Strength and range of motion in the contralateral side to pain and pain-free regions in unilateral chronic non-specific neck pain patients

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ABSTRACT

Objective: To determine if strength and range of motion (ROM) deficits are present in patients with unilateral chronic neck pain (CNP) at contralateral side to pain (CSP) and at other regions.

Design: Forty-nine patients with unilateral CNP and 98 asymptomatic subjects participated in this case-control study. ROM and muscle strength of the cervical, shoulder, trunk and hip regions were assessed bilaterally using inclinometer and dynamometer, respectively.

Results: CNP patients demonstrated reduced cervical, shoulder and trunk ROM in their ipsilateral side to pain (ISP) comparing the asymptomatic participants ($P<0.05$). The ISP cervical and shoulder ROM were also significantly lower than the CSP ($P<0.05$). Significant differences were also observable in the CSP comparing the asymptomatic group ($P<0.05$). Cervical, shoulder and scapulothoracic muscles were found weaker both in the ISP and CSP comparing the asymptomatic group ($P<0.05$). ISP and CSP hip flexors were also found to be significantly weaker than the asymptomatic group ($P<0.01$).

Conclusion: The results revealed ROM and strength deficits in the pain-free regions of the body in unilateral CNP patients. Findings support the regional interdependence theory and emphasize the need for managing seemingly intact neighboring and more remote regions in unilateral CNP patients.

Keywords: Neck pain; muscle strength; range of motion; regional interdependence
INTRODUCTION

Chronic neck pain (CNP) is the sixth leading cause of disability with a prevalence of 30-50% in the adult population annually which has been associated with several dysfunctions in the cervical and other regions of the body. Almost half of the patients receiving treatment for their neck pain continue to present repeated episodes of pain leading to a very high recurrence rate.

Reduced cervical range of motion (ROM) and muscular strength constitute the most widely documented impairments in CNP cases. Cervical ROM and muscular strength have thus been commonly addressed both in the assessment and treatment of CNP patients. Cervical strength training has shown to effectively reduce neck pain and neck pain-related disability. Long-term cervical strength training has been suggested to improve quality of life in patients with neck pain. Weakness of the cervical muscles may lead to mechanical instability of the cervical spine and accelerate fatigue rate in these muscles contributing to the CNP development or symptoms exacerbation. Limitation in cervical ROM has been also associated with the severity of disability in these patients.

Although the cervical region is classically the targeted area in CNP cases, recent approaches emphasize the need for a broader perspective. The regional interdependence model states that at least part of the patients’ primary musculoskeletal symptoms originate from sources outside the painful region. Such impairments may directly or indirectly influence the painful structures regardless of their proximity to the painful area. Some previous studies have demonstrated adequate hip ROM and strength to be necessary for proper kinetic energy transfer from the lower to the upper extremities during the throwing task in athletic activities. Myofascial and biomechanical connections between the pelvis and contralateral shoulder complex have been
claimed to lead to altered upper extremity kinematics and kinetics following hip dysfunction\textsuperscript{21-24}. Pelvic re-alignment has thus been proposed to be effective in contralateral shoulder ROM improvement\textsuperscript{24}. There is evidence for associations between impairments in discrete body regions (e.g. low back pain with knee osteoarthritis\textsuperscript{25}, pes planus\textsuperscript{26} and decreased strength and ROM of the lower extremity\textsuperscript{27}). Thoracic-level interventions have been found effective alleviating cervical\textsuperscript{28} and shoulder pain\textsuperscript{29}. This is while the regional interdependence model has not yet been incorporated into CNP assessment and rehabilitation. This may have yielded an incomplete picture of CNP, resulting in frequent relapses of the disorder\textsuperscript{30,31}.

