

PEER REVIEW HISTORY

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ARTICLE DETAILS

TITLE (PROVISIONAL)	Identifying relationships between sleep posture and non-specific spinal symptoms in adults: A scoping review
AUTHORS	Cary, Doug; Briffa, Kathy; McKenna, Leanda

VERSION 1 - REVIEW

REVIEWER	Eivind Skarpsno Norwegian University of Science and Technology, Norway
REVIEW RETURNED	11-Dec-2018

GENERAL COMMENTS	<p>Overall comment: Overall, this is an interesting paper that clearly shows the lack of data about sleep posture and spinal symptoms. However, the paper has some limitations that should be addressed properly. I have therefore added some comments the authors should consider. I also think the paper would benefit from a thorough edit for grammar and syntax.</p> <p>Abstract:</p> <ol style="list-style-type: none">1) The authors mention two aims in the Abstract, however, three objectives are stated in the methods and discussion.2) It is correct that this scoping review highlight the potential importance of sleep posture with respect to spinal symptoms. However, based on the four included studies (and the low quality of these studies), I think the authors are too optimistic in the following statement: "Side lying appears protective of cervical symptoms and possibly spinal symptoms in general...". If the authors agree, I think the paper will benefit from a modification of the conclusion. I think this paper would be of interest for clinicians and researchers, and I therefore propose that the authors put more focus on the weaknesses (and future directions). <p>Methods:</p> <ol style="list-style-type: none">1) Follow up on comment 1 (Abstract). Please be more clear in the aim and objectives, and make sure that there is consistency throughout the paper.2) Table 1: Case-control studies and cross-sectional studies are epidemiological studies. Please modify this column.3) Table 1: I know that two of the papers are from the same population; however, it is a bit confusing that the authors write that they found four papers when they include five. <p>Discussion:</p> <ol style="list-style-type: none">1) First paragraph: Three objectives (see previous comment: Abstract #1)2) Page 20, line 41: "The study designs identified in this scoping review were appropriate to use for the research question". Maybe
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	<p>I'm wrong, but I do not think a case-control study is appropriate for this objective. Likewise, there are clear limitations with cross-sectional studies. For instance, prospective studies with repeated measurements would probably be the best. Nevertheless, it depends on the research question.</p> <p>3) Page 20, line 50: "There was a strong gender bias in two studies, and a restricted age of included participants in one study". This is not a limitation. For instance, previous studies indicates that both age and sex are associated with body postures and nocturnal movements. Thus, the best way to deal with this potential confounding is by using a homogenous sample (restricted by gender, age, etc.).</p> <p>4) The included studies have major limitations that should be addressed properly. For instance, self-report is a major limitation. Further, the quality of the included study is poor, which prevent recommendations. The study should also discuss the need for high quality studies and be clearer about future directions.</p>
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REVIEWER	Achim Elfering University of Bern, Switzerland
REVIEW RETURNED	19-Dec-2018

GENERAL COMMENTS	<p>Only four studies out of 4186 hits were included in this review. Two studies examined symptoms arising from the lumbar spine, one the cervical spine, and one the whole spine. Results suppose side lying appears protective of cervical symptoms and possibly spinal symptoms in general.</p> <p>A merit of the study is that it stimulates further study on sleep posture, daily pain, and waking symptoms. However, the review also has some weaker points that should be addressed in a revision:</p> <p>1 Sleep posture is self-reported in three studies and assessed by infrared measurement in another study. However, one might question reliability of self-reported sleep posture. And, is it about the dominant sleep posture, or time in one posture, or change of sleep postures ? The questionnaire items are not very distinct, and the results do not differentiate. Moreover, how many nights per person have to be observed in order to explain the association between sleep posture and waking symptoms within a person? Finally, the direction of potential influence is unclear. Reversed causation (changing posture because of symptoms) is also likely. Thus, the review should focus more on a methodological discussion and an make more recommendations for future research (now recommendations on page 20 include 20 lines from line 21 to line 41).</p> <p>2 Actigraphy studies were excluded. Nevertheless, as a reader, I would like a comparison of effect sizes that relate to sleep posture and effect sizes that relate to activity during night, or indicators of sleep quality like sleep fragmentation and sleep efficiency.</p> <p>3 A minor point is clear writing. Not all sentences were clear,, e.g., Line 13 : Is this sentence correct? „When upright, compressive load due to gravity and muscle contraction(17, 18) is likely to be far less during the day than during sleep, creating a low</p>
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	compression environment.“ or should it be « far less during sleep than during the day » ?
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REVIEWER	Tássia Silveira Furlanetto Federal University of Rio Grande do Sul Brazil
REVIEW RETURNED	17-Jan-2019

