PEER REVIEW HISTORY

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ARTICLE DETAILS

TITLE (PROVISIONAL)	Is prolonged sitting at work associated with the time course of neck-shoulder pain?: a prospective study in Danish blue-collar workers
AUTHORS	Hallman, David; Gupta, Nidhi; Heiden, Marina; Mathiassen, Svend Erik; Korshøj, Mette; Birk Jørgensen, Marie; Holtermann, Andreas

VERSION 1 - REVIEW

REVIEWER	Dr. Subas Neupane University of Tampere, Finland
REVIEW RETURNED	01-Jul-2016

GENERAL COMMENTS	This is nicely written manuscript in an interesting topic with objectively measured exposure and self-reported outcome. However, there are some issues that needs further clarification in order to improve the quality of the manuscript. Abstract: Results part is somehow conflicting results. More results in clearer way should be presented. Main texts: The selection of blue-collar workers to study their sitting at work needs to be justified although the authors have explained briefly in the methods. In general understanding the blue-collar workers work in different posture which are mostly standing with less sitting time. The occupational sectors of their study subjects are presented only in the table but it should also be explained briefly in the methods part. The authors have measured both sitting at work and leisure, but have they tried combining both sitting time and its association with neck-shoulder pain intensity? In page 7, line 8-13, the authors have presented categorical sitting variables but later in the analysis they used continuous variable, can they justify why categorical variable was not used? The authors wrote about the trajectories of neck-shoulder pain in the statistical analysis but it was not reflected in their study aim. It's not clear how the trajectory analysis was done in their study. How those three categories (low, middle and high tertile) or trajectories group were created should be explained clearly. If Linear Mixed Models generated three trajectories group then why did they use continuous pain score in the regression analysis? The use of 'time' variable and the interaction term (sitting * time) are not clearly explained. I guess time comes from each measurement point (14 levels) with higher the number of levels more the working time?? In discussion, the authors says that more sitting at work was associated with a higher overall intensity of neck-shoulder pain but later, it says that "our findings suggest that more sitting at work has

	a favorable influence on the course of neck-shoulder pain ….". I did not understand the conflicting results presented and discussed by authors in these two paragraphs. The authors should justify what that mean?

REVIEWER	Professor Karen Walker-Bone Arthritis Research UK/MRC Centre for Musculoskeletal Health and Work
REVIEW RETURNED	08-Aug-2016

GENERAL COMMENTS	The authors present a well-conducted study of the course of neck/shoulder pain among a group of blue collar workers from three occupational groups: transportation, cleaning and manufacturing. Everybody in the study had data recorded by placement of four accelerometers at baseline in order to accurately measure sedentary behaviour at work. Neck/shoulder complaints were obtained at baseline and followed up monthly with text messaging. This paper covers an important topic at a key time and makes an original contribution because of the accelerometry data and the long-term follow-up over 12 months. A few questions/comments: 1. The Abstract suggests a positive association of sitting time at work with higher overall pain intensity over 12-months in the fully adjusted model (p=0.055). I presume this relates to the data presented in model 3 in Table 2 in which the p-value reported is 0.05? Clearly this is a VERY borderline association at the 95% confidence limit (technically not significant) and given that the confidence intervals are 0.0-0.025, I wonder if this statement in the abstract and manuscript should be toned down a little? 2. I was very surprised by the very high prevalence rate ofo neck/shoulder pain among these participants at baseline - 29% were pain-free, so that 71% had symptoms. Looking at the case definition however, "In the past 12 months, how many days in all have you had pain or discomfort in the neck/shoulders?" then this case definition does appear to be inclusive of fairly minor neck/shoulder symptoms? Given that the mean baseline pain intensity score on a 1-10 scale was 3.1 and 45% of people reporting symptoms had taken no medication at all over the past 3 months, I think that this is borne out. I wonder therefore whether the authors have found very limited impact of sitting because of the inclusion of fairly mild/trivial neck/shoulder symptoms? Are the authors in a position to repeat their analyses using only those who have had longer duration of pain or have taken pain medication or reporting higher intensity? If this is not possible, then I would recommend the authors to visit this issue in their Discussion and state whether they think it might be a limitation to interpretation of their results. 3. I agree with the other limitations as described in the Discussion.