Such an approach makes it plausible that, in addition to inter-segments relationships, the contralateral pain-free side may also play role in unilateral CNP signs and symptoms. Trigger points have been found bilaterally in the scapulo-thoracic muscles in unilateral shoulder impingement syndrome cases\textsuperscript{32-34}. Unlike acute and subacute cases\textsuperscript{35}, chronic unilateral low back pain patients demonstrated bilateral multifidus muscle atrophy\textsuperscript{36}. The pathophysiological mechanism of such bilateral involvements is still under question. Central sensitization and/or compensation overuse of the uninvolved side have been suggested as possible explanations\textsuperscript{34}. Ignoring possible impairments in the seemingly uninvolved side may increase the risk of new-onset pain development in patients with unilateral pain disorders. Documentation of impairments in the contralateral side and other seemingly intact regions of the kinematic chain is necessary before recommending inclusion of these regions into the assessment and rehabilitation of unilateral CNP. Thus, the aims of this study were to compare the muscular strength and ROM of i) bilateral sides in the cervical, shoulder, trunk and hip regions within patients with unilateral CNP and ii) between CNP and asymptomatic individuals.
We hypothesized that impairments would be detected both in pain-free side of the neck and in regions out of the cervical spine in the presence of unilateral CNP in terms of reduced ROM and muscular strength.

MATERIALS AND METHODS

Design
This was a case control study approved by the Human Ethical Committee of the University of social welfare and rehabilitation sciences (Approval Code: IR.USWR.REC.1394.224). The study was registered with ClinicalTrials.gov (number: NCT02789631) and is part of a larger study. This study conforms to all STROBE guidelines and reports the required information accordingly (see Supplementary Checklist, Supplemental Digital Content 1, http://links.lww.com/PHM/A866)

Participants
Forty-nine subjects (37 female) with nonspecific CNP and 98 asymptomatic participants (50 female) aging between 20 and 55 were recruited. This study was a part of a larger study with equal participants in each group. The sample size of the original study was determined based on mean difference and variance of primary dependent variables in the pilot study. The inclusion criteria for the CNP group were as follows: experiencing unilateral pain in the sub-occipital to the first thoracic vertebra, pain duration of at least 6 months with a frequency of no less than once a week and lack of any specific anatomical pathology. For the sake of ethical issues, we did not deprive the patients from taking simple painkillers such as NSAIDs which might have played a confounding role in the current study by affecting the results. The exclusion criteria included neck pain perceived by the patients as being centrally located or almost symmetrically experienced on both
sides and history of neck physical therapy within six months prior to our testing. The asymptomatic group participants were excluded if they had any history of neck pain within the year prior to the study. The common exclusion criteria for both groups were as follows: any history of trauma or surgery on the spine, congenital deformity or inflammatory disease, positive Spurling test result\textsuperscript{38} for radiculopathy sign or diagnosis of fibromyalgia. The participants were enrolled from students and official employees of the University of social welfare and rehabilitation sciences and affiliated clinics in addition to official personnel from different large companies, between October 2015 and August 2016. Participants were required to sign the informed consent form after being verbally familiarized with the purpose and content of the study. The assessor rating the strength measures was blinded to the grouping of the patients since the initial screening of the participants and statistical analyses were performed by a different assessor. All strength tests were performed by a single orthopedic physical therapist with 10 years of experience in the field.

**Data collection**

Each participant completed an intake questionnaire to report demographic information. Patients also determined their affected side and symptoms duration and completed the Persian version of the Neck Disability Index Questionnaire (NDI-P)\textsuperscript{39}, which has been found to be reliable, valid, and sensitive in objectively measuring neck pain-related disability. Pain intensity over the last week was assessed using a blank 10 cm visual analogue scale (VAS), where 0 anchored to ‘no pain at all’ and 10 to ‘the worst imaginable pain’. To avoid pain interference the testing session would be postponed if patients reported moderate or severe pain intensity corresponding to values above 3 on the VAS\textsuperscript{40}. 

