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Relationships between clinical features of neck pain and upper limb disability and reaction and response times in individuals with chronic neck pain

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ABSTRACT

Background: Dysfunction of sensorimotor integration can influence the execution of the reaction time and motor task. Although evidence suggests the association of neck pain and sensorimotor dysfunction, relationship between clinical features of neck pain and reaction and response times is still unknown.

Objectives: To examine the relationship between clinical features of neck pain and upper limb disability, and reaction and response times in individuals with chronic neck pain.

Materials and methods: Fifty-six individuals with chronic neck pain aged between 18-59 years were recruited for the study. Clinical features included pain intensity using Visual Analogue Scale (VAS), pain duration, neck disability using Neck Disability Index-Thai version (NDI-TH), and upper limb disability using Disabilities of the Arm, Shoulder and Hand-Thai version (DASH-TH). Hand reaction and response times were assessed using hand-held electronic timer with a modified computer mouse and foot reaction and response times using a pedal switch. Pearson's correlation coefficient was used to analyze the relationships between variables.

Results: NDI-TH score was mildly correlated with hand and foot reaction and response times (r ranged from 0.29 and 0.32, $p<0.05$). DASH-TH score (8 items related to neck pain) was positively correlated with hand reaction and response times (r=0.26 and 0.34, respectively, $p<0.05$) but not with foot reaction and response times ($p>0.05$). There was no correlation between intensity and duration of neck pain and the hand and foot reaction and response times ($p>0.05$).

Conclusion: There was a mild correlation between neck and upper limb disability and slower hand reaction and response times. The neck disability was mildly correlated with slower foot reaction and response times

Introduction

Dysfunction in sensorimotor control has been demonstrated to be associated with neck pain. The sensorimotor dysfunction includes reduced cervical proprioceptive sense, visual disturbance, poor head-eye coordination and impaired balance.[1-3] Additionally, changes in the sensorimotor control often cause dizziness, unsteadiness and feeling of spinning in the head in persons with neck pain.[3] The dysfunctions and symptoms are proposed as a result of altered afferent information originating from the cervical spine, which mismatched with normal afferent signals from the vestibular and visual systems.[4]

There is evidence suggesting that sensorimotor integration involves in the execution of the reaction time and motor task.[5] Abnormality of sensorimotor integration can result in a delay in a reaction time and response time,[6]

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which are important for everyday activities such as reaching and driving.[7] A recent study of Barr et al.[8] have demonstrated that patients with cervical dystonia had slower simple foot reaction time compared to healthy controls. The impaired step reaction time was also found to be moderately correlated with a higher fear of falling. Likewise, Sandlund et al.[9] showed that patients with traumatic neck pain and non-traumatic neck pain had deficits in upper limb coordination and position sense acuity. Huysmans et al.[10] also found that position sense acuity of the upper extremity and tracking performance were impaired in subjects with neck and upper extremity pain.

Several previous studies demonstrated that cervical musculoskeletal impairment was correlated to the magnitude of neck pain and disability[11-14] but not with pain duration.[12, 15, 16] For example, Falla et al.[12] demonstrated that the level of neck pain intensity was correlated with the function of the deep cervical flexor muscles. Kumbhare et al.[13] found that neck disability was correlated with cervical range of motion. Similarly, Chiu et al.[14] found relationships between physical impairments and neck pain. Alternatively, there was no correlation between duration of neck pain and cervical and axioscapular muscle impairment.[12, 15, 16] Patients with neck pain frequently have difficulties with functional use of their upper limb. A study demonstrated that patients with higher severity of neck pain had greater restrictions of the upper limb function.[17] Approximately 80% of neck pain patients reported that their neck pain was aggravated by upper limb activities. A significant moderate to high correlation was also found between the neck pain and disability and the upper limb disability.[17] While there is evidence for sensorimotor dysfunction in persons with neck pain and delayed reaction and response times are potentially modifiable risk factors associated with disability, the relationships between clinical features of neck pain and upper limb disability and reaction and response times in this population are yet to be addressed.