VERSION 1 – AUTHOR RESPONSE

Reviewer: 1

Please state any competing interests or state 'None declared':
'None declared'

Please leave your comments for the authors below
This is nicely written manuscript in an interesting topic with objectively measured exposure and self-reported outcome. However, there are some issues that needs further clarification in order to improve the quality of the manuscript.

Abstract:
Results part is somehow conflicting results. More results in clearer way should be presented.

Author response: We have revised the abstract to present the results clearer. The conflicting result of a positive association between sitting and overall NSP has been toned down in the abstract (as suggested by reviewer 2), since this effect was nonsignificant and only found in the fully adjusted model.

Main texts:
The selection of blue-collar workers to study their sitting at work needs to be justified although the authors have explained briefly in the methods. In general understanding the blue-collar workers work in different posture which are mostly standing with less sitting time.

Author response: We agree that it is important to justify the selection of blue-collar workers. The prevalence of neck-shoulder pain among blue-collar workers is generally high (Coté et al 2009). It is well known that even in blue-collar occupations, there can be a considerable occurrence of sitting at work (e.g., Hallman et al 2015). Also, blue-collar workers show a relatively large dispersion in sitting time between individuals, which is crucial to minimize the risk of attenuated regression coefficients due to insufficient contrast in the exposure. In this study, the average sitting time at work was 31% of the working hours (SD 20%), and as much as 60% of the working hours was on average spent sitting in the transportation sector. Thus, we think that our investigation of the association between sitting time and neck-shoulder pain in blue-collar workers is justified. We have now added text and two references in the methods section to be clearer in justifying the study population. See our changes on page 5, second paragraph.

Côté P, van der Velde G, Cassidy JD, et al. The Burden and Determinants of Neck Pain in Workers: Results of the Bone and Joint Decade 2000-2010 Task Force on Neck Pain and Its Associated Disorders. J Manipulative Physiol Ther. 2009; 32: S70-S86.
Hallman DM, Mathiassen SE, Gupta N, Korshøj M and Holtermann A. Differences between work and leisure in temporal patterns of objectively measured physical activity among blue-collar workers. BMC Public Health. 2015; 15.

The occupational sectors of their study subjects are presented only in the table but it should also be explained briefly in the methods part. Author response: We agree with the reviewer and have now added more information about the occupational sectors in the methods. Data collection was conducted at 15 Danish workplaces in three occupational sectors, namely: cleaning (four workplaces, n=120), transportation (two workplaces, n=448), and manufacturing (nine workplaces, n=57). The initial contact and recruitment of workplaces in these sectors were performed in collaboration with a large Danish worker union. See our revision on page 5, second paragraph.

The authors have measured both sitting at work and leisure, but have they tried combining both sitting time and its association with neck-shoulder pain intensity?

Author response: Occupational sitting and NSP is an important issue in occupational and public health. Thus, this study aimed specifically to investigate the association between occupational sitting and neck-shoulder pain. Leisure time sitting was treated as a covariate in the statistical models due to

its potential association with occupational sitting and neck-shoulder pain. However, analyses of the association between sitting during leisure (and/or sitting during work and leisure combined) and pain was not considered to be within the scope of the present study.

In page 7, line 8-13, the authors have presented categorical sitting variables but later in the analysis they used continuous variable, can they justify why categorical variable was not used?