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Portable hand held dynamometer (Digital Force Gauge: SF-500, NO. 34041224, China) with the accuracy of ±0.5% was used to assess cervical (lateral flexors), shoulder and hip (flexors, extensors, abductors, adductors, medial rotators, lateral rotators) and scapulothoracic (rhomboids, middle and lower trapezius) muscles strength by measuring the amount of force (N) required by the examiner to overcome the participant’s maximum muscular effort “make tests”. Participants were asked to gradually increase muscle contraction up to maximum effort held for 5 seconds, while the assessor kept the dynamometer in place by matching the force exerted by the participant. If the muscular contraction ‘broke’ against resistance, the data would not be recorded, and the muscle test was repeated. Participants were allowed to stop the test in case of symptoms exacerbation. Three trials (except for the neck muscles to avoid symptoms exacerbation) were recorded consecutively on each test, with a 60-second rest interval between trials. Wing Chiu and Lo found isometric cervical muscles strength scores to have very high to excellent reliability and consistency while attained from three repetitions of maximum effort and many others have used this number of trials for the same purpose. Nevertheless, conduction of an independent reliability analysis for any unique study to achieve the optimum number of repetitions for measurements would be more satisfactory which was not performed here. All tests were performed bilaterally in all participants. The maximum value obtained during the 3 repetitions for each side in patients and the mean of bilateral sides maximum value in asymptomatic participants were normalized to body mass index of each participant and used for further analysis. Detailed information on the individual strength testing procedures can be found in Appendix 1 (Supplemental Digital Content 2, http://links.lww.com/PHM/A867) and illustrated in figure 1.
The Bubble inclinometer (12-1056, 360 Inclinometer), was used for active cervical, shoulder, trunk and hip joints ROM measurements which has been shown to have “good” reliability and an acceptable level of validity\(^\text{47}\). Participants were asked to perform three repetitions of each movement (warm-ups) in each direction to increase compliance of soft tissues. The tests were performed on both sides. Three trials for each movement direction were recorded in the pain-free ROM. The mean of bilateral side average values in asymptomatic participants were used for further analysis while each side measures were analyzed independently in the CNP group. To avoid possible adverse effect of fatigue or symptom exacerbation on ROM measures, these tests always preceded strength testing. All strength and ROM tests were performed in randomly designed orders to avoid systematic bias. Participants would rest for at least 5 minutes between strength and ROM tests. ROM testing procedures are explained in detail in Appendix 2 (Supplemental Digital Content 3, http://links.lww.com/PHM/A868) and illustrated in figure 2.

**Reliability Study**

To assess the reliability of the HHD and inclinometer measurements, 21 participants (11 patients with CNP and 10 asymptomatic participants) were assessed on two independent sessions (5–7 days apart) before the main study.

**Statistical analysis**

Descriptive statistics were provided on participants’ age, height, weight, gender and patients’ pain intensity, affected side and neck pain-related disability. The Shapiro-Wilk test was used to assess the distribution pattern of the data. Possible differences in age, height, weight and body mass index of the groups were evaluated using independent t-tests. Among background
variables, gender distribution was statistically different between the groups. Multivariate analysis of covariance (MANCOVA) with gender accounted for as the covariance was thus used to evaluate the strength and ROM differences between the CNP and asymptomatic groups. Post hoc analyses were performed using LSD test to compare the groups according to the dependent variables. Effect sizes (Cohen’s $d$) were calculated for the ROM and muscles strength measures differences between the groups. The magnitude of the effect was classified as small (0.20–0.49), medium (0.50–0.79), or large (>0.8) according to Cohen method$^{48}$.

Intraclass correlation coefficient (ICC) (two-way random, absolute agreement model) was used to determine relative reliability. The statistical analyses were performed using SPSS statistical package software (version 21; SPSS Inc, Chicago, IL). Statistical significance level was set at $P < 0.05$. 

**RESULTS**

Descriptive data are summarized in table 1. Since there were no drop-outs or missing data, all analyses were performed on all 147 participants. No significant differences were observed between groups in demographic variables except for gender ($P > 0.05$).

Between sessions reliability analysis of the HHD (ICC3,1 = 0.74–0.91) and inclinometer (ICC3,1 = 0.76–0.98) measurements was indicative of a “high” to “very high” level of relative reliability in all variables according to Munro’s classification$^{49}$. The results of the Shapiro-Wilk test demonstrated that all dependent variables followed a normal distribution pattern ($P > 0.05$); the Leaven’s test results found the variance of the dependent variables to be homogenous and the box’s M test found the co-variance matrices of the dependent variables to be comparable between the 3 groups. These findings revealed that the assumptions of the MANCOVA test have been met in our analyses. MANCOVA test results
after adjusting for gender found neck rotation and lateral flexion ROM of the ISP to be significantly lower than those both in the CSP and the asymptomatic group ($P < 0.01$).

