, 31]. Our initial hypothesis stated that

increased BMI would be the stimulus for patients to sleep on their side so we expected to see an increased BMI and increased prevalence of preference for sleeping on the side in patients with CTS.

In women less than 60 years of age, there was a strong association between CTS, sleeping on the side, and BMI. The association is still present but to a lesser degree when BMI is controlled. From our data, we cannot state whether sleep position mediates the effect of BMI, the reverse, or if this is chance or confounding. Our initial hypothesis was that increased BMI causes people to sleep on their side. Our previous cross-sectional survey did not support this simple mechanism however. In addition, the absence of BMI as an associated characteristic of CTS in men suggests to us that BMI may have another mechanism of action other than as a determinant for sleeping on the side in the causation of CTS. We believe this may be evidence for the role of wrist morphology in the development of CTS and suggests another mechanism for the influence of increased BMI.

It has been noted that wrist morphology is associated with CTS [6, 8, 12]. The wrist ratio (WR), the ratio of the simple measurement of wrist height and width, is elevated in CTS patients and is also known to be higher in women compared to men [6]. We suggest that a higher WR increases the probability of compression of the median nerve with wrist deviation or may increase the probability of wrist deviation with sleep. MRI studies have shown reduced cross-sectional area of the carpal canal, especially distally, with wrist flexion [6], and it has been repeatedly shown that pressure in the carpal canal increases with wrist deviation [30]. An increased WR may increase the effect of deviation of wrist position producing compression of the median nerve. This is a second potential mechanism to explain an increased prevalence of CTS in women. We believe increased BMI acts synergistically with increased WR to create compression of the median nerve with wrist flexion or extension. We believe men are somewhat protected from the influence of increased BMI by having a lower WR. We believe that sleeping in a lateral position increases the probability of wrist flexion or extension. The effect of increased WR is then realized and enhanced by increased BMI. In this way, increased BMI can be associated with CTS in men and women but we believe it will be more profound in women. This also provides a mechanism for the influence of any entity that increases the volume of the carpal tunnel.

We were surprised that older women with CTS related a preference for sleeping on their side less than the control population. The reason for this is not clear from our study. The proportion of elderly women who prefer to sleep on their side is high so a large sample will be required to evaluate this association in the elderly.

Table 1 Percentage of patients who prefer to sleep on their side

Survey population	No night waking	83/139	60%
Survey population	Night waking	81/107	76%
Cases	Unlikely or possible diagram	4/5	80%
Cases	Classic or probable diagram	55/62	89%

Bland believes that CTS in the older population has a different pathophysiology than CTS in younger patients [4]. We did find that CTS in older women is significantly associated with neck pain. Neck pain could cause the patients to have a preference for sleep position other than on their side and could be a site of proximal nerve compression that further enables the development of distal compression. One elderly woman with CTS who stated a preference for sleeping on her back (and coded as such) wrote a note in the margin of her questionnaire that she truly preferred to sleep on her side but she could not as it would make her hands go numb! It is possible that patients with CTS may alter their sleep position to avoid wrist deviation although it is not clear why this would affect only the older population of women. We also note that the reporting of preferred sleep position other than on the side does not indicate the patient never sleeps in a lateral position. Kubota has shown that sleep position varies through the night with the stated preference representing the most assumed position [16]. There may be some women with wrist morphology who could develop significant compression of the nerve with lesser time spent in a wrist deviated position. Further, our hypothesis does not exclude the possibility that the median nerve can be compressed with other sleep positions.

Our theory is that sleeping on the side, which is related to age and gender, increases the probability of wrist deviation. Increased BMI and wrist morphology act in concert with wrist deviation to increase pressure on the median nerve. Our theory also integrates the possible causes of CTS not related to sleep. Sleep position is one cause of wrist deviation, causing increased pressure in the carpal tunnel. This could be enhanced by any other cause of increased pressure such as synovial swelling or a mass in the carpal tunnel. Theoretically our hypothesis can accommodate mechanisms of compression of work-induced CTS whether from lumbrical incursion, synovial swelling, or deviated wrist position at work. A synergistic mechanism of symptom development could be from increased susceptibility of the median nerve in the carpal tunnel as might be the case with diabetes or multiple level compression. This theory is the first to unify this group of previously seemingly disparate associations of CTS.