Author response: The primary analyses (linear mixed models) are based on continuous sitting data because categorizing continuous data is not recommended as it results in loss of information and reduces the precision of the individual exposure estimates (Royston et al. 2006). Thus, the categorized sitting variables were used for interpretation of the results. We have now made this clearer in the manuscript. The interaction between continuous sitting time and changes in pain over 12 months cannot be visualized without creating categories of the predictor (i.e. sitting), and thus, the change in pain is presented across three categories (tertiles) of sitting time (see Figure 1) to ease interpretation. We have now specifically described this in the methods section. For consistency, we have now revised the results by excluding the analysis of differences (ANOVA) between tertiles of sitting time in baseline pain intensity. See our revisions in methods on page 7, second paragraph, and page 8, first paragraph; and results on page 10, last paragraph.

The authors wrote about the trajectories of neck-shoulder pain in the statistical analysis but it was not reflected in their study aim. Author response: we believe that the trajectory analysis is reflected in the study aim: to investigate the relationship between sitting time and the course of neck-shoulder pain across one year. Trajectories refer to the time course of pain. However, to be clearer, we have revised the aim to include trajectories. See changes on page 5, first paragraph.

It's not clear how the trajectory analysis was done in their study. How those three categories (low, middle and high tertile) or trajectories group were created should be explained clearly. If Linear Mixed Models generated three trajectories group then why did they use continuous pain score in the regression analysis?

Author response: We agree that the trajectory analysis needs to be clearly explained in the statistical section to avoid confusion. The analyses are not based on trajectory groups. Pain was treated as a continuous variable. As explained above, trajectories refer to the individual course of neck-shoulder pain over the 1-year period. Thus, linear mixed model was used to determine the extent to which sitting time predicts the individual course of neck-shoulder pain intensity across the 14 measurement points over 1 year. We have now revised the statistical analysis section to avoid confusion, and specified that it is based on individual, and not group level, trajectories. Please see our changes on pages 8-9 in the revised manuscript.
The use of 'time' variable and the interaction term (sitting * time) are not clearly explained. I guess time comes from each measurement point (14 levels) with higher the number of levels more the working time?? Author response: It is correct that "time" refers to the 14 measurement points. We have revised the statistical analysis section accordingly. See revision on page 8.

In discussion, the authors says that more sitting at work was associated with a higher overall intensity of neck-shoulder pain but later, it says that "our findings suggest that more sitting at work has a favorable influence on the course of neck-shoulder pain ….". I did not understand the conflicting results presented and discussed by authors in these two paragraphs. The authors should justify what that mean?

Author response: Yes, we can see that this may lead to confusion and misinterpretation by the reader. Given that the borderline significance of the main effect of sitting on higher overall pain was only found in the fully adjusted model, and interactions were present in all models, we think that this small

effect should not be over interpreted. Thus, to ease interpretation, we have toned down the nonsignificant association between sitting and overall pain in the abstract, discussion and conclusion (as suggested by reviewer 2). See our changes in abstract, page 2; results, page 12, first paragraph, and page 12, last paragraph; discussion on page 15, first paragraph, page 16, paragraph 4; conclusion on page 18.

Reviewer: 2

Reviewer Name
Professor Karen Walker-Bone

Institution and Country
Arthritis Research UK/MRC Centre for Musculoskeletal Health and Work

Please state any competing interests or state 'None declared':
None declared

Please leave your comments for the authors below
The authors present a well-conducted study of the course of neck/shoulder pain among a group of blue collar workers from three occupational groups: transportation, cleaning and manufacturing. Everybody in the study had data recorded by placement of four accelerometers at baseline in order to accurately measure sedentary behaviour at work. Neck/shoulder complaints were obtained at baseline and followed up monthly with text messaging.

This paper covers an important topic at a key time and makes an original contribution because of the accelerometry data and the long-term follow-up over 12 months. Author response: we would like to thank the reviewer for pointing out these positive aspects of our study.

A few questions/comments:
1. The Abstract suggests a positive association of sitting time at work with higher overall pain intensity over 12-months in the fully adjusted model (p=0.055). I presume this relates to the data presented in model 3 in Table 2 in which the p-value reported is 0.05? Clearly this is a VERY borderline association at the 95% confidence limit (technically not significant) and given that the confidence intervals are 0.0-0.025, I wonder if this statement in the abstract and manuscript should be toned down a little?