All ISP shoulder joint movements except medial rotation were found to be significantly limited in comparison with the asymptomatic group ($P < 0.05$). Lateral rotation ($P < 0.01$) and abduction ($P = 0.03$) ROMs were also lower in the ISP compared to the CSP. There was also lower lateral rotation ROM in the CSP comparing the asymptomatic group.

In the trunk region, the ISP showed significantly lower rotation and lateral flexion ROM than those in the asymptomatic group ($P = 0.01$). Trunk rotation ROM in the CSP was also significantly lower than that in the asymptomatic group ($P < 0.01$).

Strength tests results found ISP cervical lateral flexors and rotators to be significantly weaker than those in the asymptomatic group ($P < 0.01$).

All tested shoulder ($P < 0.01$) and scapulo-thoracic muscles ($P < 0.05$) were also significantly weaker in the ISP comparing to the asymptomatic group muscles. Statistically significant differences were also observed between extensors, lateral and medial rotators strength of the CSP and the asymptomatic group participants ($P = 0.02$ for all).

In the hip region, no significant differences were found in ROM or strength measures between the ISP, CSP and asymptomatic group measures except flexion strength which was significantly weaker both in the ISP and the CSP than that in the asymptomatic group ($P < 0.01$ for both). The detailed description of the ROM and strength measures and the statistical comparisons are reported in tables 2 and 3, respectively.
DISCUSSION

To the best of our knowledge this is the first study comparing bilateral ROM and muscular strength at different regions in patients with unilateral CNP and comparing those with asymptomatic participants. The results found high to very high reliability for muscle strength and joint ROM measurements performed by HHD and inclinometer, respectively. Despite not being within the aims of the current study, such finding advocates usage of such simple clinical instruments for the evaluation of CNP patients. Reduced strength and ROM in the unilateral CNP patients were found not only in the cervical ISP but also in the shoulder, scapulo-thoracic, trunk and even hip regions comparing the CSP and the asymptomatic group measures. It is worth mentioning that such differences were not limited to statistical methods. The moderate to large effect size revealed that these differences were also clinically considerable. While significant P-values show that the differences are not present by chance, effect size magnitude indicates the size of the difference, which is clinically relevant. The CSP ROM and strength measures, although being considerably different from those of the ISP, were not comparable with the asymptomatic group either. The observed impairments in the CSP confirm bilateral involvement in the presence of unilateral CNP. Detection of multiple strength and ROM deficits in regions outside the painful neck may also support the regional interdependence model.

Our findings showed that the cervical region in the unilateral CNP patients contains weaker muscles (rotators, lateral flexors) and less mobile joints (rotation, lateral flexion) in comparison with the CSP and asymptomatic participants. Neck muscles weakness\(^{12,50}\) and ROM limitation\(^{11}\) have been widely documented in these patients. Strengthening, endurance and coordination training of these muscles has been recommended by the clinical practice guidelines for neck pain and disability reduction\(^{51}\). Neck muscles weakness may lead to impaired motion control and
mechanical instability of the cervical spine\textsuperscript{17}. This may in turn increase the stress imposed on passive elements such as spinal ligaments, facet joints and intervertebral disks and thus exacerbate symptoms from an already painful neck.

Chronic nociceptive inputs have been reported to provoke adaptive alterations in the motor control mechanisms extending beyond the painful region\textsuperscript{52} via central mechanisms\textsuperscript{53}. Finding weaker sacpulo-thoracic muscles (lower and middle trapezius, rhomboid) in the ISP of our CNP patients is also consistent with previous studies\textsuperscript{51,54}. Altered scapular alignment in the presence of CNP\textsuperscript{55}, suggested to increase articular and soft tissue stresses\textsuperscript{56,57}, has also been associated with impaired scapulo-thoracic muscles function\textsuperscript{51}. This finding further emphasizes the need for training scapulo-thoracic muscles in patients with CNP as recommended by guidelines such as that of the orthopedic section of the American Physical Therapy Association\textsuperscript{50}.

