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Determining the reliability of craniocervical flexion test in asymptomatic individuals

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Background: The inter-rater reliability of the craniocervical flexion test (CCFT) has not been established.
Objective: To investigate the intra-rater and inter-rater reliabilities of the CCFT in asymptomatic subjects.
Methods: Sixty asymptomatic subjects were randomly selected for the study. The CCFT was measured on each subject by two testers for inter-rater reliability and by one of the testers after a gap of seven days for the intra-rater reliability. Before testing, the participants were trained for the movement and compensations were corrected.
Results: The CCFT has high inter-rater reliability (intra-class correlation coefficient = 0.907, standard error of mean = 0.735) and high intra-rater reliability (intra-class correlation coefficient = 0.986, standard error of mean = 0.287). A Bland & Altman limits of agreement analysis has confirmed the high inter- and intra-rater reliabilities of the test.
Conclusion: The CCFT has high inter-rater and intra-rater reliabilities in asymptomatic subjects.

Keywords: Craniocervical flexion test; deep cervical flexors; reliability.

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Introduction

The human neck is a complex structure that is highly susceptible to irritation. In fact, 10% of people will have neck pain in any given month. Almost any injury or disease process within the neck or adjacent structures will result in reflexive protective muscle spasm and loss of motion. Reported incidence rate increases with age up to 40 to 60 years, and then decreases slightly. Neck pain is a common and significant problem in modern society, with one year prevalence values in world population varying from 16.7% to 75.1%, with a mean of 37.2%.[1]

An understanding of anatomy and physiology and of their association with the pathogenesis of neck pain provides a better understanding about neck pain. The primary function of the cervical spine is to orient the head against the opposing forces of gravity while permitting multi-directional movement. To complete this task, the cervical spine must be mechanically stable, both in static as well as dynamic postures. In neutral upright posture, resistance to cervical spine motion by passive structures is minimal.[2] About 80% of the mechanical stability of cervical spine is contributed by the neck muscles and the remaining 20% by the osseoligamentous structures.[3] All the muscles of cervical spine play a role in movement and postural control, however, the different location, attachment, lever arm and fiber composition of individual muscles determine their primary function.[4] Deep and superficial axial muscles have different roles in stabilizing and moving the spine. As the deep axial muscles have small moment arms and attachment to adjacent vertebrae, they are believed to stabilize the spine. The more the superficial muscles have larger movement of arm and attachment to skull and trunk, thus they are believed to be predominantly prime movers.

According to Janda, each muscle group has a predisposition to become either tight or weak. In particular, postural muscles are prone to tightness, whereas phasic muscles are prone to weakness. Janda has described the upper crossed syndrome and has observed regular impairment of deep neck flexor muscles in patients with neck pain disorders.[5] Likewise, forward head posture is also considered as one of the postural risk factors among neck pain patients.[6] The reduced range of upper cervical extension may reflect a habituated sitting posture with more extended upper cervical spine.[7] Dysfunction of deep cervical flexors (DCF) is seen in different conditions like non-specific neck pain,[8] whiplash-associated disorder (WAD)[9] and cervicogenic headache.[10] Specific therapeutic retraining of DCF has demonstrated efficacy in management of patients with neck pain and cervicogenic headache.[11]

Endurance measurement is done by using three methods: electromyographic method (changes occurring in the EMG signal and in the action potential velocities during a contraction) (usually questionnaires) to measure perceived effort during sustained contractions (subjective estimation not fatigue) and clinical tests that measure time-dependent changes (mechanical fatigue).[12] Commonly, the craniocervical flexion test (CCFT) is used. Different methods used to assess DCF function found in the literature are the CCFT, conventional cervical flexion (a test that instruct the subjects to "tuck in their chins" (craniocervical flexion) and then to raise their heads from supine position), craniocervical flexion dynamometry, electromyography analysis, digital imaging, magnetic resonance imaging and ultrasonography. Clinically, only the first three methods can be used. The conventional cervical flexion and the craniocervical dynamometry (which measures the maximal voluntary contraction) both assess the superficial and deep flexor muscles. These methods do not allow clinical differentiation between the superficial and deep muscles.