Author response: We appreciate that the reviewer pointed out the apparent mistake with the p-value (0.05) in Table 1. The correct p-value is 0.055, as stated in the abstract. This is now corrected in the revised manuscript. Also, we have added one decimal for the p-values in Table 3.
We agree that this borderline effect, which was only present in the fully adjusted model, should be interpreted with caution, and thus we have toned down this statement in the abstract and throughout the manuscript. See our changes in abstract, page 2; results, page 12, first paragraph, and page 12, last paragraph; discussion on page 15, first paragraph, page 16, paragraph 4; conclusion on page 18.

2. I was very surprised by the very high prevalence rate of neck/shoulder pain among these participants at baseline - 29% were pain-free, so that 71% had symptoms. Looking at the case definition however, "In the past 12 months, how many days in all have you had pain or discomfort in the neck/shoulders?" then this case definition does appear to be inclusive of fairly minor neck/shoulder symptoms? Author response: We agree that the high prevalence of neck-shoulder pain may be due to the inclusion of mild symptoms, although it is also likely due to the study population of blue-collar workers (Coté et al. 2009). Indeed a more restrictive criteria, such as >7 days with neck-shoulder pain over the past 12 months, would have reduced the prevalence rate to 46% as seen in

Table 1.
Côté P, van der Velde G, Cassidy JD, et al. The Burden and Determinants of Neck Pain in Workers: Results of the Bone and Joint Decade 2000-2010 Task Force on Neck Pain and Its Associated Disorders. J Manipulative Physiol Ther. 2009; 32: S70-S86.
Given that the mean baseline pain intensity score on a 1-10 scale was 3.1 and 45% of people reporting symptoms had taken no medication at all over the past 3 months, I think that this is borne out. I wonder therefore whether the authors have found very limited impact of sitting because of the inclusion of fairly mild/trivial neck/shoulder symptoms? Are the authors in a position to repeat their analyses using only those who have had longer duration of pain or have taken pain medication or reporting higher intensity? If this is not possible, then I would recommend the authors to visit this issue in their Discussion and state whether they think it might be a limitation to interpretation of their results.

Author response: We agree that the mean pain score of 3.1 (SD 2.7) on the 0-10 scale represents mild to moderate pain intensity. However, it should be taken into account that the mean pain intensity is based on the whole population, also including those with no pain (0 rating, n=180), while as many as 33% of the workers had a pain intensity score of at least 5. Also, the proportion (45%) of workers without pain medication during the past year is calculated based on all workers, including those reporting no pain. Of those reporting neck-shoulder pain (i.e. at least 1 day over the past year), the proportion of workers without pain medication is reduced to 36%. Thus, we believe that the severity and dispersion of symptoms in this working population is adequate for investigating the impact of sitting on the course of neck-shoulder pain. Since the study was designed to investigate the relationship between sitting and neck-shoulder pain in the whole population of blue-collar workers (n=625) we would like to avoid additional analyses in smaller sub-groups, which would lead to a less representative study sample and reduce the statistical power. We have now revised the discussion by adding this as a possible limitation of the study. See our revisions on page 17, last paragraph.
3. I agree with the other limitations as described in the Discussion.

VERSION 2 – REVIEW

REVIEWER	Subas Neupane University of Tampere
REVIEW RETURNED	11-Sep-2016

GENERAL COMMENTS	Thank you for the thoroughly revised manuscript. All my concerned were sufficiently answered and I have no further comments or questions to the authors.

REVIEWER	Professor Karen Walker-Bone Arthritis Research UK/MRC Centre for Musculoskeletal Health and Work, Southampton, UK
REVIEW RETURNED	18-Sep-2016

GENERAL COMMENTS	The authors have in my opinions addressed the comments of both reviewers and I believe the paper is clearer as a result