The purpose of this study was therefore to investigate the relationships between clinical features of pain (intensity, duration and self-perceived disability) and hand and foot reaction and response times in individuals with chronic neck pain.

Materials and methods

Participants

Fifty-six women and men with idiopathic neck pain aged between 18-59 years were recruited from physical therapy clinics, university, office and community in Chiang Mai. To be eligible for the study, participants had to have neck pain lasting for at least 3 months and have a score of ≥5/50 on the Neck Disability Index-Thai version (NDI-TH).[18] Participants were excluded if they had a previous history of trauma and surgery to the head, neck, upper and lower extremities, a previous history of neurologic disorders, musculoskeletal disorders that could affect reaction and response time, uncorrected visual problems, suspected vestibular pathology, and use of medications that could impact the reaction and response times. Participants were asked to refrain from consuming alcohol and caffeine 2 hours and sleep at least 6 hours prior to testing day.

The study was approved by the research ethics committee, Faculty of Associated Medical Sciences, Chiang Mai University (AMSEC-61EX-039). All participants received information about the study and signed written informed consent forms before the commencement of the study.

Questionnaires

Visual Analogue Scale (VAS)

Visual analog scale was used to measure intensity of neck pain.[19] VAS is a horizontal line with 0-10 cm in length. The scale is anchored on the left with the phrase "no pain", and on the right with the phrase "worst imaginable pain". The possible score ranges from 0 to 10.

Neck Disability Index-Thai version (NDI-TH)

NDI-TH was used to measure self-reported neck-pain related disability.[20] It contains 10 items including pain intensity, personal care, lifting, reading, headaches, concentration, work, driving, sleeping, and recreation. Score of each item ranges from 0 to 5. The maximum score is 50, with higher score indicating greater disability. Neck disability is defined as follows: 0-4 = no disability, 5-14 = mild, 15-24 = moderate, 25-34 = severe, and 35-50 = complete. NDI-TH was shown to be a reliable and valid tool for evaluating disability related to neck pain.[20]

Disabilities of the Arm, Shoulder and Hand-Thai version (DASH-TH) score

DASH-TH is a measurement of self-related upper extremity disabilities and symptoms.[21] It originally consists of a 30-item disability and symptom measure with a 5-point Likert scale (1=no difficulty to 5=unable). Eight items of DASH-TH were chosen from a study of Osborn and Jull [17] as they were mostly relevant to participants with neck pain. The eight items were 1) place an object on a shelf above your head, 2) do heavy household chore, 3) garden or do yard work, 4) carry a shopping bag or briefcase, 5) carry a heavy object, 6) change a light bulb overhead, 7) recreational activities in which you take some force or impact through your arm, shoulder, or hand, and 8) recreational activities in which you move your arm freely.[17] Response scores were summed and used for analysis. A possible total score of the DASH-TH ranges from 8 to 40.[17] DASH-TH was shown to have high content validity and internal consistency.[21]

Reaction and response time tests

Hand and foot reaction and response time tests were measured by a training examiner. Five practice trials were given to each participant for familiarization, followed by 10 experimental trials for each test.[22] The reaction and response times were recorded in seconds and an average value for each test was used for analysis.[22] The measurements used for hand and foot reaction and response times were as follow:

Hand reaction time and response time were measured using a hand-held electronic timer with a modified computer mouse. The light stimulus is located closed to response switches of the modified computer mouse.[22] A built-in timer was set with a delay of 1 to 5 seconds after pressing the start button. Participants sat on a chair with their feet flat on

floor and placed their index finger of the dominant hand over the right mouse button. For hand reaction time, participants were verbally instructed to press the button as fast as possible when red light came on. For hand response time, the modified computer mouse was positioned on a table with a distance of 40 centimeters from the starting home position.[23] Participants sat on a chair and rested their dominant hand on the starting point over the edge of the table. Participants were asked to press their index finger on the right mouse button as fast as possible when the red light came on. Following each trial, participants had to return dominant hand to the starting point. The trial was repeated if participant's hand was not return to the starting position.