It is important to be aware that the activity of superficial muscles may mask the impaired performance of the DCF muscles. From the available literature, it is seen that CCFT can give specific information about the DCF. The CCFT developed by Jull is an easy, non-invasive, low load clinical test used to assess as well as retrain the DCF.[13]

This test consists of precise and controlled performance and maintenance of positions of craniocervical flexion. There is no head lift component which engages the more superficial muscles like sternocleidomastoid and anterior scalene muscles.[13] In this method, an air filled pressure sensor is placed between the testing surface and upper neck to monitor the flattening of cervical lordosis along with the contraction of deep cervical flexors.[13] The instrument used is "Stabilizer" Pressure Biofeedback Unit (PBU), Chattanooga, USA. The outcome measure used in this study is Cumulative Performance Index (CPI) which is obtained by adding preceding score to performance index (PI). PI is defined as activation score (pressure level the subject is able to achieve) * number of successful repetitions.

This outcome measure is not yet used in Indian population and it has also not been used till date for evaluating the inter-rater reliability in any of the populations. This point is unique to this study. This study therefore tries to find the reliability of the CCFT, moreover, the scoring system used in this study for measuring the endurance of the deep cervical flexors is not yet explored among Indian population.

The purpose of this study is to test the intra-rater and inter rater reliabilities of the CCFT in asymptomatic individuals. If reliability of the CCFT is good, it can be used as an effective assessment tool for assessing the DCF endurance.

Methods

In this study, 60 asymptomatic subjects were studied. Sample size was calculated using the software *Power Analysis and Sample Size 11.* Sample size was estimated based on the 95% confidence interval (CI). For an expected ICC of 0.9 with 95% CI, the minimum sample size required was less than 15. Sample size calculated using the formula also provided a minimum sample size requirement of 15 with 95% CI:

$$\mathrm{SS} = \frac{Z^2 \times (p) \times (1-p)}{C^2},$$

where $Z = 1.96$ for 95% confidence level, $P = 0.99$, $1 - P = 0.01$, $C = 0.05$ (error term).

At the same time, a large sample size would result in a more precise reliability estimate with a narrow CI. Hence, 60 subjects were recruited.[14] According to the calculation, only five subjects should be studied and two observations per subject should be taken. In practice, there were conventional choices for high statistical power; when the p value is set at 0.05, and power will generally be somewhere between 80% and 95%, depending on the resulting sample size.[15] Total three municipal wards (community blocks are known as wards in India) were selected out of 38 wards. About 20 subjects were studied in each municipal ward randomly selected. Subjects were selected randomly from different areas of Surat, India, by using systematic random sampling. The design of the study used is cross-sectional study. Inclusion criteria included respondents from ages 20 to 60 years, from either gender as well as subjects without any kind of cervical pathology.

Likewise, history of severe neck pain in the last 12 months, current neck pain, undergone neck surgery, frequent headaches (> once per month), previous cervical spine trauma, long-term steroid usage and those who had undergone dental work in the previous 12 months and those with any neuromuscular conditions (including cervical spondylosis) are excluded from the study.

These are easy and non-invasive standardized tool available for measuring endurance of DCF. It is also utilized in the previous studies. Hence, this tool was selected. The Pressure Biofeedback Unit (PBU) (stabilizer, Chattanooga, USA), along with a screening form, recording sheet, towel and a stop watch was used for data collection.

The PBU consists of a non-elastic three-chambered pneumatic bag, a catheter and a manometer gauge ranging from 0 mm Hg to 200 mm Hg, with an accuracy of ± 3 mm Hg (Fig. 1(a)).[16] The outcome measure was CPI. A PI (AS * number of successful repetitions) could be calculated.[10] However, an AS of 2 mm Hg * 10 repetitions and an AS of 4 mm Hg * 5 repetitions yielded the same PI.[10] Hence, the PI as a quantity could not be exclusively identified or ranked, and would not comply with any criteria for classification as one of the four main levels of measurement.[17] Data obtained were CPI, which was obtained by adding preceding score to the PI. Table 1 shows the calculation of CPI.