GENERAL COMMENTS	<ul style="list-style-type: none"> - Introduction: it is important identify what are spinal symptoms. Just pain? Or diseases and other dysfunctions will also be considered? This clarity of the spinal symptoms should be present in the rest of the text. - Exclusion Criteria: The use of sleeping pills was found? - Overall, the text is very well written and methodologically very consistent. I congratulate the authors for their commitment to the development of the study
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VERSION 1 – AUTHOR RESPONSE

Reviewer 1

1. Overall comment: Overall, this is an interesting paper that clearly shows the lack of data about sleep posture and spinal symptoms. However, the paper has some limitations that should be addressed properly. I have therefore added some comments the authors should consider. I also think the paper would benefit from a thorough edit for grammar and syntax.

a. Author reply; Thank you to the Reviewer for their time and expertise in reviewing our manuscript. We have appreciated the comments made by the reviewer and as a result of the changes suggested, now believe the manuscript is better focused and addresses key points relating to improving future research in the area of sleep posture and waking symptoms.

2. Abstract:

The authors mention two aims in the Abstract, however, three objectives are stated in the methods and discussion.

a. Author reply; As suggested by the Reviewer, we have reviewed objectives and now have the three objectives listed consistently throughout the paper. We have added the objectives into the Abstract from line 29 to 32. For consistency the words ‘sample size’ have been removed from the discussion section.

3. It is correct that this scoping review highlight the potential importance of sleep posture with respect to spinal symptoms. However, based on the four included studies (and the low quality of these studies), I think the authors are too optimistic in the following statement: “Side lying appears protective of cervical symptoms and possibly spinal symptoms in general...”. If the authors agree, I think the paper will benefit from a modification of the conclusion. I think this paper would be of interest for clinicians and researchers, and I therefore propose that the authors put more focus on the weaknesses (and future directions).

a. Author reply; As suggested by the Reviewer we have altered the conclusion, lines 49 - 52 to read “This scoping review highlights the importance of evaluating sleep posture with respect to waking symptoms and has provided preliminary information regarding relationships between sleep posture and spinal symptoms. However, there were not enough high-quality studies to adequately answer our research question.”

4. Methods:

Follow up on comment 1 (Abstract). Please be more clear in the aim and objectives, and make sure that there is consistency throughout the paper.

a. Author reply; As noted in Point 1, changes have been made to make aims and objectives consistent throughout the paper. Under objective 3 line 347- 348 in the discussion, the sentence “In respect to Objective 3; results, conclusions and recommendations, authors recommended side lying as the sleep posture least likely to provoke cervical or lumbar spinal symptoms.” has been included.

5. Table 1: Case-control studies and cross-sectional studies are epidemiological studies. Please modify this column.

a. Author reply; The word Epidemiology has been added in Table 1, next to both case-controlled and cross-sectional.

6. Table 1: I know that two of the papers are from the same population; however, it is a bit confusing that the authors write that they found four papers when they include five.

a. Author reply; As noted by the Reviewer this is confusing. In the original identification of papers to include, some additional data from the 5th paper was considered important, but later not used in the extraction. For this reason, reference to the 5th paper has been removed from the section Study Design and Population Characteristics, Table 1 and Table 3.

7. Discussion:

First paragraph: Three objectives (see previous comment: Abstract #1)

a. Author reply; As previously noted by the Reviewer in Point 1, this has been changed.

8. Page 20, line 41: “The study designs identified in this scoping review were appropriate to use for the research question”. Maybe I’m wrong, but I do not think a case-control study is appropriate for this objective. Likewise, there are clear limitations with cross-sectional studies. For instance, prospective studies with repeated measurements would probably be the best. Nevertheless, it depends on the research question.

a. Author reply; Our research question was, ‘is there a relationship between sleep posture and spinal symptoms?’ Epidemiological studies are valuable to examine possible association between variables, such as sleep posture, in this case between those with and without spinal symptoms. We agree with the Reviewer that a prospective, repeated measures design is also a good option for this research question. This research design would enable the collection of baseline data associated with sleep posture and spinal symptoms, comparing those with and without spinal symptoms and note changes in those symptoms following a sleep posture intervention. This is in fact the research design chosen by the authors of this scoping review in a completed intervention study to be published.

b. As identified by the Reviewer, cross sectional studies feature strongly in this scoping review and to address this the following was included “Nonetheless, considerably more research including longitudinal studies are required before causal relationships between sleep posture and spinal symptoms could be concluded.” from line 350 – 352 and “should be further explored in future research using larger scale longitudinal studies” line 421 – 422.

