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A review of functional outcome measures for cervical spine disorders: literature review

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The purpose of this paper is to assess the reliability, validity and usefulness of three outcome measures: cervical ranges of motion, sagittal neck muscle strength and presence or absence of the flexion relaxation phenomenon (FRP) in the neck. The literature search included the Index Medicus and computerized database of MEDLINE for relevant material. Articles were selected if they contained primary data on neck range of motion, sagittal muscle strength and FRP. The results of 59 articles and 2 textbooks were analyzed. Normative values of cervical ROM have been reported in healthy subjects ranging in age from 18 to 74 years. The extent of degrees of motion lost per year did not differ between male or female subjects, but females started with higher degrees of active range of motion, which they maintained throughout life. Instrumented methods of recording muscle strength have included strain gauge dynamometers and modified sphygmomanometers. Parameters such as gender, age and stature were also observed to have important effects on muscle strength. The ratio of extension to flexion maximum isometric peak force has been estimated to range between 1.40–1.70 in normal subjects. Therefore, the extensor muscles of the neck are approximately 40% stronger then the neck flexor muscles. Evidence suggested that neck pain sufferers have weaker neck flexors than normal subjects. The FRP refers to the absence of myoelectrical activity in extensor muscles upon full forward flexion and has been documented in the cervical spine of asymptomatic subjects. In conclusion, inclinometric methods used for measurements of cervical range of motion were found to be safe, effective and reliable. The Cervical Range of Motion Device appeared to be well suited for clinical practice. The ratio of cervical extension-flexion maximum isometric voluntary contraction has been determined in asymptomatic subjects. The presence of the FRP in the neck has also been observed in normals. Future study is needed to investigate the functional limitations relating to acute and chronic mechanical neck pain which account for a portion of total neck disability.
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KEY WORDS: cervical vertebrae, objective measurement, neck strength and mobility, range of motion, myoelectric signal, flexion relaxation.

Cette étude porte sur la fiabilité, la validité et l'utilité de trois méthodes d'évaluation : les degrés de mobilité cervicale, la force des muscles sagittaux du cou et la présence ou l'absence du phénomène de flexion-relaxation (PFR) au niveau cervical. La documentation utilisée comprenait le répertoire Medicus et des données informatiques provenant de MEDLINE. Les articles sélectionnés devaient contenir des informations primaires sur la mobilité cervicale, sur la puissance des muscles sagittaux et sur le PFR. Les résultats de 59 articles et de 2 manuels furent analysés. Des résultats normaux ont été obtenus dans les tests de ROM (Range of Motion-degré de mobilité) cervicaux chez des sujets en santé dont l'âge variait entre 18 et 74 ans. Le degré annuel de perte de mouvement s'est avéré le même chez les sujets masculins et féminins. Toutefois, les femmes présentent au départ des degrés de mobilité supérieure et elles conservent cette marge toute leur vie. Les méthodes instrumentales employées pour mesurer la puissance musculaire comprenaient des dynamomètres et des sphygmomanomètres modifiés. Des paramètres comme le sexe, l'âge et la stature se sont également avérés d'une grande importance quant à la puissance musculaire. Le ratio flexion/extension cervicale @ puissance isométrique maximale a été estimé entre 1,40 et 1,70, chez des sujets normaux. Donc, les muscles extenseurs cervicaux présentent environ 40% plus de puissance que les muscles de flexion cervicale. Il apparaît évident que les personnes souffrant de douleurs cervicales présentent des fléchisseurs cervicaux plus faibles que les sujets normaux. Le PFR réfère à l'absence d'activité myoélectrique des extenseurs lors d'un pleine flexion et a été observé dans la région cervicale de sujets asymptomatiques. Il en résulte que les méthodes inclinométriques utilisées pour mesurer le degré de mobilité cervicale se sont avérées sécuritaires et efficaces. L'appareil calculant le niveau de mobilité cervicale (Cervical Range of Motion Device) s'est révélé efficace en pratique privée. Le ratio de contraction isométrique volontaire maximale des extenseurs et des fléchisseurs cervicaux a été déterminé dans le cas des sujets asymptomatiques. La présence du PFR a également été observée dans le cou des sujets normaux. Des études subséquentes seront requises afin d'étudier les limitations fonctionnelles reliées à la douleur cervicale d'origine mécanique, car, aigües ou chroniques, ces douleurs sont responsables d'une partie des dysfonctions cervicales totales.
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MOTS-CLÉS : vertèbre cervicale, mesures objectives, force et mobilité du cou, degré de mobilité, signal myoélectrique, flexion-relaxation.