To avoid any misinterpretation, the preceding score was added to the PI, thus resulting in a CPI which reflects the entire test, not just the position at which it terminates.[18]

Both raters were qualified manipulative physiotherapist with more than five years of academic

Table 1. Calculation of CPI.

Pressure (mm Hg)	PI (activation score * repetitions)	Range of possible scores at this level	Added score*
20			
22	2 × [1–10] repetitions	0–20	0
24	4 × [1–10] repetitions	24–60	20
26	6 × [1–10] repetitions	66–120	60
28	8 × [1–10] repetitions	128–200	120
30	10 × [1–10] repetitions	210–300	200

*Added score is equivalent to 10 repetitions of the levels below that of the current activation score. The total score therefore includes all attempts at all activation scores achieved.

and clinical experience in orthopedic and manipulative physical therapy and were well versed in the CCFT procedures based on the recommended guidelines.[19]

Random selection of the subjects for the study was divided into two steps. In the first step, three municipal wards were randomly selected from a total of 38 municipal wards (community blocks are known as wards in India) in Surat, Gujarat, India. In the second step, five subjects per age group were selected from each ward by systematic random sampling method.

One tester performed the test on each subject twice for the intra-rater reliability and two testers performed the test on each subject for the inter-rater reliability. All the subjects completed the screening form and signed the written informed consent form.

The following steps for the CCFT were followed:

Subjects were positioned in crook lying position so that forehead and chin are in a horizontal plane (Fig. 1(b)). Additionally, layers of towel were used under the head if the subject needed. Deflated pressure sensor was placed behind the neck and then inflated to a baseline pressure of 20 mm Hg, which was a standard pressure sufficient to fill in the space between the testing surface and the neck, without pushing the neck into lordosis. The device provided the feedback and direction to the patient to perform the required five stages of the test. The patients were instructed that the test is not one of the strengths, but rather one of the precisions. Subjects were asked to perform gentle and slow head nodding action, as if saying "yes". All the participants were advised to place their tongue on roof of mouth, with lips together and teeth slightly apart, in order to reduce activity of jaw musculature.[19] Once the set up was done, the dial of PBU is turned to the subject. Practice session was done to ensure that the subject properly understood the required movement. Once the subject learnt how to perform the craniocervical flexion action, a brief rest period was given. Subjects were asked to elevate target pressure from 20 mm Hg to 22 mm Hg and hold it for 2 s to 3 s before relaxing and returning to the starting position (20 mm Hg) (Fig. 1(c)). This was repeated through each 2 mm Hg increment up to 30 mm Hg, with verbal and visual cueing on correct technique given by the investigator. The investigator monitored the movement of head and activity of superficial cervical flexors by observation only. Compensation strategies like increased superficial cervical flexors activity, overshooting target pressure, dial needle flickering and neck retraction were also identified. If incorrect strategies were identified, verbal guidance was given to avoid such faulty strategies and further practice was given. Pressure was elevated in 2 mm Hg increments from a baseline value of 20 mm Hg to a maximum of 30 mm Hg.

(a) "Stabilizer" Pressure Biofeedback Unit (PBU) (b) Subject positioning (c) Position of the PBU dial

Fig. 1. (a) Deflated pressure sensor cuff is placed behind the neck and then inflated to a baseline pressure of 20 mm Hg, which is a standard pressure sufficient to fill in the space between the testing surface and the neck, without pushing the neck into lordosis and the dial used for visual cueing. (b) Subject is positioned in supine lying with knee flexed to 90° and a walking frame is placed on top to mount the dial of the pressure feedback unit for visual feedback. The investigators in this position will observe the movement of head and activity of superficial cervical flexors. (c) Pressure sensor unit is mounted on the walking frame and the inflated cuff is placed behind the neck along with verbal and visual cueing the subject is asked to elevate target pressure from 20 mm Hg to 22 mm Hg and hold it for 2 s to 3 s before relaxing and returning to the starting position (20 mm Hg). This is repeated through each 2 mm Hg increment up to 30 mm Hg.