Compromised trunk muscles function has also been documented in previous studies\textsuperscript{58-60} which is consistent with our findings. Ghaffarinejad et al. have reported considerable alterations in the trunk muscles motor control strategy facing an internal perturbation in patients with CNP\textsuperscript{59}. Mosely et al. have claimed that CNP patients are more vulnerable to low back pain due to reduced voluntary trunk muscle control\textsuperscript{52}. Increased spinal segments stiffness\textsuperscript{52} acquired for dampening the reactive forces and utilized as a compensatory response to chronic pain\textsuperscript{61}, has been associated with limited ROM and disuse weakness of the trunk muscles. Reduced trunk rotation and lateral flexion ROM could be explained by spinal stiffening secondary to increased muscle co-contraction. This may further increase augment compressive loads on the spine.

Another interesting finding of the current study was weaker all shoulder muscles and hip flexors in the ISP of the patients comparing asymptomatic group participants. Additionally, the ISP
shoulder flexion, extension, abduction and lateral rotation ROM was smaller than those in the asymptomatic participants. Functional associations between cervical and shoulder regions have been documented by several studies and explained by muscular and myofascial interconnections between the two regions\textsuperscript{62}. Cervical multifidus muscle has been found to be recruited during isometric shoulder muscles contractions\textsuperscript{63}. Shoulder stabilization exercises have also been found to be effective reducing cervical pain and disability\textsuperscript{64}. The tight mechanical connections between the two regions may inhibit shoulder muscles activation to avoid movement-induced pain in the neck region. This may further induce muscular weakness and ROM limitation in the shoulder region possibly in response to CNP \textsuperscript{64}. Lee et al. reported a similar concomitant weakness in trunk and knee muscles in chronic low back pain cases\textsuperscript{65}. The authors suggested the fear avoidance mechanism as a possible explanation.

Hip flexor muscles were also found weaker in the ISP of our CNP patients compared to the asymptomatic group participants. The pelvic and lumbar spine attachments of these muscles might put them at risk of insufficiency in cases of altered pelvic and lumbar alignment\textsuperscript{24} as was the case in our CNP patients. Such alterations in the lumbo-pelvic segments in the presence of CNP might be explained by chain kinematic reactions through the spine to favor gaze stability and center of mass restoration\textsuperscript{66}. Since sagittal trunk alignment was not examined in this study, this possible explanation may not be confirmed by our results. On the other hand, functional impairment in pain-free regions of the patients may indicate that pain-mediated supra-spinal alterations may have imposed a generalized effect. Since it is unlikely that hip movements exacerbate neck symptoms, hip flexor muscles weakness may not be interpreted by the pain avoidance behavior model. Proximity of cortical representations of the tested regions (neck,
shoulder, hip) on the primary motor cortex and their neural interconnections\textsuperscript{67} may better explain such a generalized effect.

Most of the strength and ROM measures in the CSP of our CNP patients, although not always statistically different from the ISP and asymptomatic group measures, were rated as intermediate between the two. Determination of the CSP involvement mechanism was not within the scope of the current study, but generalized muscular inhibition\textsuperscript{60} and fear avoidance attitudes\textsuperscript{68,69} might partially explain such alterations. Bilateral atrophy of the longus colli muscle in patients with unilateral radicular neck pain, reported in a recent study\textsuperscript{70} may further support such an explanation. Nevertheless, further research is needed to determine if factors commonly associated with CNP, such as decreased ROM and muscular weakness, correlate with kinesiophobia. Petersen and Wyatt compared the strength of the ISP and CSP lower trapezius muscle in patients with unilateral CNP\textsuperscript{54} and found a significant difference. But since there was no control group in their study it cannot be postulated if the CSP muscles were different from those in asymptomatic participants to judge them as being affected or not.