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Introduction

Musculoskeletal disorders are the most frequent cause of physical disability, affecting 5–7% of the Canadian population.[1] Twenty percent of Canadians have been estimated to suffer from significant illness as a consequene of such conditions, and about 30% of adults have musculoskeletal complaints.[1]

Neck pain is one of the more common musculoskeletal complaints, with a point prevalence of 9–14% amongst adults, and a life-time prevalence of about 33%.[2–4] The point prevalence increases with age, being highest in the 50–59 year-old range, with about 30% of females being affected and about 15% of males.[3] A common cause of chronic neck pain is from whiplash injuries resulting from motor vehicle accidents. Reports estimate that 45 to 85% of patients having suffered a whiplash injury, continue to complain of symptoms after five years.[5] This high rate of persisting neck pain has a direct impact upon health care costs and permanent disability.[6]

In clinical practice, disability from neck injuries is frequently associated with impaired function that is not explained by structural lesions.[7] In fact, physical impairment has been reported to account for less than 50% of the total disability while a further third of the disability could be explained by psychological and behavioral factors.[8] Similar controversy is seen in other areas of the spine where pathology fails to explain the persistence of the pain.[9,10]

Since the usual goals of therapy are to alleviate symptoms and improve patient functioning, it is important to develop relevant assessment criteria of physical function in neck pain sufferers. Unfortunately, there is a paucity of information relative to objective measures of function in patients with neck pain. Much of the available literature is derived from the study of asymptomatic subjects. Objective measures have concentrated primarily on neck ranges of motion, muscle strength and ergonomic measures. The purpose of this paper is to review the literature pertinent to these primary objective measures.

Sources and methods

The initial search included Index Medicus and the MEDLINE computerized database from 1966 to 1992 for relevant articles. Articles were selected if they contained primary data on neck ranges of motion, sagittal muscle strength and flexion relaxation phenomenon (FRP). The results of 59 articles and 2 textbooks were analyzed. The Medical Subject Heading terms used were: cervical vertebrae, objective measurement, neck strength and mobility, range of motion, neck muscles, myoelectric signal, flexion relaxation, kinesiology/biomechanics. The bibliography of the retrieved articles were evaluated for further references and additional sources were suggested following personal communication with content experts.

Results

Range of motion

Restricted cervical spine range of motion (ROM) often accompanies painful conditions.[5] In clinical practice, measurement of such restriction is important for both assessment of the patient's condition and evaluation of treatment outcome. Several investigators have analyzed the normal cervical motion by means of plain film x-ray and cinematography.[11–20] Although accurate, these methods are costly and may be a health hazard. Several non-invasive instruments have also been tested[21–28] (see Table 1). The selection of instrument use in clinical practice should be guided by factors such as reliability, precision, ease of application, interpretation and cost. The majority of goniometers, regardless of their levels of sophistication (which ranges from complex electrogoniometers to simple gravity assisted pendulum types), tend to yield reproducible results.

