Reliability and validity of measurements of cervical retraction strength obtained with a hand-held dynamometer

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ABSTRACT

Objectives: The purpose of this study was to describe the reliability and validity of measurements of cervical retraction strength obtained with a hand held dynamometer (HHD) from healthy adults.

Background: Impaired neck muscle strength is related to neck pain, abnormal posture, and various cervical pathologies. While sophisticated devices to objectively measure neck strength exist, many are not practicable in typical orthopedic practices or have questionable validity and reliability.

Methods: Forty participants were included in the analysis of neck strength using isometric testing with an HHD fixed in a cradle on a table top. The highest neck retraction force recorded in Newtons (N) for each participant, was used for data analysis.

Results: Both intratester and intertester reliability were excellent as judged by intraclass correlation coefficients (ICCs) (.885 – .974) and minimal detectable change (MDC) (21.1 to 47.6 N). Validity was confirmed on the basis of expected gender and age differences (ie, men were stronger than women and younger participants were stronger than older participants).

Conclusion: Fixed HHD is a reliable and valid tool for measuring isometric neck retraction strength in ostensibly healthy adults. Its value in the assessment of individuals with neck pathology awaits further examination.

KEYWORDS

Cervical retraction; hand held dynamometry; isometric neck strength

Introduction

Cervical muscle strength is required to support the head and neck [1] and stabilize the cervical spine [2]. Recent studies have observed deficits in muscle performance in individuals with cervical pathology. Decreased neck flexor and/or extensor endurance has been reported in patients with idiopathic neck pain and whiplash associated disorder (WAD) [3], non-specific neck pain and following anterior cervical fusion [4,5]. Strength deficits and the existence of imbalances between neck extension and flexion strength have also been linked to non-specific neck pain as well as tension type headaches, cervicogenic headache, and whiplash associated WAD [3,6–13]. Furthermore, it is recommended that rehabilitation programs for patients with neck pain include both endurance and strengthening activities [14]. While reliable tests of muscle endurance are available [5,15], clinicians also require objective, reliable and valid methods for quantifying neck strength to both identify deficits and to serve as outcome parameters in assessing change throughout the course of rehabilitation [16].

Historically, manual muscle testing has been used to measure muscle strength [17]. While convenient, the procedure relies on the judgment and strength of the testers [18]. More recently, procedures using dynamometers have been described. Many of these

procedures are impracticable in clinical settings [19,20]. An exception may be procedures employing hand-held dynamometers (HHD). Although these procedures can also be affected by tester strength [21], testing set-ups where this is not the case have been described. Specifically, a procedure for measuring hip extension strength while patients are supine on a table has been described [22]. We thought that a similar procedure might have applicability to the measurement of neck retraction strength.

The purpose of this study was to test the reliability and validity of measurements of cervical retraction strength obtained from healthy adults in a supine position. We expected that measurements of neck retraction strength would demonstrate good intratester and intertester reliability and known-groups validity.

Methods

Participants

A sample of convenience ($n = 40$), was recruited from the Campbell University community via email and word of mouth between May and October 2018. Ten men and 10 women between the ages of 22–30 years of age and 10 men and 10 women 60 years of age and older participated. Inclusion criteria were that the

participants were healthy by self-report and within the specified age ranges. Exclusion criteria included: current neck pain or headache, a recent neck injury (including WAD or concussion) in the last 6 months, a history of cervical surgery, neurologic diseases, or chronic obstructive pulmonary disease (COPD). All methods and procedures were approved by the Institutional Review Board (IRB) of Campbell University prior to commencing the study.

Testers

Both examiners had over 10 years of clinical experience and were Fellows in the American Academy of Orthopaedic Manual Physical Therapists (FAAOMPT). A script including test position, order of testing, and subject instructions was devised to aid the testers. One training session was held prior to data collection to assure that the technique and verbal instructions were consistent between examiners.

Examination procedures

Data collection consisted of 2 sessions approximately 1 week apart. During session 1, after obtaining informed consent and prior to testing, the Neck Disability Index (NDI) [23,24] was completed to determine baseline status. Participants were also asked to rate any neck pain they may be experiencing on the numeric pain rating scale (NPRS) [25]. The NPRS was repeated after each maximum effort trial by both examiners. Subject height and body mass were measured with a digital scale and stadiometer (Health O Meter, McCook, IL).