Since bilateral muscle involvement was seen in our unilateral CNP patients, exercise prescription might be suggested to address both sides. Core stabilizing exercises might thus be also recommended, since they activate local stabilizer muscles symmetrically in the spine\textsuperscript{71}. Further investigation might be needed to test the effect of stabilization exercises on unilateral CNP symptoms.

Alterations reported in the bilateral sensorimotor representation and motor cortex activation\textsuperscript{72,73} may explain findings of the current study. Motor function impairments and primary motor cortex alterations have been largely correlated in chronic musculoskeletal cases\textsuperscript{74}. Such structural
alterations of the primary motor cortex have been proposed to be responsible for dysfunctions at pain-free regions\textsuperscript{75}.

The findings of the current study may have some clinical implications: first, we found CNP-related impairments to be broader than thought before. Multiple impairments were found in pain-free regions, which require a more thorough physical examination in the evaluation of these patients. Therapeutic interventions might also be suggested to address such regions to achieve a satisfactory result. Second, not all impairments might be explained via biomechanical relationships between body regions. This proposes central mechanisms to be at least partly responsible for clinical involvements. This finding besides those of some imaging and electrophysiological studies, suggest inclusion of therapeutic interventions addressing cortical motor centers in the rehabilitation of CNP cases. It is quite evident that confirmation of such claims warrants clinical trials.

**Limitation**

ROM and alignment measures were estimated by simple clinical tests which may have imposed some concerns on the accuracy of the measurements. Besides not being feasible to be administered for such a large sample size, use of sophisticated laboratory instruments was purposefully avoided to make the results generalizable to simple clinical settings. Another issue to be considered in this study is the unequal sample size of the groups. As declared within the manuscript, the data analyzed in this study has been derived from a larger study. Not all CNP patients in the original study were eligible to be included in the present analysis. This led to a discrepancy of the groups sample size, which warrants caution interpreting the results.
Investigation of some other variables such as electromyographic activity of the muscles might have implications for the study of the mechanisms by which CNP affects biomechanics of the spine and the extremities. But including too many outcome measures could adversely affect the validity of the results by inflating statistical errors. Investigation of such variables is recommended for future studies.

CONCLUSION

The results of the current study unveiled both ROM and muscular strength impairments in the ISP and CSP neck regions. Similar impairments were also detected in both neighboring (shoulder, scapular and trunk regions) and even far regions (hip) which were pain-free in our unilateral CNP cases. The CSP was found to include multiple impairments although not being as severely affected as the ISP. Pain avoidance and supra-spinal mechanisms are suggested to explain such findings besides the mechanical interconnections between the kinematic chain components.
ACKNOWLEDGEMENT

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**Figure 1.** Muscle strength testing procedure for A) neck lateral flexion, B) shoulder external rotation, C) hip adduction.

**Figure 2.** Range of motion testing procedure for A) neck rotation, B) trunk rotation, C) hip abduction and D) hip adduction.
Figure 1
Figure 2
Table 1. Demographic characteristics of the CNP and control group participants

<table>
<thead>
<tr>
<th></th>
<th>CNP (n=49)</th>
<th>Asymptomatic (n=98)</th>
<th>Mean difference</th>
<th>Mean difference (CNP- Asymptomatic) (95%CI)</th>
<th>t(DF)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>m:12, f:37</td>
<td>m:48, f:50</td>
<td></td>
<td></td>
<td></td>
<td>&lt;0.01</td>
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<tr>
<td>Age (year)</td>
<td>35.39±8.66</td>
<td>34.03±9.84</td>
<td>-1.35</td>
<td>-4.65,1.94</td>
<td>-0.81(141)</td>
<td>0.49</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>67.59±17.93</td>
<td>69.55±16.18</td>
<td>1.96</td>
<td>-1.76,6.29</td>
<td>0.66(140)</td>
<td>0.32</td>
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<tr>
<td>Height (cm)</td>
<td>165.59±7.96</td>
<td>168.65±9.86</td>
<td>3.06</td>
<td>-0.39,7.82</td>
<td>1.87(139)</td>
<td>0.54</td>
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<tr>
<td>BMI (kg/cm²)</td>
<td>20.34±4.58</td>
<td>20.69±3.78</td>
<td>0.34</td>
<td>-1.05,1.75</td>
<td>0.48(145)</td>
<td>0.67</td>
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<tr>
<td>Past week VAS (cm)</td>
<td>4.47±2.47</td>
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<tr>
<td>Pain duration (month)</td>
<td>34.21±7.82</td>
<td>N/A</td>
<td></td>
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<tr>
<td>NDI (/50)</td>
<td>10.14±5.92</td>
<td>N/A</td>
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</table>