Ten repetitions were carried out at each 2 mm Hg increment and each contraction is held for 10 s.[20] Both the therapists simultaneously did the procedure for the inter-rater reliability.

All the subjects were again tested after one week by one of the testers keeping the time and environment same. Data thus obtained were used to calculate intra-rater reliability of the CCFT. The same testing procedure and equipment was used for all the subjects. The above procedure utilized was the one given by Jull *et al.*[21]

Data analysis was done using the SPSS software (version 20.0). Results are considered to be significant at $p < 0.05$ and CI of 95%. An intra-class correlation coefficient for intra- and inter-rater reliabilities was used for the study. Bland–Altman limits of agreement analysis for assessing the agreement between two testers' scores were taken by tester one, twice. Standard error of measurement (SEM) was used to calculate the variability in measurements of same tester and measurements taken by two testers.

Results

The mean score for tester one was found to be 10.80 ± 9.45 and 10.83 ± 10.07 for tester two. In the retest, tester one obtained the mean score of 10.83 ± 9.51. Intra-class correlation coefficient (ICC) for both intra- and inter-rater reliabilities along with the CIs with a p-value of < 0.05 is used. The ICC value of the study indicated high reliability. The ICC intra-rater reliability was 0.986 at CI lower 0.977 and CI higher 0.992. For inter-rater reliability, it is 0.907 at CI lower 0.899 and CI higher 0.907. Figure 2 shows the Bland–Altman limits of agreement analysis between two testers. The Bland–Altman chart is a scatter-plot with the difference of the two measurements for each sample on the vertical axis and the average of the two measurements on the horizontal axis. Three horizontal reference lines were superimposed on the scatter-plot — one line at the average difference between the measurements, along with lines to mark the upper and lower control limits of plus and minus 1.96 * sigma, respectively, where sigma was the standard deviation of the measurement differences. When the two methods were comparable, then differences should be small, with the mean of the differences close to 0.[22] It showed reasonable agreement between the testers as most of the values fell in the range of $\mathrm{M} \pm 2\mathrm{SD}$ ($p < 0.05$). It indicated excellent reliability. Figure 2 shows the Bland–Altman limits of agreement analysis between two testers. The SEM is a measure of

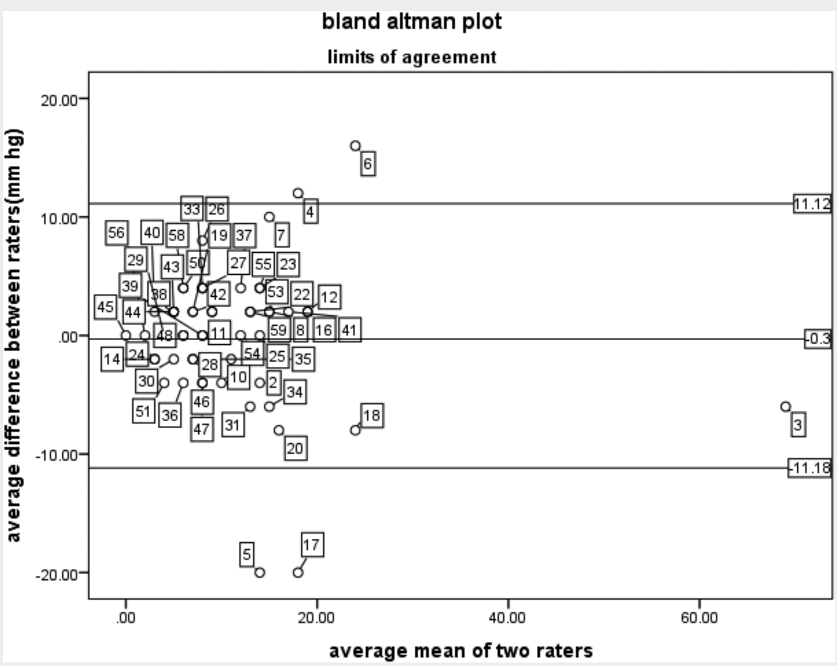

Fig. 2. Bland–Altman limit of agreement analysis between scores taken by the same tester twice. Three horizontal reference lines are superimposed on the scatter-plot — one line at the average difference between the measurements, along with lines to mark the upper and lower control limits of +/−1.96 sigma, which is the standard deviation of the measurement differences.