An example of a goniometer is the Cervical Range of Motion device (CROM)™ This pendular-type goniometer has been reported to have good test-retest and interexaminer reliability, with intraclass correlation coefficients reported to be generally greater than 0.80.[28] Youdas et al.[28] also tested the accuracy of the CROM by measuring the differences between known angles on a rotary table to those obtained from three CROM instruments for each of the dial meters. On the basis of small differences obtained (mean differences for the transverse, sagittal and frontal planes ranged from 0 to 2 degrees, 0.5 to 0 degrees and −1.5 to 2 degrees, respectively), they concluded that the CROM was an accurate device. Although the standard deviations were not reported and the precision of the CROM remains unknown, the objectivity of other cervical ROM instruments has been determined. Comparing the Rolyan medical plastic goniometer and the Spinal Rangiometer, Zachman et al.[28] reported large confidence intervals between examiners (20–40 degrees) and interexaminer standard errors of estimate of 5–12 degrees for both devices. They concluded that clinical trials which employ these instruments should use caution in interpreting results if small therapeutic changes (e.g. < 20 degrees) are expected and small sample size employed. Although such caution may also apply to the CROM, this particular instrument is ideally suited for clinical use since it is easy to use, comfortably worn by the subject, lightweight, easily interpreted and inexpensive.[27]

Normative values of cervical ROM have been determined in healthy males and females subjects ranging in age from 12 to 79 years.[18,19,28] Among both males and females of the same age, females have a greater active ROM than males for all active ROMs except neck flexion.[28] That is, female subjects have 5 degrees greater cervical extension and 2–4 degrees greater lateral bending and rotation than males of the same age. Foust et al.[18] found that the mean and standard deviations of combined flexion and extension ROM was 137.2 ± 14.8 degrees in young adults (age 18–24), 115.5 ± 17.4 degrees in the early middle-age group (35–44 years), and 96.5 ± 16.2 degrees in the elderly (62–74 years). In a similar study,[19] the range in all three planes was found to decrease linearly with age beyond the third decade. Indeed, both sexes can expect a 40% decrease in cervical range of motion over a lifetime, with a loss of about 25% for males and

TABLE 1
Measurements of sagittal active cervical range of motion in healthy subjects

REFERENCE	METHOD	SUBJECTS			MOVEMENT (in degrees)		
		n	sex	age (yrs)	FLEXION Mean (SD)	EXTENSION Mean (SD)	TOTAL SAGITTAL RANGE
Alung, Larsson[17]	Electro-goniomet	10		24–58	—	—	140 ± 18
Buck et al.[21]	Bubble	47	M	18–23	66 (8)	73 (9)	139
	Goniomet	53	F	18–23	69 (10)	69 (9)	150
Defibaugh[22]	Pendulum Goniomet	30	M	20–48	58 (8)	79 (11)	137
Ferlic[23]	Protractor	59	M & F	25–34	—	—	127 ± 21
Leighton[22]	Gravity	294	M	*	—	—	142 ± 16
Foust et al.[18]	X-ray	31	M	18–24			136.9
		31	F	18–24	—	—	137.5
		30	M	35–44			109.1
		30	F	35–44			122.0
Lind et al.[19]	X-ray	35	M	12–79	—	—	68 ± 41.5
		35	F	12–79			76 ± 39
Mior et al.[26]	Pendulum	30		21–36	—	—	120 ± 7.5
Capuano-Pucci et al.[27]	Pendulum	14	M	20–26	50.3 (9)	70.8 (9)	120.1
		16	F	20–26			

* College athletes

13% for females by early-middle age.[15,18,28,29] In the sagittal plane, extension motion decreases more than that in flexion. From a practical standpoint, with each 10-year change in age, both males and females will lose about 5 degrees of neck extension and about 3 degrees of active ROM for each of the five other movements.[28] It is, therefore, important that clinicians and researchers avoid using previously reported singular values as estimates of normal cervical active ROM for both genders and across all ages.[28]

Neck muscle strength

Another objective measure that is important in the assessment of patients with neck pain is neck muscle strength. Weakness of the anterior cervical muscles is thought to contribute to persistent pain in patients complaining of chronic neck pain.[30] Silverman et al.[30] postulated that neck trauma sustained in whiplash injuries produces a reflex inhibition of the flexor muscles via the muscle spindle system and, in time, the anterior neck muscles weaken and atrophy, resulting in postural alteration and increased susceptibility to injury. Few authors, however, have quantified this weakness. The present review will specifically address cervical muscle strength in the sagittal plane.

