Author's response to reviews

Title: The effect of mental stress on lumbar position sense acuity

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Author's response to reviews:

Point-by-point answers to the comments from Mikael Bergenheim

Minor essential Revisions
Page 4, first paragraph: The references have been deleted.

Page 5 end of paragraph 1: "Text for this section" has been removed.

Page 13, first paragraph: The order of the references has been changed.

Spelling errors in the references on page 15 and 18 have been corrected.

Top of page 19: "RefType: abstract" has been deleted.

Table 1: "stress 2" has been changed to "stress" and "stress 1" changed to "novelty stress".

Discretionary Revisions
Methods
1) Unfortunately, no photo of the experimental setup is available. However, to meet the reviewer comment about the position of the arms the following has been added (Page 7, Line 1):

"Further, the arms were strapped to the attachment in front of the participant"

2) Gender effects were tested but no difference was found.

Discussion
1) As the reviewer points out the stress load in the present study is different from a working situation. The stressor used in the present study was not intended to mimic real work life stressors. However, because it was the idea that increased sympathetic outflow would alter the proprioceptive output from the muscle spindles and thereby the position sense acuity in the present study, it was important to use a stressor which has been demonstrated to activate the sympathetic nervous system strongly. Further, because the outcome of the proprioceptive task also depends on attention, it was important to choose a stressor not relying on attention thereby preventing potentially biasing the proprioceptive outcome it was. In future studies it is important to mimic real work life stressors to investigate if this would alter proprioceptive acuity as suggested by the reviewer.

2) In future studies it could be of interest to study proprioceptive acuity in patients with low back pain. However, as pain has been documented to decrease proprioceptive acuity it was important to include subjects without pain thereby excluding the possibility of potentially biasing the effect of mental stress in the present study.

3) We fully agree that it would have been a good idea to use an exposure already known to influence proprioception. Unfortunately, this was not done. However, the fact that we found a difference between the active and passive task, as pointed out by the reviewer, ensured us that the method could detect changes.

4) We find the use of absolute values of blood pressure and heart rate relevant because these values give the reader an impression of the actual level of the baseline and stress values and not only expressed in changes from baseline.
Point-by-point answers to the comments from Stein Knardahl

Major Compulsory Revisions

1.1 We fully agree on the comments raised, i.e. the limitations of the study. Discussion of these limitations is described in the following.

* Regarding the choice of muscle group: Because increased MSNA has been demonstrated during mental stress it would have been straighter to test proprioceptive acuity in the lower extremity during increased MSNA. However, lower extremities are not that relevant in an occupational health perspective. Further, because epidemiological studies have identified associations between work-related psychosocial stressors and low back disorders, the low back muscles were targeted in the present study.

* Regarding whether MSNA is elevated by the psychological challenge in the present study the following sentence has been added (Page 14 line 23 to page 15 line 1):
"The effectiveness of the electrical shock stressor in activating the sympathetic system is assessed through its cardiovascular effects but it is unknown whether this stressor also elicits changes in MSNA and muscle spindle firing rate in the back muscles".

* Regarding whether an increased MSNA includes the innervation of the spindles the following sentence has been added (Page 14, line 3-8):
Finally, Hjortskov et al.(31) demonstrated a facilitation of the short latency stretch reflex in the relaxed soleus muscle during manoeuvres known to increase MSNA, i.e. mental arithmetic, static handgrip exercise and post-handgrip ischemia. This is consistent with the idea that sympathetic nervous activity can exert a direct influence on human muscle spindles."

Because of this addition, the following reference has been added to the reference list:

* Regarding the effect of MSNA on spinal muscles the following has been added (Page 15, line 12-15):
"Further, not all muscle spindles receive sympathetic innervations, and the proportion that does, vary between muscles (16). Therefore, it may be that the low back muscles involved in the trunk movement in the present study, just as the arm muscles, are not under sympathetic control".

