Journal of Bodywork & Movement Therapies 24 (2020) 242–245

Contents lists available at ScienceDirect

Journal of Bodywork & Movement Therapies

journal homepage: www.elsevier.com/jbmt

Diagnostic Methods

The lateral neck flexor endurance test: Normative values in the young adult population

Brian T. Swanson [a, b, *], Heather M. Bromaghin [b], Nate Bubacy [b], Austin Messick [b], Larissa Tinker [b]

[a] University of Hartford, West Hartford, CT, USA
[b] University of New England, Portland, ME, USA

ARTICLE INFO

Article history:
Received 11 February 2019
Received in revised form
25 September 2019
Accepted 8 March 2020

ABSTRACT

Background: Unilateral muscular deficits have been identified in individuals with neck pain, although no unilateral clinical tests have been described in the literature. Assessment of lateral neck flexor endurance may allow identification of abnormal unilateral muscle function. The lateral neck flexor (LNF) endurance test, where an individual holds their head parallel to the ground while side-lying, may be a clinical option. We sought to (1) determine inter-rater reliability of the LNF endurance test and (2) establish normative LNF values in healthy individuals.

Methods: Inter-rater reliability was assessed for four raters, working in pairs to assess a pilot sample of 20 individuals. Normative data was subsequently collected for 60 healthy adults, age 20–40. All participants completed the International Physical Activity Questionnaire to assess physical activity and the LNF endurance test was assessed once per side.

Results: The LNF endurance test demonstrated excellent inter-rater reliability: $ICC_{(2,1)} = 0.972$ [0.941–0.987]. Left and right median LNF hold times were 122.0, 133.94 s for males and 97.42, 93.73 s for females, respectively. Individual median hold time ratios were 72.1% for males and 68.7% for females. There were no meaningful correlations between reported physical activity and LNF endurance.

Conclusion: The LNF endurance test is a reliable measure. Males generally displayed greater LNF endurance than females, although variability within groups was high. Based on the observed values in this healthy population, 120 s for males and 90 s for females with a 70% side:side ratio appear to be useful normative benchmarks although further research is required including clinical populations.

1. Introduction

Multiple studies have investigated isometric endurance tests for the deep neck flexors (DNF) and cervical extensors (Domenech et al., 2011; Edmondston et al., 2008; Jarman et al., 2017; Lourenço et al., 2016; Sebastian et al., 2015). DNF and cervical extensor endurance tests are bilateral assessments used clinically to test muscular endurance in people both with and without neck pain (Domenech et al., 2011; Edmondston et al., 2008; Jarman et al., 2017; Lourenço et al., 2016; Sebastian et al., 2015). Previous research has established reliability and normative data for these individuals in both adolescent and adult populations, and have investigated the effects of age, gender, and activity level on muscular endurance (Domenech et al., 2011; Edmondston et al., 2008; Jarman et al., 2017; Lourenço et al., 2016; Sebastian et al., 2015). Although results from these studies have helped to influence treatment recommendations among participants with neck pain, there is currently no test present in the literature to assess unilateral muscular endurance or the lateral neck flexor (LNF) musculature.

The results from the DNF and cervical extensor endurance tests have been useful to clinicians due to their reliability (Sebastian et al., 2015) and cost-effectiveness (Domenech et al., 2011). Researchers have identified significant differences between male and female hold times for both the DNF and cervical extensor endurance test in individuals without neck pain, which has laid the foundation for assessing hold times among symptomatic individuals (Domenech et al., 2011; Sebastian et al., 2015). Previous

* Corresponding author. Department of Rehabilitation Science, University of Hartford, 200 Bloomfield Ave, West Hartford, CT, 06117, USA.
E-mail address: bswanson@hartford.edu (B.T. Swanson).

https://doi.org/10.1016/j.jbmt.2020.03.002
1360-8592/

Fig. 1. Inclinometer apparatus in place during test procedure.

research has demonstrated that there is little correlation between cervical muscular endurance tests and age or physical activity level, suggesting that the results of these tests are not dependent on age or lifestyle (Domenech et al., 2011; Jarman et al., 2017; Sebastian et al., 2015). It has also been established that the DNF and cervical extensor tests are cost-effective, easy to apply, and can be performed safely for individuals with neck pain without the risk of a prolonged increase in symptoms (Domenech et al., 2011; Jarman et al., 2017; Sebastian et al., 2015). Since research has provided a guide of normal values for practitioners based on gender and the presence of neck pain, clinicians have incorporated the use of these muscular endurance tests to assess baseline values in patients with neck pain and dysfunction. Clinicians have also used these test positions in treatment to strengthen these muscle groups due to their complementary stabilizing functions (Domenech et al., 2011; Edmondston et al., 2008; Jarman et al., 2017; Sebastian et al., 2015).