Quantification of muscle weakness is achieved using either instrumented or non-instrumented methods. Non-instrumented methods (e.g. manual muscle testing) are commonly used clinically and rely on subjective interpretations. Krout and Anderson,[31] using manual muscle testing, found weakness in the anterior neck muscles in chronic neck pain patients. These methods, however, are far less reliable and valid than those obtained with instruments.[32]

Instrumented methods of recording muscle strength include strain gauge dynamometers and modified sphygmomanometers. The modified sphygmomanometer dynamometer (MSD) utilizes an inflated cuff attached to a digital pressure gauge to record changes in pressure while the subject provides maximum resistance. Measures are reported in mmHg and are compared over time, and with other muscles. Using the MSD, Vernon et al.[33] attempted to determine the neck extension-flexion strength ratio (E/F ratio) in 40 healthy male young adults. Extension strength was approximately 40% stronger than flexion strength in normal subjects. When compared to data obtained from a group of 12 male and 12 female neck pain patients, 16 with non-traumatic chronic neck pain (average duration 22.5 weeks) and 8 with "whiplash-type" injuries (average duration 110 weeks), the symptomatic subjects demonstrated an extension-flexion strength ratio (E/F ratio) twice that found in normals. The authors concluded that whiplash sufferers, in particular, demonstrated significant reduction of the flexor's strength values (Table 2). Unfortunately, several confounders were inherent in this study. The absence of a

TABLE 2
Neck strength of both asymptomatic and symptomatic patients measured with a modified sphygmomanometer dynamometer*

SUBJECT			STRENGTH (in KPa)		E/F RATIO
Sex	Age (yrs)	n	EXTENSION Mean (SD)	FLEXION Mean (SD)	
ASYMPTOMATIC			7927 (2128)	4615 (1317)	1.71
M	25	40			
SYMPTOMATIC					2.18
F	39	12	4336 (1516)	1982 (1250)	
M	36	12			
SYMPTOMATIC (WHIPLASH)			4655**	1184**	3.93
**	**	8			

* Adapted from Vernon et al.[33]

** Sex, age and standard deviation of this symptomatic sub-group was not available.

restraining device with their apparatus may have allowed the patient to use the trunk musculature during the assessment. Other factors included an unequal sample size, asymptomatic subjects unmatched for age and sex, and finally, a lack of standardized procedure as the asymptomatic subjects were instructed to maintain constant maximal pressure for 5 seconds while patients with neck pain were told to produce a level of pressure that reached, but did not exceed, tolerable pain. While these considerations meet ethical standards, it is obvious that the symptomatic group did not reach maximal strength rendering comparison difficult.

Nevertheless, similar findings have also been reported by authors using strain gauge dynamometers (SGD) suggesting that neck pain patients have significantly weaker flexors than asymptomatic subjects.[31] According to Krout and Anderson,[31] strain gauge dynamometers gave the most accurate measure of muscle strength. Using such an instrument, Levoska et al.[34] tested the cervical strength of asymptomatic subjects in the supine and prone positions. The reported reliability of this method for extension and lateral bending was satisfactory ($r = 0.72–0.80$) but poor for flexion force measurements ($r = 0.54$).