m: male; f: female; CNP = chronic neck pain; BMI = body mass index; VAS = visual analogue scale; NDI = Neck Disability Index; N/A = not applicable; SD = standard deviation; CI = confidence interval; *: statistically different
Table 2. The cervical, shoulder, trunk and hip muscles ROM (degree) comparison among ISP, CSP and the Asymptomatic group.

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>CNP group (mean ± SD)</th>
<th>Asymptomatic group (mean ± SD)</th>
<th>Pair wise comparison between groups</th>
<th>Effect size</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ISP</td>
<td>CSP</td>
<td>ISP</td>
<td>CSP</td>
</tr>
<tr>
<td><strong>Neck</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Rot.</td>
<td>72.85±13.54</td>
<td>79.32±10.68</td>
<td>81.73±12.10</td>
<td>-8.87</td>
</tr>
<tr>
<td>Lat. Flex.</td>
<td>37.32±7.52</td>
<td>41.87±6.11</td>
<td>42.60±8.71</td>
<td>-5.27</td>
</tr>
<tr>
<td><strong>Shoulder</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flex.</td>
<td>159.18±13.28</td>
<td>162.54±16.41</td>
<td>165.16±10.78</td>
<td>-3.05</td>
</tr>
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<td>Ext.</td>
<td>55.20±13.34</td>
<td>58.97±13.14</td>
<td>61.32±12.15</td>
<td>-2.67</td>
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<td>Abd.</td>
<td>150.81±16.78</td>
<td>157.95±13.68</td>
<td>157.42±18.17</td>
<td>-7.14</td>
</tr>
<tr>
<td>Lat. Rot.</td>
<td>82.35±9.06</td>
<td>89.35±6.45</td>
<td>93.37±9.02</td>
<td>-7.00</td>
</tr>
<tr>
<td>Med. Rot.</td>
<td>64.23±15.39</td>
<td>67.82±12.32</td>
<td>68.79±11.42</td>
<td>-4.55</td>
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<tr>
<td><strong>Trunk</strong></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Rot.</td>
<td>22.92±5.98</td>
<td>22.85±5.93</td>
<td>24.93±7.09</td>
<td>-0.06</td>
</tr>
<tr>
<td>Lat. Flex.</td>
<td>20.27±4.02</td>
<td>20.94±4.08</td>
<td>22.06±3.57</td>
<td>-0.66</td>
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<tr>
<td><strong>Hip</strong></td>
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</tr>
<tr>
<td>Flex.</td>
<td>114.29±14.23</td>
<td>114.08±12.67</td>
<td>115.24±14.84</td>
<td>0.21</td>
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</tr>
<tr>
<td></td>
<td>27.55±11.05</td>
<td>53.89±14.83</td>
<td>21.87±10.51</td>
<td>34.97±7.46</td>
</tr>
<tr>
<td></td>
<td>28.42±12.01</td>
<td>55.41±16.09</td>
<td>21.74±7.74</td>
<td>33.39±7.23</td>
</tr>
<tr>
<td></td>
<td>31.26±11.36</td>
<td>56.65±13.38</td>
<td>22.30±8.89</td>
<td>34.53±7.27</td>
</tr>
<tr>
<td>ISP - CSP</td>
<td>-0.87</td>
<td>-1.51</td>
<td>-0.42</td>
<td>0.44</td>
</tr>
<tr>
<td>ISP - Asymptomatic</td>
<td>-2.03</td>
<td>-3.27</td>
<td>-0.47</td>
<td>1.82</td>
</tr>
<tr>
<td>CSP - Asymptomatic</td>
<td>-1.15</td>
<td>-1.75</td>
<td>-0.05</td>
<td>1.37</td>
</tr>
</tbody>
</table>

*indicate statistically significant difference


33
Table 3. The cervical, shoulder, scapulo-thoracic and hip muscles strength ($\frac{N}{kgm^2}$) comparison among ISP, CSP and the Asymptomatic group.