absolute reliability — the smaller the SEM, the more reliable the measurements.[18] SEM value calculated for variability in measurements between two testers was 0.735, which was very small; whereas the value for variability in measurements of the same tester was 0.287, which was also very small. Thus, these measurements were reliable.

The true SEM value for variability in measurements between two testers ($0.735 * 1.96 = 1.441$) suggested that any individual value was within the range of ± 1.441 CPI from their measured value. The true SEM value for variability in measurements of the same tester ($0.287 * 1.96 = 0.562$) suggested that any individual value was within the range of $\pm$ 0.562 CPI from their measured value.

The smallest real difference (SRD) value for variability of measurements between two testers ($1.96 * \sqrt{2} * \mathrm{SEM} = 2.039$) and between the measurement taken by same tester ($1.96 * \sqrt{2} * \mathrm{SEM} = 0.795$) was claimed to be capable of representing "real" clinical change, but these values could not simply be generalized to a symptomatic population.

Discussion

This cross-sectional study aimed at investigating the inter-rater and intra-rater reliabilities of the CCFT in asymptomatic individuals. The PBU which was placed behind the neck, monitored the flattening of cervical spine as the deep neck flexors were activated. This test was developed because of interest in functional role of the muscles particularly in relation to active spinal segmental stabilization and the clinical need of more specific exercise for patients with neck pain. For developing the CCFT, the DCFs primary anatomical action, flexion of the head on stable cervical spine, is utilized. The result of this study shows high intra-rater and inter-rater reliabilities. Reliability refers to consistency or dependability of a measurement technique.[23] More specifically, it is concerned with consistency or stability of the score obtained from a measure or assessment technique over time and across settings or conditions.[24] Reliability of a test is important as it is a precursor to test validity. If a test is unreliable, it will not be valid. Another reason to be concerned about reliability is that it gives idea about random measurement error in subject's scores. If a test is unreliable, subject's scores will consist largely of the measurement errors. Four studies evaluating intra-rater reliability[10,24–26] and one study evaluating inter rater reliability[20] of the CCFT are available in the literature. But, one systematic review[27] has questioned the reliability of CCFT because of the methodological flaws in the previous studies. There was a lack of information on the examiners, patients, the number of subjects included and blinding. In a study that investigated the validity of PBU instrument has concluded that the PBU provides valid measures, but their findings are not conclusive due to the small sample size ($n = 15$).[28] In a recent low risk of bias study, it was found that the reproducibility of PBU was observed as ICCs of 0.74 and 0.76 for intra- and inter-examiner reproducibility.[16] This study using 60 subjects therefore establishes the reproducibility of PBU in measuring CCFT. Arumugam *et al.* evaluated the inter-rater reliability of the test.[29] But, the scoring system used and measured only the holding capacity and not the endurance of the DCF. The ICC for inter-rater reliability is 0.907 ($p < 0.05$) whereas for intra-rater reliability, it is 0.986 ($p < 0.05$). The ICC is interpreted by using the work of Portney and Watkins.[22]