Our previous cross-sectional survey and the evaluation of the cases we have chosen give us the opportunity to perform further evaluation to check the veracity of our findings. If sleeping on the side is truly associated with CTS, the patient population with the lowest proportion of CTS patients will have the lowest rate of sleeping on the side and the “most pure” group of CTS patients will have the highest proportion of patients who prefer to sleep on the side. Table 1 shows the proportion of patients who reported they preferred to sleep on their side in each of these groups, stratified by probability of CTS. As the probability of CTS

increases, the proportion of people who prefer to sleep on their side also increases. This supports our findings that sleeping on the side is truly associated with CTS.

We could have performed electrodiagnostic testing as a method to identify a population with a high probability of CTS. This would have required us to use personal identifiers to link the electrodiagnostic test with the other patient data and would require more intense IRB scrutiny and a higher level of logistic difficulty. It was our decision, strongly supported in the literature, that the history and physical examination, coupled with the hand diagram, would satisfy our requirements for diagnostic specificity [14]. We suggest the use of the hand diagram in all clinical studies of CTS to indicate the probability of disease.

Our study simply asked the participants to indicate their preferred sleep position. This has been studied in men by Kubota who found that the stated preference for sleep position is the position most assumed [16]. This study also noted the sleep position varied throughout the night so an indication of preferred sleep position on the side does not indicate this is the only position assumed during sleep and an indication of a preference for another position does not indicate the person never sleeps on the side. The stated preference for sleep position is a “noisy” measurement and further studies will require a large sample size to clarify some of our initial findings.

This study does not address work attribution of CTS except by indirectly supporting a general mechanism of causation. It seems logical that any position or activity that compresses the median nerve in the carpal tunnel to a degree that would cause numbness is a potential cause of CTS. We have provided evidence that sleeping on the side is one such activity and we believe it is an important causative factor.

References

1. Atroshi I, Gummesson C, Johnsson R, Ornstein E, Ranstam J, Rosen I. Prevalence of carpal tunnel syndrome in a general population. *JAMA*. 1999;282:153–8.
2. Atroshi I, Gummesson C, Ornstein E, Johnsson R, Ranstam J. Carpal tunnel syndrome and keyboard use at work: a population-based study. *Arthritis Rheum*. 2007;56(11):3620–5.
3. Atroshi I, Lyren PE, Gummesson C. The 6-item CTS symptoms scale: a brief outcomes measure for carpal tunnel syndrome. *Qual Life Res*. 2009;18(3):347–58.
4. Bland JD. The relationship of obesity, age, and carpal tunnel syndrome: more complex than was thought? *Muscle Nerve*. 2005;32:527–32.
5. Bland JP, Rudolfer SM. Clinical surveillance of carpal tunnel syndrome in two areas of the United Kingdom, 1991–2001. *J Neurol Neurosurg Psychiatry*. 2003;74:1674–9.
6. Bower JA, Stanisz GJ, Keir PJ. An MRI evaluation of carpal tunnel dimensions in healthy wrists: implications for carpal tunnel syndrome. *Clin Biomech*. 2006;21:816–25.