9. Page 20, line 50: “There was a strong gender bias in two studies, and a restricted age of included participants in one study”. This is not a limitation.

a. Author reply; Thank you to the Reviewer for bringing the need for greater clarity on this point to our attention. We have altered the sentences to now read “The age and gender ratios of included

studies were not representative of typical cervical and lumbar pain populations (1-3). Generalisation of the results of the included studies needs to be considered with some caution because of a strong gender bias in two studies(4, 5) and a restricted age of included participants in one study (5).” (lines 355 – 359). This point is further discussed in point 9c.

For instance, previous studies indicate that both age and sex are associated with body postures and nocturnal movements.

b. Author reply; We agree with the Reviewer that in the broader literature there are studies noting associations between sleep posture and movement that change with age (i.e., humans move less with increasing age and spend more time in side lying, specifically right side lying and less in prone.) However, we are unaware of any studies using objective measures of sleep posture that conclude or comment on gender influencing sleep posture and nocturnal movements. Gordon et al., 2007 noted that females were significantly less likely to sleep in supine, but used self-report as their measure of sleep posture. More studies, using an objective measure of sleep posture, are needed to examine the relationship between gender and all sleep postures.

Thus, the best way to deal with this potential confounding is by using a homogenous sample (restricted by gender, age, etc.).

c. Author reply; We have included in the recommendations for future research the following “Ideally studies should account for confounding factors such as age and gender through study design or statistical analysis.” from line 407 – 408.

10. The included studies have major limitations that should be addressed properly. For instance, self-report is a major limitation. Further, the quality of the included study is poor, which prevent recommendations. The study should also discuss the need for high quality studies and be clearer about future directions.

a. Author reply; An important element of this scoping review was the identification of previous research methodology and we agree with the Reviewer that the included studies have methodological research design limitations, for example, only using self-report as a measure of sleep posture.

b. In association with Aim 3 of the scoping review, we wanted to collect identified recommendations as presented by the authors of each paper (Table 3). Separate to the recommendations presented by authors of each included paper and following a synthesis of all the information from the four included studies we wanted to provide recommendations to improve the quality of future studies. As suggested by the Reviewer we have amended the Discussion section and have included a new paragraph solely addressing future research recommendations from line 404 – 422.

Reviewer 2

1. Only four studies out of 4186 hits were included in this review. Two studies examined symptoms arising from the lumbar spine, one the cervical spine, and one the whole spine. Results suppose side lying appears protective of cervical symptoms and possibly spinal symptoms in general. A merit of the study is that it stimulates further study on sleep posture, daily pain, and waking symptoms. However, the review also has some weaker points that should be addressed in a revision:

a. Author reply; Thank you to the Reviewer for their time and expertise in reviewing our manuscript. We appreciate your input in assisting us to improve aspects of our manuscript.

2. Sleep posture is self-reported in three studies and assessed by infrared measurement in another study. However, one might question reliability of self-reported sleep posture.

a. Author reply; We agree with this observation of the Reviewer. Self-report is discussed from line 371 - 374, where we report how some included authors acknowledge this as a limitation and by other non-included authors saying the same. We have emphasised the Reviewer's observation in our amended discussion section and recommended to not rely on self-report (lines 413 - 414) as a valid and objective measure of sleep posture.

3. And, is it about the dominant sleep posture, or time in one posture, or change of sleep postures? The questionnaire items are not very distinct, and the results do not differentiate.

a. Author reply; We completely agree with the Reviewer that these are important points to consider. Abanobi et al., 2015 and Gordon et al., 2007 focused on 'usual/common' sleep posture, Cary et al., 2016 measured time in each sleep posture, while Desouzart et al., 2016 did not specify at baseline participant's sleep posture. Time in a posture and changes in sleep posture can only be quantified when sleep posture is measured using a valid and objective measure which was only undertaken by Cary et al., 2016. In the final paragraph of the Discussion section, line 413 to 414 we have added "Using a valid, objective measure of sleep posture instead of self-report, would also enable determination of time spent in each sleep posture and the number of sleep posture changes".