Foot reaction time and response time were measured with a foot pedal switch as described in Lord et al.'s study.[22]

For foot reaction time, participants sat on a chair with dominant foot flat on a foot pedal switch. Participants were asked to press the foot pedal switch as fast as possible when the red light came on. For foot response time, participants stood in a comfortable position behind the starting line. Foot pedal switch was positioned on the floor in front of the participants at a distance of 40% of subject's lower limb length (LLL).[24] LLL was measured vertically from the femoral trochanter center to the ground.[24] Participants were asked to use dominant foot stepping on the foot pedal switch as fast as possible when the light came on and back to the starting position.

Procedure

Participants were screened according to the inclusion and exclusion criteria. All eligible participants were asked to sign a consent form and complete the questionnaires (general questionnaire, VAS, NDI-TH and DASH-TH). The experiment was performed in random order (hand reaction time, hand response time, foot reaction time and foot response time). The experiment took place in a quiet room and a 2-minute rest interval was given between each test.

Statistical analysis

Sample size for the study was calculated according to Roscoe's recommendation (n>50).[25] Kolmogorov Smirnov test was used to test the assumption of normality. Pearson's correlation coefficient was used to analyze relationships between the clinical features of neck pain and the reaction and response times (hand and foot). Correlation coefficient values were interpreted as follows: 0.00-0.10 negligible, 0.10-0.39 mild, 0.40-0.69 moderate, 0.70-0.89 strong and 0.90-1.0 very strong. A statistical significance level was at 0.05.

Results

Participant demographics

Demographics and characteristics of the participants are shown in Table 1. Based on NDI-TH score, 44 participants had mild disability, 11 had moderate disability and one had severe disability.

Table 1 Demographic data and clinical characteristics of the participants (n=56).

Demographic data	
Gender (% Female)	89.29
Age (years)	33.77±10.65
Height (cm)	160.20±5.74
Weight (kg)	58.69±12.00
Dominant foot (% right)	82.14
Dominant hand (% right)	100
Characteristic of pain	
Neck pain intensity (VAS, 0–10 cm)	4.55±1.53
Neck pain duration (months)	23.75±16.87
NDI-TH (0-50)	12.05±4.84
DASH-TH (8-40)	15.54±4.97

VAS: *Visual Analogue Scale, Data are expressed as mean±standard deviation, otherwise as indicated, NDI-TH: Neck Disability Index-Thai version, DASH-TH: Disabilities of the Arm, Shoulder and Hand-Thai version*

Correlations between the clinical features of neck pain and reaction and response times

There were mild correlations between NDI-TH score with hand and foot reaction and response times (r ranged from 0.29 and 0.32, $p<0.05$) (Figure 1A, 1B). DASH-TH score was mildly correlated with hand reaction time and hand response time (r=0.26 and 0.34, respectively, $p<0.05$) (Figure 2A) but not with the foot reaction and response times ($p>0.05$) (Figure 2B). There was no correlation between intensity and duration of neck pain and hand and foot reaction and response times ($p>0.05$). The correlation results are provided in Table 2 and 3.