Although assessment and strengthening of the DNFs and cervical extensors has shown to be clinically meaningful, there is no research testing unilateral muscular function. Previous research has suggested that individuals with unilateral neck pain present with unilateral muscular dysfunctions (Falla et al., 2004). Falla et al. observed myoelectric manifestations of muscle fatigue in the ipsilateral sternocleidomastoid and anterior scalene muscles in participants with unilateral neck pain (Falla et al., 2004). Similarly, Larsson et al. demonstrated reduced blood flow and decreased EMG activity of the trapezius muscle ipsilateral to the painful side in participants with chronic neck pain (Larsson et al., 1998). These findings suggest that ipsilateral muscle dysfunction may be an important factor to consider in individuals with unilateral neck pain (Falla et al., 2004; Larsson et al., 1998). While these findings are intriguing, these previous studies utilized laser-doppler flowmetry and EMG manifestations to establish the role of the unilateral musculature-methods which are not readily available in a clinical setting (Falla et al., 2004; Larsson et al., 1998). We propose that the lateral neck flexor endurance test may be an efficient and clinically useful method to assess unilateral cervical muscular function. Therefore, the primary purpose of this study is to establish normative isometric LNF endurance values in asymptomatic adults. Additionally, the secondary purpose of this study is to determine inter-rater reliability of the LNF endurance test.

2. Methods

A prospective normative research study was performed between March and October 2018 at one university research center. The protocol was reviewed and approved by the Institutional Review Board (IRB) prior to the initiation of the study. All participants reviewed and signed a consent form approved by the IRB before participation. Following consent, all participants underwent a brief physical exam and were asked to provide information regarding demographics and physical activity levels.

2.1. Participants

A total of 60 healthy volunteers (30 male, 30 female) between the ages of 20–40 years old were recruited from a sample of convenience via flyer and word of mouth to participate in the normative data collection process. Individuals who were eligible to take part in this study included those who: (1) reported having no neck pain in the previous six months and (2) did not have neck pain on the day of

Fig. 2. Position during test performance.

Table 1
Characteristics of the participants according to gender.

	Women		Men	
No. Participants	30		30	
Age, y (mean ± SD)	24.33 (±1.83)		24.93 (±2.90)	
Lateral Neck Flexor Endurance, s (mean ± SD)	Left 120.72 (±69.24)	Right 110.03 (±62.73)	Left 134.50 (±62.42)	Right 158.54 (±94.40)

Table 2
Values for Left and Right Hold times by Gender (in seconds).

	Women			Men		
Quartiles	25	50	75	25	50	75
Left	65.25	97.42	168.25	103.79	122.0	163.21
Right	64.68	93.73	137.74	96.54	133.94	209.17

testing. All potential participants were screened for possible exclusion criteria via questionnaire. Exclusion criteria were based on those proposed by Domenech et al. (Domenech et al., 2011) including: complaints of pain in the neck or thoracic region within the prior six months, existing medical diagnosis of any cervical abnormalities, previous surgery to the thoracic or cervical spine, symptomatic cervical joints upon examination, reports of headaches of sufficient intensity to limit daily activity within the preceding six months, previous diagnosis of systemic, muscular, or connective tissue disorders, any history of cancer, reported history of prior injury to the neck or upper thoracic spine, known history of nervous system disorders, or history of medical conditions that may impact exercise performance such as insulin-dependent diabetes mellitus. A detailed explanation of the testing procedure was provided and all participants provided written informed consent prior to testing.

2.2. Pre collection training

Prior to data collection, all investigators performed approximately 2 h of training of the LNF endurance test to familiarize themselves with the testing methodology and standardize performance. To establish reliability, two pairs of testers (four total investigators) independently rated the hold time for twenty trials of the LNF endurance test.

2.3. Reliability pilot testing

A convenience sample of twenty individuals, not included in the normative data collection, volunteered to complete reliability testing. Two examiners performed simultaneous testing of each individual, blinded to the others examiners recorded time. If either examiner issued a cue to correct the participants performance, this was deemed to be the first cue for both testers, and independently stopped timing at their determination of the second deviation from the test position as described.

2.4. IPAQ

All participants in the normative data collection phase completed the International Physical Activity Questionnaire (IPAQ). Self-reported measures such as the IPAQ offer a convenient, low cost method to quantify the volume of various types of physical activity (PA) performed. The IPAQ's use for population-based epidemiological studies is well supported (Garriguet et al., 2015; Kim et al., 2013; Wanner et al., 2016). The International Physical Activity Questionnaire (IPAQ) long form was used to measure PA by measuring hours and/or minutes performing physical activity and days per week performing activities at a moderate-to- vigorous-intensity (Craig et al., 2003).