When neck muscle strength testing is combined with electromyography (EMG), the relationship between muscle activity and force generated can be calculated. If the relationship between EMG activity and muscular force is known, the EMG values can be used to evaluate the muscular strength exerted in a particular task.[35]

The EMG activity of the posterior neck muscles during isometric contraction has been studied. The semispinalis, splenius, longissimus, and to a lesser extent the trapezius muscles, are considered neck extensor muscles.[36–39] While these muscles also produce other movements of the neck, the semispinalis capitis muscle is equally activated in extension and in a direction falling mid-way between pure extension and pure lateral bending. As a result, it is the muscle most frequently chosen to measure the myoelectrical response during strength testing of the extensor muscles of the neck.[40]

Few studies have dealt with EMG recordings of the neck flexors. Costa et al.,[41] Sousa et al.[42] and Vitti et al.[43] have described the action of the sternocleidomastoid muscle (SCM) as being representative of the flexion component of neck movement. Using surface EMG, Ashton-Miller et al.[44] measured muscle activity during isometric neck flexion strength tests (submaximal and maximal voluntary contraction) in ten healthy adult males. Electrodes were taped bilaterally over the following eight target muscles at the C4 level: SCM, erector spinae, splenius capitis and infrahyoid. As expected, a positive linear

TABLE 3
Neck strength in the 80–90 percentile of USA population for group stature*

			STRENGTH (in Newtons)		
	SUBJECT		EXTENSORS	FLEXORS	E/F RATIO
Sex	Age (yrs)	n	Mean (SD)	Mean (SD)	
F	18–24	11	127 (36)	91 (29)	1.39
F	35–44	11	126 (28)	72 (16)	1.75
F	62–74	11	119 (46)	70 (31)	1.71
M	18–24	10	191 (38)	162 (52)	1.17
M	35–44	10	203 (45)	158 (38)	1.28
M	62–74	10	149 (22)	113 (20)	1.32
				Average =	1.43

* Adapted from Foust et al.[18]

correlation was found between muscle activity signal and the measured flexion effort level (force) for both right and left SCM and infrahyoid muscles. However, it was generally noted that the extensors (erector spinae) and lateral flexor/extensors (splenius capitis) were essentially quiescent, except at 100% maximum voluntary contraction. This suggests that the antagonist musculature is activated during maximum effort. Perhaps this helps stabilize the head and neck or prevent injury to the flexor muscles or other neck structures by acting as a "restraining device".

The relationship between the neck extensor and flexor muscle groups has also been reported. Data derived from Foust et al.[18] revealed that the maximal E/F ratios measured by EMG and strain gauge ranged from 1.1:1 to 1.75:1, averaging 1.40:1 for both males and females (Appendix, Table 3). Moroney et al.[45] calculated slightly higher mean E/F ratios using a sophisticated biomechanical model. They also concluded that the neck extensors were normally about 40% stronger than the flexor. These findings are consistent with Vernon et al.'s results discussed earlier.

Parameters such as gender, age and stature were also observed to have important effects on muscle strength.[18] For example, the mean sagittal isometric peak contractions of males were shown to be about 60% greater than that of females in every age and stature group. For both sexes, maximum voluntary strength diminished by an average of 25% over the adult lifespan. With the females strength tended to decrease gradually, but only slightly throughout their lives, while males were often stronger at middle-age than when they were younger. Finally, groups of shorter stature were shown to be slightly weaker throughout their lives while taller men tended to be stronger in their youth.[18]

Isometric strength testing appears very promising in the evaluation of patient's status. Researchers and clinicians however, need to be aware of the importance to properly control for variables such as age, gender and stature when assessing patient's neck muscle strength.

Flexion relaxation phenomenon

The flexion relaxation phenomenon refers to the absence of myoelectrical activity in extensor muscles upon full forward flexion of the lumbar[10,48,49] and cervical spine.[37–39,50–53] This would suggest that as full flexion is reached, the antagonist supportive role of the extensor muscles is replaced by the more passive support from the ligamentous and articular structures.[54]

In a well designed study conducted in the mid 1960's Pauly[50] used needle electromyography and reported silence or near silence of the semispinalis muscle when the head was permitted to hang freely during full trunk flexion. The EMG signal used in this study was filtered, integrated and linearly amplified. Recent evidence supporting the existence of such a flexion relaxation response in the cervical spine has come from ergonomic studies of the effect of various head positions on neck muscle activity in asymptomatic manual workers.[39,52] Recently, Meyer et al.[59] examined 10 asymptomatic subjects who exhibited comparable cervical paraspinal muscle activity during eccentric concentric sagittal motion and observed silence of the EMG activity on full neck flexion.