Because of this addition, the following reference has been added to the reference list:

Further, the following has been added in the Background (Page 5, line 4-7):
"The diversity of sympathetic outflow to different muscle groups during mental stress, i.e. mental stress increased MSNA in the calf but not in the forearm, should also be mentioned. In this regard it is unknown whether mental stress increases MSNA in the back muscles".

1.2 The statement has been changed to (Page 12, Line 17-18):
"The observation in the present study that an increase in sympathetic nervous activity, as indicated by the increase in blood pressure and heart rate, has no....."

1.3 To discuss the capability of the method the following has been added (Page 8, line 7-17):
"The test-retest reliability (2 days in between test and retest) of the passive and active position sense procedures was tested in a pilot study involving 10 participants. The statistical analysis showed no difference between the test and retest for the passive and active tasks. Based on the results of the intra class correlation (ICC as an estimate of reliability) (0.46 for the active task and 0.69 for the passive) and standard error of measurement (SEM as an estimate of precision) (0.64o in the active task and 0.39o in the passive task) values, the test reliability and precision for spinal position sense testing were moderate according to the criteria of Shrout & Fleiss (23). These values are in accordance with previous studies e.g.(24-26). The relatively low SEM values expressed in absolute error in the passive and active procedure indicate relatively good and precise test stability (27)".

Because of this addition, the following references have been added to the reference list:
1.4 Regarding order-effects in resting cardiovascular parameters the following has been added (Page 6, Line 22-24):
"This is also confirmed by the fact that there are order effects in resting blood pressure, i.e. the blood
pressure was even increased in the resting period between the "novelty stress" and the "stress" periods."

1.5 We agree that verbal instructions may influence in this experiment. Therefore, standardized verbal instructions were given by the same experimenter as written on Page 8, line 14-19. However, we find that a detailed description of the instructions would take to much space in the paper. To clarify the following has been added (Page 8, Line 19-20):
"the participants received identical instructions about the proprioceptive tasks in the novelty stress, stress and control conditions".

Minor essential Revisions
2.1 To explain the term "Novelty stress" the following has been added (Page 6, Line 8-12):
The "novelty stress period" was without the exposure to the electrical shock stressor, but being nervous for participating in the experiment and nervous for the stressor in the following "stress period" resulting in markedly elevations in the physiological stress markers (blood pressure and heart rate).

2.2 To clarify, the following sentence (Page 10, line 4) has been extended to (in italics):
"....the participants were told that they were going to receive 8 painful electrical shocks without any presage either during the passive or active position sense task".

2.3 The axis of movement has been described in the following (Page 7, line 11) (in italics):
"Horizontal rotations in the rotational plane of the lumbar spine from right to the left were performed from a starting position of 0o..."

2.4 "incoming behaviour" has been deleted.

Point-by-point answers to the comments from Kermit G Davis
Minor essential Revisions
1. Introduction, Page 5 last sentence: To make the aim and hypothesis of the study more clear the last two sentences in the introduction have been changed from (Page 5, Line 8-12):
"We examined whether a state of high sympathetic activity would affect the proprioceptive acuity of the back muscles either through the muscle spindle system or through another unknown mechanism thus deteriorating the performance capacity of the whole system. The aim was to investigate the effect of mental stress on the position sense acuity in the rotational axis of the lumbar spine"

TO (Page 5, Line 11-15):
"We examined whether a state of high sympathetic activity would affect the proprioceptive acuity of the back muscles. Therefore, the aim was to investigate the effect of mental stress (inducing increased sympathetic activity) on the position sense acuity in the rotational axis of the lumbar spine".

2. Methods, Page 6, paragraph 1: To explain the terms "Novelty stress" and "stress" the following has been added (Page 6, Line 6-12):
"The participants were exposed to an electrical shock stressor in the "stress period", i.e. the participants were told that they would receive 8 painful electrical shocks in this period (for further description of the stressor, see page 8). The "novelty stress period" was without the exposure to the electrical shock stressor, but being nervous for participating in the experiment and nervous for the stressor in the following "stress period" resulting in markedly elevations in the physiological stress markers (blood pressure and heart rate)".

