Spine

SPINE Volume 39, Number 5, pp 362-367

Normal Values for Cervical Range of Motion

Raymond A. H. M. Swinkels, PhD*†‡ and Ilse E. J. C. M. Swinkels-Meewisse, PhD†‡

Study Design. Cohort study.

Objective. To generate normal values for active range of motion (ACROM) of the cervical spine in asymptomatic persons.

Summary of Background Data. There is a lack of normal values for ACROM based on large groups and stratified for different age categories.

Methods. Four hundred asymptomatic persons were included, 100 for each decade of age from 20 years to 60 years and in each subgroup 50 males and 50 females. ACROM was measured with the cervical range of motion (CROM) device. Analysis of variance and the Scheffé *post hoc* test was used to investigate the differences of ACROM between the decades of age. Linear regression analysis was performed to examine the influence of age and sex on ACROM.

Results. The results of this study show that the ACROM decreases significantly in persons older than 50 years for all directions except extension and side flexion compared with that in the subgroup aged 40 to 50. Age had an overall significant effect on the ACROM for all directions. Sex proved to have no significant effect on the ACROM.

Conclusion. Normal values were established for ACROM in a group of 400 persons without neck complaints. It was demonstrated that age has a significant influence on the ACROM, but sex has no influence.

Key words: range of motion, mobility, cervical spine, normal values, measurement.

Level of Evidence: N/A

Spine 2014;39:362–367

Daily, many patients are treated for complaints in the cervical region. The incidence of neck pain is 2.3 per 100 person years.[1] In the majority of cases the complaints are classified as "nonspecific," that is there is no specific cause of the neck pain that can be medically identified.[2] Fifteen percent to 43% of patients with nonspecific neck pain consult their general practitioner and 61% of them are subsequently referred for physiotherapy or manual therapy treatment.[3–5] During the examination, physical therapists routinely measure the range of motion (ROM), because in many cases 1 of the treatment goals for patients with nonspecific neck pain is to improve the mobility of the cervical spine.

A systematic review regarding the clinimetric properties of measurement instruments for the active cervical range of motion (ACROM) found 3 different types of measurement instruments. These instruments were as follows: (1) different types of goniometers/inclinometers, (2) visual estimation, and (3) tape measurements.[6] Good intra- and interobserver reliability was demonstrated for the CROM device, Cybex electronic digital instrument (EDI-320; Cybex International, Inc., Medway, MA) and a single inclinometer. The agreement was assessed for the CROM: ICC = 0.88 to 0.99.[6] The CROM received a positive rating for construct validity (r >0.65). When clinical acceptability is taken into account the CROM has been considered as the most appropriate instrument for measuring active ROM in patients with nonspecific neck pain. In many studies the CROM proved to be reliable, reproducible, and valid to a large extend (for validity ICC, 0.82–099).[6–13] However, in clinical practice, the ACROM is assessed without using a standardized measurement device. Pool *et al*[5] demonstrated that the interexaminer reproducibility of physical examination of the cervical spine on the basis of visual estimation is unreliable; despite a standardized protocol, the agreement for general mobility shows κ values between 0.05 and 0.61 (95% confidence interval). Furthermore, the following questions arise: (1) what might be considered as normal scores of the ACROM and (2) when does one define the scores restricted or pathological?

In the literature, there is little information about normal values regarding the interpretation of the measurement results for ACROM. Two studies were published concerning the ACROM, stratified for age,[14,15] but these studies used small groups per decade. In the Trott *et al*[14] study, the ACROM was examined in healthy volunteers in the age of 20 to 60 years by using the 3SPACE ISOTRAK system (Polhemus Navigational, Kaiser Aerospace, Colchester, VT), a complex electromagnetic device measuring the position and orientation of a sensor (placed on the forehead) in relation to a source (placed over the spinous process of C7). For each decade, 30 persons were examined. Hole *et al*[15] used the CROM for measurement of the ACROM. They examined 84 healthy volunteers.

From the *Department of Physiotherapy, Faculty of Health Sciences, Zuyd University of Applied Sciences, Heerlen, the Netherlands; †Zuyd University of Applied Sciences, Centre of Research Autonomy and Participation for People with Chronic Illnesses, Heerlen, the NetherlandsL; and ‡Centre for Physical Therapy and Rehabilitation, Geldrop, the Netherlands.

Acknowledgment date: October 16, 2013. First revision date: November 25, 2013. Acceptance date: November 26, 2013.

The manuscript submitted does not contain information about medical device(s)/drug(s).

No funds were received in support of this work.

No relevant financial activities outside the submitted work.

Address correspondence and reprint requests to Raymond A. H. M. Swinkels, PhD, Ulenpas 80, 5655 JD Eindhoven, the Netherlands; E-mail: swinky@xs4all.nl

DOI: 10.1097/BRS.0000000000000158

Four out of these 84 persons were between 60 and 70 years. The results of these 2 studies are reflected in Table 1. Trott *et al*[14] found small differences in ACROM for each decade of age between males and females, however, influence of sex was found to have no significant effect.

In a more recent study, ROM was measured by x-rays of the cervical spine in 1230 asymptomatic subjects. This concerned the ROM of flexion and extension of C2–C7. Side flexion and rotation were not investigated.[16]

The aim of this study was to generate normal values for the active ROM of the cervical spine, stratified for age (20–30 yr, 30–40 yr, 40–50 yr, and 50–60 yr) for large groups and to examine the effects of age and sex on the ACROM values.