Interestingly, the FRP has been reported to be absent in patients presenting with pain in the lumbar spine. In other words, continuous activity of extensor muscles has been observed during maximal flexion.[55] It is postulated that continuous muscle contraction may serve to transmit loads through muscles rather than through injured spinal ligaments in an effort to avoid increased pain.[10] It has also been theorized that collateral muscle groups would be activated to compensate for actual or anticipated pain.[10,56–58]

Harms-Ringdhal and Ekholm[60] recorded very low levels of muscular activity (0–6% of maximum) in the posterior neck muscles during the first few minutes of extreme lower cervical-thoracic spinal flexion. However, they reported that all subjects perceived a progressive increase in pain level after 15 minutes if maintained flexion, and subsequently a slight increase in EMG activity was noted in the trapezius and splenius muscles. They concluded that this increase was possibly due to pain, indicating that tonic (sustained) reflex mechanisms might have been elicited. This hypothesis has been tested by Ashton-Miller et al.[44] who have reported subtle but significant systematic increase in myoelectric activity when deep experimental muscle pain was induced by injecting 5 ml of hypertonic (5%) saline solution in active and resting SCM muscles of 10 healthy adult males. The authors demonstrated that deep muscle pain in one muscle can cause associated changes to motor output in related synergists and antagonists.

While these latter findings may suggest an absence of the FRP in experimentally induced neck pain conditions, further study is necessary to verify its presence in chronic and acute neck pain patients.

Discussion

The use of objective outcome measures play a very important role in the assessment and management of spinal health care. Too often, however, the reliability, precision and accuracy of these methods is unknown and knowledge of the normal values can not be generalized, thereby making the interpretation and conclusion of each test difficult. This literature review outlines normative values and reliability studies available for cervical range of motion, sagittal neck isometric strength and the presence or absence of electrical activity (Relaxation Phenomenon) during cervical maximal flexion.

Gender, age and pain levels are three variables that can affect cervical ROM. The cervical spine range of motion was slightly greater in females compared to males for all active ROMs except neck flexion when age matched.[28] Also, the cervical spine motion in all three planes has been reported to decrease linearly with age from the third decade on. Both males and females can expect a 40% decrease in cervical ranges of motion over a lifetime.[15,18,28,29] Specifically, with each 10-year

change in age, the decrease in active ROM will be about 5 degrees in extension and 3 degrees in each of the five other movements.

The ratio of cervical extension-flexion maximum isometric voluntary muscle contraction has been estimated to range between 1.40 and 1.70 in normal subjects, reflecting approximately a 40% greater strength of the extensor versus the flexor muscles.[18,33,45] If the work reported on the lumbar spine[46] can be extrapolated, then the cervical E/F ratio may be an indicator of neck injury and provide an important outcome measure for the success of rehabilitation programs of injured patients. It appeared from the literature review that neck pain sufferers have weaker neck flexors than normal subjects. It, therefore, would seem logical that rehabilitation programs should concentrate on restoring the strength of the anterior neck musculature resulting in normalization of the ratio. To date, no studies have specifically reported on changes in cervical flexor muscle strength after rehabilitation. Of interest however, is a recent before-after study conducted in a rehabilitation center by Highland et al.[47] They reported significant gains in isometric extensor strength and range of motion of the cervical spine after eight weeks of clinical rehabilitation in 90 patients suffering from neck pain with or without arm pain. Perceived pain was also significantly reduced. Personal communication with one of the authors revealed that the patients were also instructed on home stretching exercises and performed regular aerobic exercise which may be considered as co-interventions. Nevertheless, it supported the concept that joint motion as well as specific and general strengthening programs are indicated in rehabilitation of chronic neck injuries. Other parameters such as gender, age, stature were observed to affect neck muscle strength performances supporting the importance to compare clinical results with well established normative data.