3. Methods, Page 6, Par 1: The description of the "Procedures" has been rewritten (Page 6):
"Procedure. The procedure is illustrated in Figure 1. The study was performed over two days (2-4 days in between). The participants performed two position sense tasks (i.e. a passive and an active position sense task. These are described in the "position sense task section" below) during each of the following periods: a "stress period" and a "novelty stress period" (day 1) and during two control periods (day 2). The participants were exposed to an electrical shock stressor in the "stress period", i.e. the participants were told that they would receive 8 painful electrical shocks in this period (for further description of the stressor, see page 8). The "novelty stress period" was without the exposure to the electrical shock stressor, but being nervous for participating in the experiment and nervous for the stressor in the following "stress period" resulting in markedly elevations in the physiological stress markers (blood pressure and heart rate). The "novelty stress", "stress" and the two control periods lasted 12 minutes each. Five minutes rest separated the "novelty stress" and the "stress" periods on day one and the control 1 and control 2 periods on day two. Prior to the testing periods the participants rested in 5-minutes. The procedure was the same on day two (control day) except that the "novelty stress" and the "stress" periods were changed to control
periods (control 1 and 2)."

It was not possible to randomise the order of the stress and control periods because pilot tests indicated that the physiological markers of stress (blood pressure and heart rate) were permanently elevated on day one due to novelty with the laboratory surroundings, and did not return to resting levels when the control anc stress periods were performed in one day. This is in accordance with previous studies investigating the effect of mental stressors on motor performance (3-5; 22).

4. Methods, Page 9 Par 1:
As the reviewer points out the stressor is different from a working situation. However, the stressor used in the present study was not intended to mimic real work life stressors. Because it was the idea that increased sympathetic outflow would alter the proprioceptive output from the muscle spindles and thereby the position sense acuity, it was important to use a stressor which has been demonstrated to activate the sympathetic nervous system strongly. However, in future studies it is important to mimic real work life stressors to investigate if this would alter proprioceptive acuity.

We agree that the stress may have been greater if the shocks were actually given. The aim of the stressor was to build up a strong anticipatory arousal. The pros and contra of giving or not giving the electrical shocks was discussed with psychologists within the field of occupational health. Their advice was that the uncertainty in waiting for the electrical shocks would create greater arousal. Further, the probability of having shocks was actually not going down, i.e. the participants were told that the shocks were randomly distributed and that all 8 shocks could be given in short trains within a short period. Finally, the fact that the level of the cardiovascular stress indicators was elevated during the whole stress period indicates that the design of the study did not minimise the effect of the threats.

5. Regarding the limitations of the study:
Low number of subjects and lack of power: We agree that a relatively low number of subjects participated in the study and that this may limit the results of the study. To meet the comments the capability of the method has been discussed. Therefore the following has been added (Page 8, line 7-17):
"The test-retest reliability (2 days in between test and retest) of the passive and active position sense procedures was tested in a pilot study involving 10 participants. The statistical analysis showed no difference between the test and retest for the passive and active tasks. Based on the results of the intra class correlation (ICC as an estimate of reliability) (0.46 for the active task and 0.69 for the passive) and standard error of measurement (SEM as an estimate of precision) (0.64o in the active task and 0.39o in the passive task) values, the test reliability and precision for spinal position sense testing were moderate according to the criteria of Shrout & Fleiss (23). These values are in accordance with previous studies e.g.(24-26). The relatively low SEM values expressed in absolute error in the passive and active procedure indicate relatively good and precise test stability (27)."

Further, regarding the low numbers of subjects and the short term stressor the following has been added (Page 15, Line 16-20):
"A limitation of the study is the relatively low number of subjects participating in the study. A larger study group may have influenced the results. Further, it could be argued that the short term exposure to the stressor may have minimised the effects. However, despite the short term exposure the cardiovascular stress indicators were markedly heightened during the "novelty stress" and the "stress" periods".