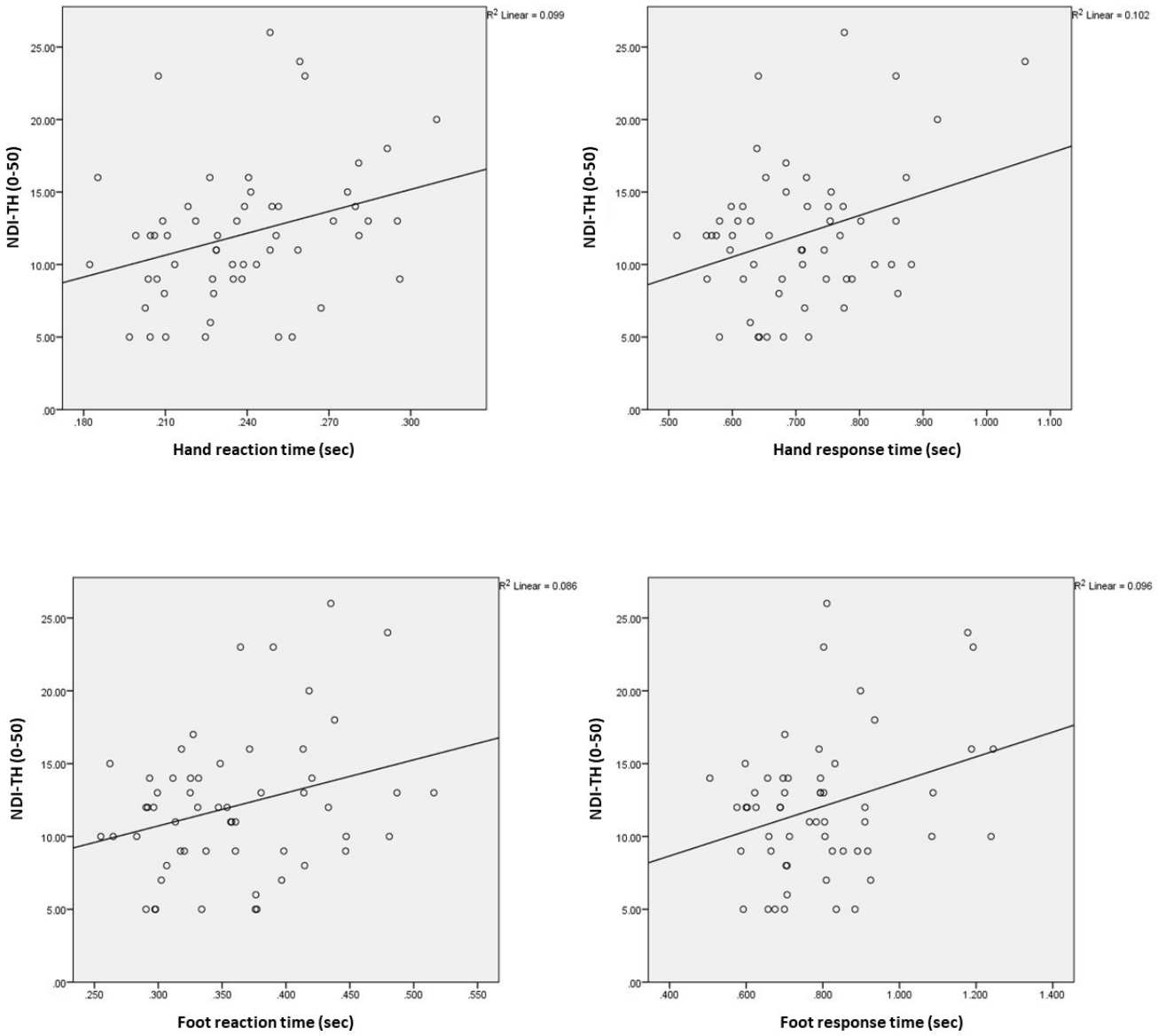

Figure 1. *The correlations between NDI-TH and reaction and response times A) hand B) foot*