Tester 1 stayed in the examination room with the subject while tester 2 went into an adjacent room with the door closed. Examiner 1 demonstrated the cervical retraction maneuver in standing and then had each participant practice until they felt comfortable with the movement and could perform it independently. Participants were then positioned supine on a 5 cm exercise mat with their limbs extended. A Microfet II HHD (Hoggan Scientific, LLC Salt Lake City, UT) was placed in a cradle under the most prominent area of the posterior skull. Risers were placed under the device as needed so that the patient was looking straight up to the ceiling using the orientation of the nose and the ear as a guide (Figure 1). The participant was again asked to retract the head and neck into the HHD with the instructions to 'draw your chin and head down into the table'. Once the examiner was satisfied with the movement, a single practice trial was performed at 50% maximum effort. The dynamometer was reset before each repetition to eliminate the weight of the head. After a 1-minute rest the test was repeated with maximum contraction provided over 5 seconds [22,26] with verbal encouragement from the tester in the form of 'push, push, push'. After another 1-minute rest the second trial of maximal contraction was performed [22]. If the subject experienced pain after the first trial, more time was allowed between trials for the pain to reduce to baseline. The risers were removed, the patient returned to sitting and tester 1 exited the room.

Tester 2 then entered, set-up the patient on the table, provided verbal instructions, and repeated the practice and 2 maximum trials for cervical retraction strength with the HHD along with recording the NPRS values. The results from each examiner were blinded

Figure 1. HHD set up for assessing isometric cervical retraction strength.

and kept in a locked file cabinet. Four to 9 days later (6.3 ± 1.2) [27,28], each subject returned. At that point, examiner 1 asked each subject if the status of their neck had changed since the first session and if they experienced any adverse effects from the testing. The subject was briefly reinstructed in the cervical retraction movement and repeated the cervical retraction strength testing as described above, for intratester reliability.

Sample size

Sample size was determined ($\alpha = 0.05$, Power = 80%) via MedCalc assuming a 25% difference in strength between age groups. This was based on reference values for adult grip strength measured with a Jamar dynamometer where the differences in grip strength ranged from 22.7% to 25.9% for 25–29 vs 65–69 year olds [29]. The calculated minimal sample size for each group was 5 participants, which was doubled to ensure adequate power.

Data analysis

Data analysis was performed with SPSS version 24 (IBM Corp. Armonk, New York, USA). The highest strength measurement of the 2 trials was used for data analysis [26,30]. Relative test-retest and intertester reliability were determined using intraclass correlation coefficients (ICCs) (model 3,1). Absolute reliability was determined by calculating the minimal detectable change (MDC) (95%) using the relevant intraclass correlation coefficient and standard deviation. Known groups validity was determined using a 2 (gender) x 2 (age group) general linear model analysis.

Results

Neck disability index

Thirty-four participants scored between 0–8% on the NDI indicating no disability. Six participants scored between 10–28% indicating mild disability [24]. However, these elevated scores were related to intermittent headaches, sleeping disturbances, and difficulty with concentration for various reasons and were not associated with neck pain.

Numeric pain rating scale

On the first day, prior to testing, 39 participants rated their neck pain as 0/10 and one participant as 1/10 NPRS. The 1/10 pain rating was extremely minor and was not actually located in the neck but in the right suprascapular area. It was not deemed to be relevant and the subject did not feel that it would limit them in anyway, so they were allowed to participate. After

neck retraction testing, one younger female and one older male reported pain as 3/10 NPRS. Time was given for the pain to return to baseline before attempting the second maximum effort trial. During the second session, all 40 participants rated their resting pain as 0/10 NPRS. After the neck retraction testing one older male reported pain as a 2/10 and another as a 4/10 NPRS. Again, the second maximum effort trial was not performed until the pain returned to 0/10 NPRS. All subjects reported 0/10 NPRS pain before leaving the testing area.

Reliability and validity

Patient demographics and statistics relevant to reliability of neck retraction strength are presented in Table 1. There was excellent relative intertester and intratester reliability with ICC values ranging from .911 – .974 and .885 – .968 respectively. Absolute intertester reliability, as indicated by MDC, ranged between 21.1N – 39.1N. For absolute test-retest reliability, the MDC ranged from 22.2 N – 47.6 N. Known groups validity was supported by significant differences for isometric neck retraction force between gender categories (men > women, $p < .0001$) and age categories (young > old, $p = 0.002$). There was no significant interaction between age and gender ($p = 0.52$).

Discussion

Based on the results of this investigation, the reliability and validity of hand-held dynamometry to measure neck retraction strength appears to be supported. The high reliability results are similar to other cervical dynamometry studies which used more sophisticated and less commonly available equipment [26,30,31]. The MDC values for absolute intertester reliability (21.1 N – 39.1 N) and test-retest reliability (22.2 N – 47.6 N) echo those found by Versteegh (26.08 N – 46.29 N) who also used HHDs in their study of neck strength with self-generated resistance [32]. The known groups validity results are also confirmatory. That is, as expected, men were stronger than women participants, and younger individuals were stronger than older [22].