Although the reliability is good, the subjects have poor contractile capacity of DCF because the mean of the scores recorded by one rater is 10.80 mm Hg and by another rater is 10.833 mm Hg. Individuals could not achieve higher pressure levels and none of them were able to achieve 30 mm Hg. The Bland–Altman agreement analysis also supports these results. The Bland–Altman plot shows mean measurements against the differences. The result of this plot shows that most of the readings fall in $\mathrm{M} \pm 2$ SD ($p < 0.05$). The results of this study are similar to those found by James and Doe, who have also used CPI as an outcome measure.[25] They have also showed high intra-rater reliability. But the difference between the two studies lies in the scores. The mean scores of CCFT seen in this study are very less compared to that seen in study of James and Doe. Racial differences and a wide variability of age range selected in this study could be a reason for this difference. The results for inter-rater reliability cannot be compared to any other study as no study has yet evaluated it using this CPI outcome measure, either in symptomatic or asymptomatic individuals. Accuracy of the scores could be influenced by testers' scoring abilities. For these reasons, the testers' were adequately experienced and trained in administering the test procedure. As both the testers scored the test simultaneously, factors like duration of contraction or fatigue will have a homogenous effect on the performance of test. This study shows that the CCFT is a good method to assess the DCF endurance. Common compensations seen in subjects during the test were chin retraction or taking the chin down with fast movement. Both these compensations were corrected by properly training the subjects.

Conclusion

This study shows that the CCFT is a good method to assess the DCF endurance. The PBU has an accuracy of $\pm 3\,\mathrm{mm\,Hg}$. This can cause random error between tests. But, this random error must be reduced by maintaining the same area of contact between neck and pneumatic bag for all trials. Common compensations seen in subjects during the test were chin retraction or taking the chin down with fast movement. Both these compensations were corrected by properly training the subjects. Results of this study support the use of CCFT as an objective outcome measure in evaluating DCF endurance. The results of this study cannot be generalized as it is done on asymptomatic subjects. As this is the first study evaluating the inter-rater reliability using the CPI as an outcome measure, further research needs to be done by using the same CPI, to make future comparison possible.

Conflict of Interest

There are no conflicts of interest.

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Author Contributions

Seema Kotwani and D.N Bid conceived and designed the study, conducted research, provided research materials. Thangamani Ramalingam collected and Dinesh Ghatamaneni organized the data. Paul Silvian and Khalid Alahmari analyzed and interpreted data. Seema Kotwani wrote initial draft and Paul Silvian and Dinesh Ghatamaneni wrote the final draft of the paper. D.N Bid provided logistic support. Paul Silvian has carried out the revision of the manuscript. Khalid Alahmari provided the native language proofing. All authors have judiciously reviewed and approved the final draft and are responsible for the content of the manuscript.

References

1. Fejer R, Kyvik KO, Hartvigsen J. The prevalence of neck pain in the world population: A systematic critical review of the literature. Eur Spine J 2006;15 (6):834–48.
2. Oatis CA. Kinesiology: The Mechanics and Pathomechanics of Human Movement. Philadelphia: Lippincott Williams & Wilkins, 2009.
3. Panjabi MM, Cholewicki J, Nibu K, Grauer J, Babat LB, Dvorak J. Critical load of the human cervical spine: An in vitro experimental study. Clin Biomech 1998;13(1):11–7.
4. Cholewicki J, Panjabi MM, Khachatryan A. Stabilizing function of trunk flexor–extensor muscles around a neutral spine posture. Spine 1997;22 (19):2207–12.
5. Janda V. Muscles and motor control in cervicogenic disorders: Assessment and management. In: Physical Therapy of the Cervical and Thoracic Spine. New York: Churchill Livingstone, 1994:195–216.
6. Haughie LJ, Fiebert IM, Roach KE. Relationship of forward head posture and cervical backward bending to neck pain. J Man Manip Ther 1995;3 (3):91–7.
7. Rudolfsson T, Björklund M, Djupsjöbacka M. Range of motion in the upper and lower cervical spine in people with chronic neck pain. Man Ther 2012;17(1):53–9.
8. O'Leary S, Jull G, Kim M, Vicenzino B. Craniocervical flexor muscle impairment at maximal, moderate, and low loads is a feature of neck pain. Man Ther 2007;12(1):34–9.
9. Jull GA, Deep cervical flexor muscle dysfunction in whiplash. J Musculoskelet Pain 2000;8(1–2):143–54.
10. Jull G, Barrett C, Magee R, Ho P. Further clinical clarification of the muscle dysfunction in cervical headache. Cephalalgia 1999;19(3):179–85.
11. Jull G, Trott P, Potter H, Zito G, et al. A randomized controlled trial of exercise and manipulative therapy for cervicogenic headache. Spine 2002;27(17):1835–43.
12. Strimpakos N. The assessment of the cervical spine. Part 2: Strength and endurance/fatigue. J Bodyw Mov Ther 2011;15(4):417–30.
13. Jull GA, O'leary SP, Falla DL. Clinical assessment of the deep cervical flexor muscles: The craniocervical flexion test. J Manip Physiol Ther 2008; 31(7):525–33.