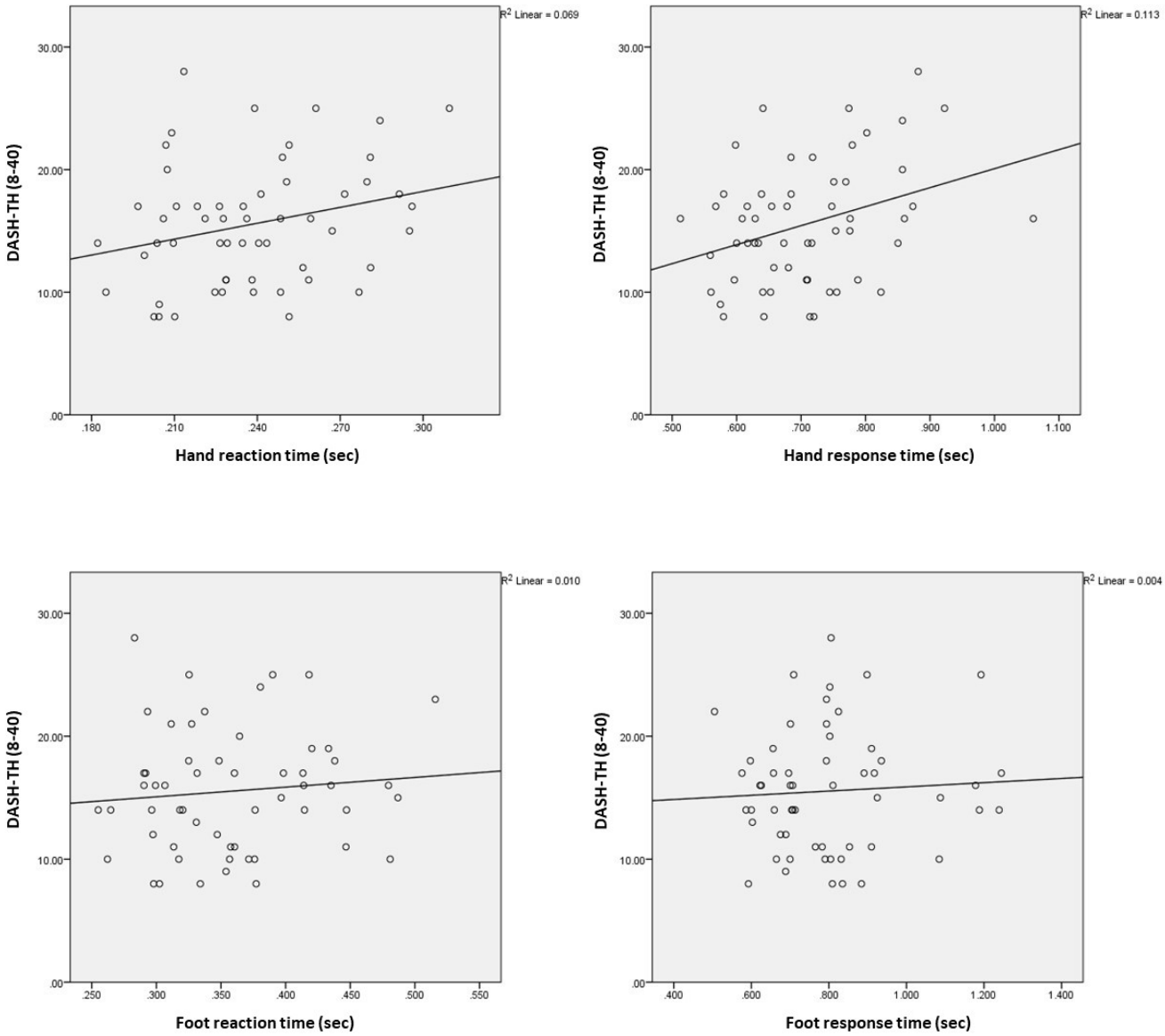

Figure 2: *The correlations between DASH-TH and reaction and response times A) hand B) foot*

Table 2 Correlations between the pain and disability and hand reaction and response times.

Clinical features	Reaction time (sec)	*p* value	Response time (sec)	*p* value
Neck pain intensity (VAS, 0-10 cm)	0.19	0.16	-0.05	0.72
Neck pain duration (months)	0.03	0.81	-0.07	0.61
NDI-TH (0-50)	0.32	0.02	0.32	0.02
DASH-TH (8-40)	0.26	0.05	0.34	0.01

Data were analyzed using Pearson's correlation, VAS: Visual Analogue Scale, NDI-TH: Neck Disability Index-Thai version, DASH-TH: The Disabilities of the Arm, Shoulder and Hand-Thai version

Table 3 Correlations between the pain and disability and foot reaction and response times.