4. Moreover, how many nights per person have to be observed in order to explain the association between sleep posture and waking symptoms within a person?

a. Author reply; This is another good point identified by the Reviewer. However, included studies did not collect this information, rather they asked general questions about sleep posture and spinal symptoms. From our broader reading we are unaware of any research that specifically answers this question. What is reported from studies is that sleeping routines vary from person to person, more so than an individual from night to night (6-9). This would indicate that examining a person over two to three nights may be a good balance between accuracy of data and inconvenience to participants. It has also been shown when using a particular recording protocol (Cary et al 2016), a first night effect was not induced, which indicates that observed sleep postures were representative of the person being observed using the protocol, but also that sleep routines were reasonably consistent over two nights. Our paper titled "Examining the reliability and validity of a portable sleep posture assessment protocol, using infrared cameras, under a variety of light and bed cover situations in the home environment" has been accepted for publication in *WORK: A Journal of Prevention, Assessment & Rehabilitation* details the validity of this recording protocol.

5. Finally, the direction of potential influence is unclear. Reversed causation (changing posture because of symptoms) is also likely. Thus, the review should focus more on a methodological discussion and an make more recommendations for future research (now recommendations on page 20 include 20 lines from line 21 to line 41).

a. Author reply; We agree with the Reviewer that methodology is very important in regards to the answering the research question and have added "Nonetheless, considerably more research including longitudinal studies are (10)required before causal relationships between sleep posture and spinal symptoms could be concluded." from line 350 – 352.

6. Actigraphy studies were excluded. Nevertheless, as a reader, I would like a comparison of effect sizes that relate to sleep posture and effect sizes that relate to activity during night, or indicators of sleep quality like sleep fragmentation and sleep efficiency.

a. Author reply; Actigraphy is commonly used in sleep research because it is affordable and can efficiently collect data over a period of several days. However, the aims of this scoping review focused on papers examining the relationship between sleep posture and spinal symptoms and no papers

included in the scoping review used actigraphy to measure sleep posture in relation to spinal symptoms and data was therefore not collected.

b. Effect size was calculated using an online calculator (11) for Desouzart et. al., and the following information has been added, “Firstly, a pooled standard deviation for each group was calculated for change from baseline to final measure. Then this pooled standard deviation from each group was used to calculate the between group effect size and 95% confidence interval (see Table 3). The resultant confidence interval indicates that significant differences between groups was unlikely.” Line 284 – 288 and the following was added in Table 3 “Between group effect size calculated to be 0.81 (95% CI -0.11 to 1.72).”

c. Effect size for Cary et. al., 2016 was calculated using the Independent Samples Jonckheere-Terpstra Test and the results are included in Table 3 as “Independent Samples Jonckheere-Terpstra Test; supine $r_j = 0.03$; SSL $r_j = 0.00$; $\frac{3}{4}$ SL $r_j = 0.34$ and prone $r_j = 0.31$.” and an associated footnote.

d. The recommended method (10) to present effect sizes for papers using regression analysis is by presenting odds ratios. Odds ratios were used to describe effect sizes (Table 3) in the other two epidemiological papers (4, 12) and additional information was added to assist in interpretation of the presented odds ratios.

e. Sleep fragmentation and sleep efficiency were not relevant to the aims of this scoping review and data was therefore not collected.

7. A minor point is clear writing. Not all sentences were clear, e.g., Line 13: Is this sentence correct? “When upright, compressive load due to gravity and muscle contraction(17, 18) is likely to be far less during the day than during sleep, creating a low compression environment.” or should it be « far less during sleep than during the day » ?

a. Author reply; We thank the Reviewer for highlighting this sentence and following their recommendation it now reads “Compressive load due to gravity and muscle contraction(13, 14) is likely to be far more during the day than during the night.” lines 91 – 92.

Reviewer 3

1. Introduction: it is important identify what are spinal symptoms. Just pain? Or diseases and other dysfunctions will also be considered? This clarity of the spinal symptoms should be present in the rest of the text.

a. Author reply; Spinal symptoms as discussed and referenced in the Introduction section include cervical and lumbar pain, but also stiffness and bothersomeness. We have changed the first sentence to “Cervical and lumbar symptoms like pain” and included “Other types of symptoms like stiffness and bothersomeness, still important to patients are less well investigated.” at line 79 - 80, acknowledging that symptoms other than pain are also experienced. Data extracted from the included studies was based upon inclusion criteria, outlined at line 140 and included studies that examined spinal symptoms of pain, stiffness and bothersomeness. Diseases and other dysfunction were specifically excluded from inclusion in this scoping review and details of these and all other exclusions are noted from line 148 to 161.