14. Karanicolas PJ, Bhandari M, Kreder H, et al. Evaluating agreement: Conducting a reliability study. J Bone Joint Surg 2009;91(Supplement 3):99–106.
15. Whitley E, Ball J. Statistics review 4: Sample size calculations. Crit Care 2002;6(4):335.
16. Falla D, Lindstrøm R, Rechter L, Boudreau S, Petzke F. Effectiveness of an 8-week exercise programme on pain and specificity of neck muscle activity in patients with chronic neck pain: A randomized controlled study. Eur J Pain 2013;17(10):1517–28.
17. Bland JM, Altman D. Statistical methods for assessing agreement between two methods of clinical measurement. Lancet 1986;327(8476): 307–10.
18. Atkinson G, Nevill AM. Statistical methods for assessing measurement error (reliability) in variables relevant to sports medicine. Sports Med 1998;26(4):217–38.
19. Jull GA, Falla DL, Treleaven JM, Sterling MM, O'Leary SP. A therapeutic exercise approach for cervical disorders. In: Boyling J, Jull G, eds. Grieve's Modern Manual Therapy. Edinburgh, UK: Churchill Livingstone, 2004:451–470.
20. Hudswell S, Von Mengersen M, Lucas N. The cranio-cervical flexion test using pressure biofeedback: A useful measure of cervical dysfunction in the clinical setting? Int J Osteopath Med 2005;8(3):98–105.
21. Jull G, Kristjansson E, Dall'Alba P. Impairment in the cervical flexors: A comparison of whiplash and insidious onset neck pain patients. Man Ther 2004;9(2):89–94.
22. Portney LG, Watkins MP. Foundations of Clinical Research: Applications to Practice. Vol. 2. Upper Saddle River, NJ: Prentice Hall, 2000.
23. Leary MR, Hoyle RH. Handbook of Individual Differences in Social Behavior. New York: Guilford Press, 2009.
24. MacKenzie SB, Podsakoff PM, Podsakoff NP. Construct measurement and validation procedures in MIS and behavioral research: Integrating new and existing techniques. MIS Q 2011;35(2):293–334.
25. James G, Doe T. The craniocervical flexion test: Intra-tester reliability in asymptomatic subjects. Physiother Res Int 2010;15(3):144–9.
26. Wing Chiu TT, Hung Law EY, Fai Chiu TH. Performance of the craniocervical flexion test in subjects with and without chronic neck pain. J Orthop Sports Phys Ther 2005;35(9):567–71.
27. de Koning CH, van den Heuvel SP, Staal JB, Smits-Engelsman BC, Hendriks EJ. Clinimetric evaluation of methods to measure muscle functioning in patients with non-specific neck pain: A systematic review. BMC Musculoskelet Disord 2008;9(1):142.
28. de Paula Lima PO, de Oliveira RR, de Moura Filho AG, Raposo MC, Costa LO, Laurentino GE. Reproducibility of the pressure biofeedback unit in measuring transversus abdominis muscle activity in patients with chronic nonspecific low back pain. J Bodyw Mov Ther 2012;16(2):251–7.
29. Arumugam A, Mani R, Raja K. Interrater reliability of the craniocervical flexion test in asymptomatic individuals — A cross-sectional study. J Manipulative and Physiol Ther 2011;34(4):247–53.