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>CNP group (mean ± SD)</th>
<th>Asymptomatic group (mean ± SD)</th>
<th>Pair wise comparison between groups</th>
<th>Effect size</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ISP</td>
<td>CSP</td>
<td>ISP</td>
<td>CSP</td>
</tr>
<tr>
<td><strong>Neck</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Rot.</td>
<td>2.46±0.92</td>
<td>2.81±0.98</td>
<td>3.19±1.18</td>
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</tr>
<tr>
<td>Lat. Flex.</td>
<td>2.36±0.95</td>
<td>2.60±0.98</td>
<td>3.01±1.03</td>
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</tr>
<tr>
<td>Flex.</td>
<td>4.55±2.04</td>
<td>4.97±2.07</td>
<td>5.67±1.71</td>
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<tr>
<td>Ext.</td>
<td>3.73±1.47</td>
<td>4.03±1.48</td>
<td>4.83±1.47</td>
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<tr>
<td>Med. Rot.</td>
<td>2.96±1.41</td>
<td>3.16±1.42</td>
<td>3.86±1.14</td>
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<tr>
<td>Med. Rot.</td>
<td>2.92±1.46</td>
<td>3.13±1.45</td>
<td>3.88±1.24</td>
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<tr>
<td>Scapula-thoracic</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Lower Trapz.</td>
<td>2.33±1.07</td>
<td>2.71±1.09</td>
<td>2.94±1.10</td>
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<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Joint</td>
<td>ISP - CSP</td>
<td>ISP - Asymptomatic</td>
<td>CSP - Asymptomatic</td>
<td>p</td>
</tr>
<tr>
<td>---------------------</td>
<td>-------------</td>
<td>--------------------</td>
<td>--------------------</td>
<td>-------</td>
</tr>
<tr>
<td>Middle Trapz.</td>
<td>2.39±0.96</td>
<td>2.75±1.05</td>
<td>3.09±1.19</td>
<td>0.35</td>
</tr>
<tr>
<td>Rhomboid</td>
<td>2.73±1.15</td>
<td>3.06±1.26</td>
<td>3.42±1.29</td>
<td>0.06</td>
</tr>
<tr>
<td>Flex.</td>
<td>5.70±2.67</td>
<td>5.63±2.66</td>
<td>7.07±2.60</td>
<td>0.24</td>
</tr>
<tr>
<td>One jointed Ext.</td>
<td>4.84±2.80</td>
<td>4.60±2.30</td>
<td>5.31±2.19</td>
<td>0.08</td>
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<tr>
<td>Two jointed Ext.</td>
<td>5.63±2.64</td>
<td>5.55±2.65</td>
<td>6.31±2.23</td>
<td>0.04</td>
</tr>
<tr>
<td>Hip</td>
<td>6.06±2.74</td>
<td>6.01±2.36</td>
<td>6.50±2.40</td>
<td>0.51</td>
</tr>
<tr>
<td>Abd.</td>
<td>4.33±1.69</td>
<td>4.35±1.66</td>
<td>4.85±1.77</td>
<td>0.55</td>
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<tr>
<td>Add.</td>
<td>2.82±0.83</td>
<td>2.80±0.86</td>
<td>3.27±1.19</td>
<td>0.02</td>
</tr>
<tr>
<td>Lat. Rot.</td>
<td>2.97±1.00</td>
<td>3.02±1.01</td>
<td>3.54±1.38</td>
<td>0.05</td>
</tr>
<tr>
<td>Med. Rot.</td>
<td>2.97±1.00</td>
<td>3.02±1.01</td>
<td>3.54±1.38</td>
<td>0.37</td>
</tr>
</tbody>
</table>

*indicate statistically significant difference