Clinical features	Reaction time (sec)	*p value*	Response time (sec)	*p value*
Neck pain intensity (VAS, 0-10 cm)	0.09	0.53	0.04	0.76
Neck pain duration (months)	0.08	0.54	0.00	1.00
NDI-TH (0-50)	0.29	0.03	0.31	0.02
DASH-TH (8-40)	0.10	0.47	0.06	0.66

Data were analyzed using Pearson's correlation, VAS: Visual Analogue Scale, NDI-TH: Neck Disability Index-Thai version, DASH-TH: Disabilities of the Arm, Shoulder and Hand-Thai version

Discussion

Results of this study demonstrated that NDI-TH was mildly correlated with the hand reaction and response times. This suggests that patients with higher levels of neck disability are likely to have slower hand reaction and response times. The results also demonstrated that higher level of disability related to upper extremity (DASH-TH scores) was mildly correlated with slower hand reaction and response times in patients with neck pain. Nevertheless, the correlations observed were relatively mild. The relationships between neck and upper extremity disabilities and hand reaction and response times are expected and considerably relevant as both NDI-TH and DASH-TH involved limitation of activities of daily living caused by neck pain.[20, 21] However, it is important to note that NDI-TH measures disability related to specific activity like personal care, reading, lifting and driving whereas DASH-TH is more focused on disability of arm, hand, and shoulder. Eight activity items on DASH-TH were chosen in accordance with a study of Osborn and Jull [17] which found that such eight activity items scored positive by 50% of participants and there was a moderate to high correlation between the neck disability index and the disabilities of the arm, shoulder and hand scores. In addition, the result from this study revealed mild relationships between NDI-TH score and the foot reaction and response times, suggesting that patients with neck pain with greater disability took a long time to respond to a stimulus. NDI-TH is a functional status questionnaire concerning neck pain and limitation of activities of daily living due to neck pain. The association between NDI-TH and foot reaction and response times was likely to be found, although its association was relatively mild in the study. This result is in accordance with a previous study which showed significant negative correlations between stepping reaction time and cervical range of motion and mobility in patients with cervical dystonia.[8] Not surprisingly, DASH-TH was not correlated with foot reaction and response times, like the results of hand reaction and response times as DASH-TH only focused on the upper extremity impairments. It has been well documented that deep cervical muscles, which contain higher density of muscle spindles play an important role for cervical proprioception and are associated with the sensorimotor dysfunction in patients with neck pain[26, 27] A mismatched cervical afferent input can also lead to sensorimotor symptoms and impairment.[4] Thus, the overall slower hand and foot reaction and response times may be indicative of impaired sensorimotor integration caused by abnormal cervical afferent input.

There was no correlation between pain intensity and duration of pain and hand and foot reaction and response times. These results may suggest that a higher level and a longer duration of neck pain did not influence time taken to respond to a stimulus. On other words, delayed reaction and response times occurred with no relation to the length of history of symptoms. Our results are consistent with previous studies which found no correlation between the duration of neck pain and disability [12,15,16] but are in contrast to most studies which demonstrated a correlation of pain intensity and physical impairment.[12-14] Discrepancy of the results may be due to variations of participants' characteristics and pain severity. Further research is needed to confirm the findings of the relationships between pain intensity and reaction and response times in persons with neck pain.

There are some limitations to this study. Most participants recruited into the study were women (89.29%). The average intensity of neck pain was mild to moderate and the average neck disability was only mild. These potentially limit the generalizability of the study's results. Further research is needed to confirm the study findings. Additionally, further investigation of reaction time and response time between individuals with neck pain compared with healthy control is also warranted.

Conclusion

The study showed that the higher level of neck and upper limb disability was mildly correlated with slower hand reaction and response times. There was also a mild correlation between a higher neck disability and foot reaction and response times. Pain intensity and duration were not found to be associated with reaction and response times. The overall results may suggest the higher the disability, the slower reaction and response times in individuals with neck pain.

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Conflicts of interests

The authors declare no conflict of interest.

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