2.5. LNF endurance test operant definition and testing procedure

All participants completed the LNF endurance test. In order to monitor frontal plane changes in cranio-cervical positioning during the LNF endurance test, an inclinometer apparatus (Fig. 1) similar to that utilized by Sebastian et al. (Sebastian et al., 2015) was chosen since the tool has shown validity in measuring active cervical range of motion. Prior to the start of testing, the inclinometer apparatus was strapped to the participant's head and positioned such that the center of the inclinometer was directly cranial to the individual's external auditory meatus.

The LNF endurance test was performed in the following manner. Participants began in a side lying position with their arms crossed with a pillow placed under their head. The participant was then instructed to retract their chin so that their external auditory meatus was in line with their acromion and lift their head to a midline position. The investigator then adjusted the participant's head to confirm that no cervical rotation was present and the inclinometer read zero degrees(Fig. 2). The participant was allowed one practice trial of 5 s on each side, with 30 s of rest allowed prior to further testing. While resting, the participant was asked to remain in side lying with their head on the pillow, making sure not to lift it. Following the designated rest period, the participant was asked to perform the LNF endurance test for their maximum achievable time. Timing of the test began when the participant assumed the starting position described above and was terminated when one of four termination criteria was met: (1) the participant's head position deviated more than 4° superiorly or inferiorly as indicated by the inclinometer, (2) the tester noted when the participant no longer maintained the chin tuck position, (3) the participant deviated from a neutral rotational position (as assessed with a plumb line on the apparatus, adjusted to be in contact with the table in neutral rotation), and (4) the participant was unwilling or unable to continue. During the test, the participant was allowed only one deviation from the testing position, which was corrected with a verbal cue (e.g. “raise your head”, “tuck your chin”, “nose up/down”). Upon the second deviation, the test was terminated for that side. All participants were tested once per side, alternating between sides, with a 2 min break between trials. Participants alternated right/left side first to minimize any order effect to testing.

2.6. Data analysis

All data were analyzed in aggregate form using SPSS v21 (IBM, Chicago, IL. USA). Reliability data were assessed using intraclass correlation coefficients (ICC) model 2,1. Descriptive statistics, including means and standard deviations, were used to characterize study participants where appropriate. Overall hold times were assessed for measures of central tendency by side and gender. Means and standard deviations are reported; however, due to high variability, median values and accompanying interquartile ranges are also reported. Ratios of left:right hold times, calculated as the shorter/longer duration on a case by case basis, were reported for both overall group values and individual observations.

3. Results

A total of 60 participants (age 24.6 ± 2.42 years) participated in the normative portion of study. Demographic characteristics are described in Table 1. Inter-rater reliability measured by four investigators was $ICC_{(2,1)} = 0.972$ [0.941–0.987] $F = 35.074$, 29, $p < .0001$. Mean (SD) LNF endurance performance times for females were 110.03 (±62.73) seconds and 120.72 (±69.24) seconds for the right and left sides respectively, while the performance times for males were 158.54 (±94.40) seconds and 134.50 (±62.42) seconds for the right and left sides respectively. Due to high variability of hold times observed, median values and interquartile ranges were determined to more accurately reflect normative values; left and right median LNF hold times were 122.0, 133.94 s for males and 97.42, 93.73 s for females. The side to side ratio across all participants, based on aggregate mean hold times was 88.0% (males 84.4%, females 91.1%); however the mean of the side to side ratios, based on observed individual performance, was 69.1%. The ratios for the pooled 50% median values were 91.1% for males and 96.2% for females; however, the median values for the observed individual ratios were 72.1% and 68.7% for males and females, respectively. Trivial to small correlations were observed between self-reported activity levels and LNF endurance test scores ($r = 0.020–0.214$) that were not statistically significant (see Table 2).

4. Discussion

The primary purpose of this study was to establish interrater reliability and normative hold times for the LNF endurance test in participants without neck pain. Results from the study suggest that normative median measurements are approximately 120 s for males and 90 s for females and may serve as useful targets in a clinical setting. Restoring equal ratios has been proposed in the continuing education setting (Cook, 2017); based on the results of this study, it appears a 70% side:side ratio is an appropriate outcome when comparing endurance values per side. Using the IPAQ, no meaningful correlations were observed between self-reported activity levels and LNF endurance. This lack of correlation suggests that the LNF endurance test assesses unilateral neck flexor endurance rather than general level of physical activity.