2. Exclusion Criteria: The use of sleeping pills was found?

a. Author reply; We are unsure of the nature of this statement from the Reviewer and are answering in the belief that the Reviewer is asking was the use of sleeping pills examined in relation to papers included in this scoping review. Included studies such as Desouzart et al., 2016 (pg. 236)

specifically excluded participants if they were taking sleep tablets or antidepressants and Gordon et al., 2007 and Abanobi et al., 2015 noted the consumption of medications as part of their data collection. Cary et al., 2016 had no exclusion criteria as the main aims of their pilot study were to field test their recording protocol, determine if there was a first night effect and identify relationships between sleep posture and spinal symptoms.

3. Overall, the text is very well written and methodologically very consistent. I congratulate the authors for their commitment to the development of the study.

a. Author reply; We would like to thank the Reviewer for their insightful comments, which have provided us with an opportunity to improve the quality of our original paper.

References

1. Hurwitz E, Randhawa K, Yu H, Côté P, Haldeman S. The Global Spine Care Initiative: A summary of the global burden of low back and neck pain studies. *European Spine Journal*. 2018;1-6.
2. Côté P, Cassidy J, Carroll L, Kristman V. The annual incidence and course of neck pain in the general population: A population-based cohort study. *Pain*. 2004;112:267-73.
3. Hoy D, Bain C, Williams G, March L, Brooks P, Blyth F, et al. A systematic review of the global prevalence of low back pain. *Arthritis & Rheumatology*. 2012;64(6):2028-37.
4. Abanobi O, Ayeni G, Ezeugwu C, Ayeni O. Risk-disposing habits of lowback pain amongst welders and panel beaters in Owerri, south-east Nigeria. *Indian Journal of Public Health*. 2015;6:332-7.
5. Desouza G, Matos R, Melo F, Filgueiras E. Effects of sleeping position on back pain in physically active seniors: A controlled pilot study. *Work: A Journal of Prevention, Assessment & Rehabilitation*. 2016;53:235-40.
6. Chen YX, Guo Y, Shen LM, Liu SQ, editors. The quantitative effects of mattress and sleep postures on sleep quality. *International Asia Conference on Industrial Engineering and Management Innovation: Core Areas of Industrial Engineering, IEMI 2012 - Proceedings*; 2013.
7. Deun D, Verhaert V, Willemen T, Wuyts J, Verbraecken J, Exadaktylos V, et al. Biomechanics-based active control of bedding support properties and its influence on sleep. *Work: A Journal of Prevention, Assessment & Rehabilitation*. 2012;41(Supplement 1):1274-80.
8. Kubota T, Ohshima N, Kunisawa N, Murayama R, Okano S, Mori-Okamoto J. Characteristic features of the nocturnal sleeping posture of healthy men. *Sleep and Biological Rhythms*. 2003;1(2):183-5.
9. Verhaert V, Haex B, De Wilde T, Cluydts R, Berckmans D, Verbraecken J, et al., editors. Automatic posture recognition during sleep. *Proceedings of 17th World Congress on Ergonomics*; 2009, August; Beijing, China: International Ergonomics Association.
10. Field A. *Discovering Statistics Using IBM SPSS Statistics*. 5 ed. Los Angeles: SAGE Publications; 2017.
11. Centre for Evaluation and Monitoring. Effect Size Calculator 2018 [Available from: <https://www.cem.org/effect-size-calculator>].

12. Gordon S, Grimmer K, Trott P. Sleep position, age, gender, sleep quality and waking cervico-thoracic symptoms. *Internet Journal of Allied Health Sciences and Practice*. 2007;5.
13. Dolan P, Earley M, Adams M. Bending and compressive stresses acting on the lumbar spine during lifting activities. *Journal of Biomechanics*. 1994;27:1237-48.
14. Kingma I, Baten C, Dolan P, Toussaint H, van Dieën J, de Looze M, et al. Lumbar loading during lifting: A comparative study of three measurement techniques. *Journal of Electromyography and Kinesiology*. 2001;11:337-45.

VERSION 2 – REVIEW

REVIEWER	Eivind Skarpsno NTNU, Norway
REVIEW RETURNED	15-Apr-2019

GENERAL COMMENTS	The authors have responded to all my comments.
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