A unique aspect of our study is that we chose to examine cervical retraction strength, a combined motion of upper cervical flexion and lower cervical extension [33]. We found no other studies that examined the strength of this motion. This may be of clinical importance as it is a common rehabilitation exercise used to counteract the deleterious effects of forward head posture [34,35], and as part of the treatment for many cervical conditions, including cervical radiculopathy [36,37].

Cervical muscle strength is important for optimal functioning of the head-neck complex [16]. Knowing

Table 1. Baseline characteristics, isometric neck retraction force and reliability.

Group	Age (y) Mean (SD)	Height (cm) Mean (SD)	Mass (kg) Mean (SD)	Force(N): S1T1. Mean (SD)	Force(N): S1T2. Mean (SD)	Force(N): S2T1. Mean (SD)	Intertester Reliability ICC _a (CI ₉₅) MDC _{95%}	Intratester Reliability ICC _a (CI ₉₅) MDC _{95%}
Men (younger)	25.5 (2.6)	181.0 (3.7)	81.4 (9.5)	246.4 (47.4)	244.1 (55.4)	258.0 (55.5)	.923 (.722,.980) 39.1	.885 (.605,.970) 47.6
Women (younger)	24.4 (2.1)	171.8 (5.6)	63.8 (7.5)	140.9 (42.7)	132.9 (39.3)	145.2 (43.9)	.962 (.856,.990) 21.1	.963 (.860,.991) 22.2
Men (older)	67.0 (3.9)	173.9 (6.6)	92.6 (17.3)	159.6 (76.1)	155.8 (85.9)	162.3 (75.5)	.968 (.879,.992) 38.3	.967 (.873,.992) 36.8
Women (older)	64.6 (4.1)	172.6 (19.4)	69.0 (12.0)	119.9 (30.4)	118.6 (37.9)	119.7 (35.4)	.911 (.684,.977) 27.7	.887 (.611,.971) 30.2
Combined	45.4 (20.9)	174.8 (11.0)	76.7 (16.3)	166.7 (69.7)	162.8 (74.4)	171.3 (74.6)	.974 (.951,.986) 31.9	.968 (.940,.983) 35.7

a N = newton, S = session, T = tester, ICC = intraclass correlation coefficient, CI_{95%} = confidence interval, MDC_{95%} = minimal detectable change.

that weaker neck muscle strength is characteristic of individuals with neck pain [19] and that improvements in neck strength benefit both pain [38] and disability [39–41] indicates that this is an important measurement which warrants a valid and reliable test. The equipment and procedure used in this study are affordable, easy to administer, and clinically viable.

Strengths and limitations

The strengths of our study include following a standardized protocol in which we took the best isometric neck retraction force from 2 trials and utilized a between sessions design with blinding between the 2 examiners on visit 1 [42]. Fixing the dynamometer obviates the issue of tester strength [43–45], and zeroing the HHD before each repetition reduces the potential error associated with the weight of the head and gravity. The study was designed to have immediate clinical application.

Possible limitations include normalizing the test position and accommodating the forward head position of many of the older adults with risers (Figure 1). A different starting position could affect force production. Rezasoltani found that the neck extensors were strongest with the head and neck in a neutral position [46]. A second limitation is that Tester 1 always performed the testing of each subject first. Although adequate rest time was given to each subject between repetitions, there may have been some fatigue or motor learning in the subjects by their 6th repetition: a practice trial and 2 maximum effort trials with each examiner. Thirdly, the HHD was placed under the most prominent area of the skull, the external occipital protuberance. This was found by palpation and was more difficult to position in individuals with more hair.

Suggestions for future research

The positive findings of this study notwithstanding, we acknowledge that the measurements were obtained from ostensibly normal individuals. We have no information as to how neck retraction force measurements differ between healthy and involved individuals or how pathology might affect the reliability and validity measurements. Individuals with current neck pain or disability may not generate comparably reliable or valid measurements. Moreover, while the MDC provides some indication of the responsiveness of neck retraction force measurements, we do not know what would constitute a meaningful change in neck retraction strength for patients with neck retraction weakness for whom a component of the intervention is neck retraction strengthening [47,48]. Investigation of these issues is warranted.

Conclusion

This study demonstrates that isometric HHD is a safe (no adverse events reported), reliable and valid means for measuring isometric cervical retraction force in ostensibly normal adults. These and other clinimetric properties warrant further investigation in patients with cervical pathology.

Disclosure statement

No potential conflict of interest was reported by the authors.

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