7. Boz C, Ozmenoglu M, Altunayoglu V, Velioglu S, Alioglu Z. Individual risk factors for carpal tunnel syndrome: an evaluation of body mass index, wrist index, and hand anthropometric measurements. *Clin Neurol Neurosurg*. 2004;106:294–9.
8. Farmer JE, Davis TRC. Carpal tunnel syndrome: a case-control study evaluating its relationship with body mass index and hand and wrist measurements. *J Hand Surg Eur*. 2008;33(4):445–8.
9. Graham B. The value added by electrodiagnostic testing in the diagnosis of carpal tunnel syndrome. *J Bone Joint Surg Am*. 2008;90(12):2587–93.
10. Graham B, Regehr G, Naglie G, Wright JG. Development and validation of diagnostic criteria for carpal tunnel syndrome. *J Hand Surg*. 2006;31A:919–24.
11. Gupta R, Rummler L, Steward O. Understanding the biology of compressive neuropathies. *CORR*. 2005;436:251–60.
12. Kamolz L-P, Beck H, Haslik W, Hogler R, Rab M, Schrogendorfer KF, et al. Carpal tunnel syndrome: a question of hand and wrist configuration. *J Hand Surg*. 2004;29B(4):321–4.
13. Katz JN, Larson MG, Sabra A, Krarup C, Stirrat CR, Sethi R, et al. The carpal tunnel syndrome: diagnostic utility of the history and physical examination findings. *Ann Intern Med*. 1990;112:321–7.
14. Katz JN, Stirrat CR, Larson MG, Fossel AH, Eaton HM, Liang MH. A self-administered hand symptom diagram for the diagnosis and epidemiologic study of carpal tunnel syndrome. *J Rheumatol*. 1990;17(11):1495–8.
15. Keller RB, Largay AM, Soule DN, Katz JN. Maine Carpal Tunnel Study: small area variations. *J Hand Surg*. 1998;23A:692–6.
16. Kubota T, Ohshima N, Kunisawa N, Murayama R, Okano S, Mori-Okamoto J. Characteristic features of the nocturnal sleeping posture of healthy men. *Sleep Biol Rhythms*. 2003;1:183–5.
17. Lozano-Calderon S, Anthony S, Ring D. The quality and strength of evidence for etiology: example of carpal tunnel syndrome. *J Hand Surg Am*. 2008;33(4):525–38.
18. Mackinnon SE. Pathophysiology of nerve compression. *Hand Clin*. 2002;18(2):231–41.
19. McCabe SJ, Uebele AL, Pihur V, Rosales RS, Atroshi I. Epidemiologic associations of carpal tunnel syndrome and sleep position: is there a case for causation? *Hand NY*. 2007;2(3):127–34.
20. McCabe SJ, Xue Y. Evaluation of sleep position as a potential cause of carpal tunnel syndrome: preferred sleep position on the side is associated with age and gender. *Hand*. 2010. doi:10.1007/s11552-010-9271-y.
21. Moghtaderi A, Izadi S, Sharafadinzadeh N. An evaluation of gender, body mass index, wrist circumference, and wrist ratio as independent risk factors for carpal tunnel syndrome. *Acta Neurol Scand*. 2005;112:375–9.
22. Mondelli M, Giannini F, Giacchi M. Carpal tunnel syndrome incidence in a general population. *Neurology*. 2002;58:289–94.
23. Nathan PA, Keniston RC. Carpal tunnel syndrome and its relation to general physical condition. *Hand Clin*. 1993;9:253–61.
24. Nordstrom DL, Vierkant RA, DeStefano F, Layde PM. Risk factors for carpal tunnel syndrome in a general population. *Occup Environ Med*. 1997;54:734–40.
25. Padua L, Aprile I, Caliandro P, Carboni T, Meloni A, Massi S, et al. Symptoms and neurophysiological picture of carpal tunnel syndrome in pregnancy. *Clin Neurophysiol*. 2001;112:1946–51.
26. Phalen GS. The carpal-tunnel syndrome. Seventeen years' experience in diagnosis and treatment of six hundred fifty-four hands. *J Bone Joint Surg Am*. 1966;48A:211–28.
27. Radecki P. A gender specific wrist ratio and the likelihood of a median nerve abnormality at the carpal tunnel. *Am J Phys Med Rehabil*. 1994;73(3):157–62.
28. Stolp-Smith KA, Pascoe MK, Ogburn Jr PL. Carpal tunnel syndrome in pregnancy: frequency, severity, and prognosis. *Arch Phys Med Rehabil*. 1998;79:1285–7.
29. Wainner RS, Fritz JM, Irrgang JJ, Delitto A, Allison S, Boninger ML. Development of a clinical prediction rule for the diagnosis of carpal tunnel syndrome. *Arch Phys Med Rehabil*. 2005;86:609–18.
30. Weiss ND, Gordon L, Bloom T, So Y, Rempel DM. Position of the wrist associated with the lowest carpal-tunnel pressure: implications for splint design. *J Bone Joint Surg Am*. 1995;77:1695–9.
31. Werner RA, Albers JW, Franzblau A, Armstrong TJ. The relationship between body mass index and the diagnosis of carpal tunnel syndrome. *Muscle Nerve*. 1994;17(12):1491–3.