The LNF endurance test has been shown to be a reliable unilateral endurance test to assess the lateral neck flexors. By establishing normative data, clinicians now have a baseline for assessing performance and establishing programs targeted at improving LNF endurance. Future research should be conducted considering additional factors, such as a larger sample size, a larger age range, and additional geographic locations to evaluate if these or other factors, particularly the presence of unilateral neck pain, are predictive of the performance of participants on the LNF endurance test. There are several notable limitations to this study. While previous work has not demonstrated differences in muscular performance across multiple age ranges, the sample population included only individuals between the ages of 20–40. There were high levels of variability between participants for their demonstrated LNF endurance capabilities. As a normative study, the data cannot be easily extrapolated to clinical contexts.

The results from this study form a foundation for future research and may assist clinicians in the objective identification of milestones for unilateral endurance deficits in participants utilizing the LNF test. Currently, an understanding of the influence of LNF endurance on pain and dysfunction is non-existent and merits further research.

5. Conclusion

This is the first normative data set for the LNF endurance test and lays the foundation for future research and clinical assessment. Interrater reliability for the LNF endurance test was high. Men generally displayed greater LNF muscle endurance than women; however, the between-participants and between-sides variability in LNF muscle endurance capabilities was high. The observed hold times did not demonstrate a significant correlation to level of physical activity, suggesting that the test assesses the individual's muscular endurance of the LNF rather than overall fitness levels. The LNF endurance test appears to be a reliable test which may be clinically useful in the assessment of LNF endurance; however, future research is needed to assess LNF endurance in a broad range of participant and clinical populations.

Clinical relevence

- The LNF endurance test demonstrates high levels of inter-rater reliability.
- Healthy individuals demonstrate median hold times of approximately 90 s for females and 120 s for males.
- A side:side ratio of 70% is demonstrated in healthy individuals regardless of gender.

References

Cook, C.E., 2017. Evidence-Based Examination of the Cervical Spine. MedBridge Education.
Craig, C.L., Marshall, A.L., Sjorstrom, M., Bauman, A.E., Booth, M.L., Ainsworth, B.E., Pratt, M., Ekelund, U., Yngve, A., Sallis, J.F., 2003. International physical activity questionnaire: 12-country reliability and validity. Med. Sci. Sports Exerc. 35, 1381–1395.
Domenech, M.A., Sizer, P.S., Dedrick, G.S., McGalliard, M.K., Brismee, J.-M., 2011. The deep neck flexor endurance test: normative data scores in healthy adults. PM&R 3, 105–110.
Edmondston, S.J., Wallumrød, M.E., MacLéid, F., Kvamme, L.S., Joebges, S., Brabham, G.C., 2008. Reliability of isometric muscle endurance tests in subjects with postural neck pain. J. Manipulative Physiol. Therapeut. 31, 348–354.
Falla, D., Jull, G., Rainoldi, A., Merletti, R., 2004. Neck flexor muscle fatigue is side specific in patients with unilateral neck pain. Eur. J. Pain 8, 71–77.
Garriguet, D., Tremblay, S., Colley, R.C., 2015. Comparison of physical activity adult questionnaire results with accelerometer data. Health Rep. 26, 11.
Jarman, N.F., Brooks, T., James, C.R., Hooper, T., Wilhelm, M., Brismée, J.-M., Domenech, M.A., Kotara, S.J., Sizer, P.S., 2017. Deep neck flexor endurance in the adolescent and young adult: normative data and associated attributes. PM&R 9, 969–975.
Kim, Y., Park, I., Kang, M., 2013. Convergent validity of the international physical activity questionnaire (IPAQ): meta-analysis. Publ. Health Nutr. 16, 440–452.
Larsson, R., Cai, H., Zhang, Q., Öberg, P., Larsson, S., 1998. Visualization of chronic neck—shoulder pain: impaired microcirculation in the upper trapezius muscle in chronic cervico-brachial pain. Occup. Med. 48, 189–194.
Lourenço, A.S., Lameiras, C., Silva, A.G., 2016. Neck flexor and extensor muscle endurance in subclinical neck pain: intrarater reliability, standard error of measurement, minimal detectable change, and comparison with asymptomatic participants in a university student population. J. Manipulative Physiol. Therapeut. 39, 427–433.
Sebastian, D., Chovvath, R., Malladi, R., 2015. Cervical extensor endurance test: a reliability study. J. Bodyw. Mov. Ther. 19, 213–216.
Wanner, M., Probst-Hensch, N., Kriemler, S., Meier, F., Autenrieth, C., Martin, B.W., 2016. Validation of the long international physical activity questionnaire: influence of age and language region. Prev. Med. Rep. 3, 250–256.