The use of isometric testing to describe human performance is widespread. However, there are few "real-life" situations that would require an individual to sustain a maximal contraction except perhaps in response to an anticipated sport injury or whiplash. Isometric (static) testing can evaluate variables such as duration, force and repetition but fails to look at displacement and motion variables (velocity and acceleration). Although knowledge of the normative data and comparison to symptomatic groups from an essential clinical and research basis, this information may be of limited use. Future research should investigate measures of acceleration and velocity changes that more truly represent "real-life" functional neck capabilities. Isoinertial and free dynamic testing are such measures.

The FRP refers to the absence of myoelectrical activity in extensor muscles upon full forward flexion and has been documented in the cervical spine of asymptomatic subjects.[10,37–39,50–53] While some studies have suggested an absence of the RFP in experimentally induced pain conditions,[44,60] further study is necessary to verify its presence in chronic and acute neck pain patients and to determine whether this phenomenon will have similar clinical applications as reported for the lumbar spine. Triano and Schultz[10] compared results of a disability questionnaire to measures of lower trunk motion and muscle function. They found the Oswestry Low Back Pain Disability Questionnaire related significantly to the presence or absence of relaxation of back muscles during full trunk flexion. Also, mean trunk strength ratios of extension to flexion were inversely related to disability scores, and trunk mobility was meaningfully reduced. Such observations suggest that an association exists between the Oswestry Disability ratings and the objective measures of myoelectrical signal levels, trunk strength ratios, and ranges of trunk motion.

Much of the available literature regarding disability questionnaires have concentrated upon low back pain and activities of daily living (ADL). Recently, a neck disability questionnaire, fashioned after Oswestry Low Back Pain Questionnaire, was developed at CMCC.[61] The Neck Disability Index (NDI) measures specific ADL in neck pain patients. The NDI has been reported to be reliable and have face validity, but has not been tested in acutely injured patients or compared with objective measures of neck function. Examining the relationship between the limitations of activities of ADL and functional outcome measures such as cervical range of motion, neck muscle strength and presence or absence of the FRP could help establish a better rationale for rehabilitation of chronic mechanical neck pain.

Conclusion

Normative values of cervical range of motion have been determined from plain film x-ray and goniometric studies in healthy subjects ranging in age from 18 to 74 yerars. Females have been reported to have a greater active ROM than males in all planes except in flexion.

Instrumented methods of recording muscle strength included modified sphygmomanometers, strain gauge dynamometers and electromyography. The ratio of extension to flexion maximum isometric voluntary contraction has been estimated to range between 1.40–1.70 in normal subjects. This suggests that the extensor muscles of the neck are approximately 40% stronger then the neck flexor muscles. Gender, age, stature and pain level are all parameters affecting peak isometric strength performances in normal subjects.

The FRP refers to the absence of myoelectrical activity in extensor muscles upon full forward flexion and has been documented in the cervical spine. Presence or absence of this phenomenon in neck pain patients remains to be clearly established.

For clinical purposes, most goniometers appear to give reproducible results and are inexpensive. The CROM fulfills the criteria for a good instrument. However, the "in office" use of instrumented methods for testing isometric strength remains uncommon due to the absence of simple, inexpensive devices with tested reliability. Sophisticated instruments are inaccessible due to their costs and are therefore restricted to research labs and rehabilitation centers. The FRP should be further investigated before making any claims as to its clinical significance. In

addition, future study is needed to investigate the functional impairment aspect of physical disability, which accounts for a portion of total neck disability.

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