MATERIALS AND METHODS

Participants

Four hundred people without any neck complaints were included, 100 for each decade of age and in each subgroup 50 males and 50 females. Exclusion criteria were as follows: neck pain, pain medication, severe diseases, neck surgery in the history, any treatment for neck complaints during the last 2 years, neck trauma in history requiring medical treatment, presence of tremor, shoulder pain, and pregnancy. All persons signed an informed consent.

Measurement Procedure

For all measures, we used the CROM device because it is easy to use and has high inter- and intraobserver reliability.[6] The CROM is fixed on the head like spectacles on the nose and on both ears (see Figure 1). Volunteers were seated on a stool with both feet flat on the ground and the arms relaxed on the thighs. They received clear instructions concerning the posture and the movements to make. The movements were made 3 times in each direction before starting the measurement.

The investigated active movement directions were flexion, extension, side flexion (left and right), and rotation (left and right). All participants were asked to sit down on a (standardized) stool, with both feet flat on the floor and the arms relaxed on the upper legs. After a brief instruction and demonstration participants were asked to make the movements twice before measurement, as a kind of warming up to reach maximum ROM.

Data Analysis

Data analysis was performed with SPSS (Statistical Package for Social Sciences; IBM Corporation, Software Group, Somers, NY), version 19. Descriptive statistics included mean ROM and standard deviation for each decade of age. Analysis of variance and the Scheffé *post hoc* test was used to investigate the differences of ACROM between the decades of age. The Scheffé test was used because this is defined as the most conservative test.[17] To investigate the effect of age and sex on ACROM a linear regression analysis was performed.

Assumptions of linearity of the covariate and homogeneity of slopes were assessed before proceeding to inferential analyses. This study is approved by the Dutch Trial Register under number TC3256.

TABLE 1. Average Active Range of Motion C0–C7 in Separate Decades of Age (N = 30 in Each Group) Measured by 3SPACE ISOTRAK System* and Measured With a CROM-Device†

	Movement Direction					
Age	Flexion	Extension	Side Flexion Left	Side Flexion Right	Rotation Left	Rotation Right
20–29						
Trott *et al*[14] (1996), N = 30	57.4	76.1	45.5	47.6	71.7	78.0
Hole *et al*[15] (1995), N = 24	63.7	81.3	47.1	44.3	74.5	72.4
30–39						
Trott *et al*[14] (1996), N = 30	46.8	64.8	40.3	44.8	71.1	77.5
Hole *et al*[15] (1995), N = 22	58.9	66.3	37.6	36.1	70.3	69.6
40–49						
Trott *et al*[14] (1996), N = 30	47.4	61.2	38.8	39.4	64.2	73.9
Hole *et al*[15] (1995), N = 17	55.6	64.6	36.3	34.3	60.3	65.4
50–59						
Trott *et al*[14] (1996), N = 30	45.1	60.0	32.4	35.4	63.4	70.4
Hole *et al*[15] (1995), N = 17	50.8	58.5	31.9	30.7	61.4	59.5

*Trott *et al*[14] (1996).
†Hole *et al*[15] (1995).

Figure 1. Position of the CROM on the head. CROM indicates cervical range of motion.

RESULTS

The mean ACROM and standard deviation for each decade of age is presented in Table 2. The results of analysis of variance are presented in Table 3 for each direction of ACROM with a $P \leq 0.05$.

The results of this study show that the ACROM decreases significantly for all directions in the decade of 50 to 60 years when compared with persons younger than 40 years (Table 3). Furthermore, there was a significant difference in the ACROM of side flexion (left and right) and extension between the 20- to 29-year decade and other decades. Comparing persons older than 50 years with persons aged 40 to 50 years, the flexion and rotation decrease significantly, whereas the extension and side flexion do not show any significant differences.

As part of the linear regression analysis, the linear relationship between measures was determined and demonstrated an almost perfect linear relationship. The linear regression analysis showed that age had an overall significant effect on the ACROM for all directions, however, sex proved to have no significant effect on the ACROM. The results of the linear regression analysis are reflected in Table 4.

DISCUSSION—CONCLUSION

In this study, we examined the ACROM in large groups of asymptomatic persons between 20 to 60 years. Normal values for ACROM were established. This study shows that age significantly influences the ACROM. However, there are no significant differences in ACROM between males and females.

Comparing the results of this study with that of Trott *et al*[14] and Hole *et al*,[15] the majority of the normal values in the study of Trott *et al*[14] and Hole *et al*[15] are smaller than the normal values in this study, especially in the older decades of age. The difference might be explained by the number of participants (120 and 80, respectively, *vs.* 400). Another explanation might be the difference in the used measurement instruments. In agreement with Trott *et al*[14] and Hole *et al*,[15] this study showed that there is no significant effect of sex on the ACROM. Comparison of the results with the findings of Yukawa *et al*[16] is difficult because the method of measuring was radiographical. In this investigation, the CROM was used because this measurement instrument is relatively easy to use in a clinical situation, the patient burden is low and the patient is not exposed to radiation. Furthermore, the Yukawa *et al*[16] study concerned measurement of C2–C7, whereas in this study, the whole cervical spine and cervicothoracic junction was measured.

The largest contrast for all directions was found between 20 and 29 years and 50 and 59 years of age. The analysis shows that there is a varying significant effect of age between

TABLE 2. Normal Values of ACROM and SD Stratified for Age

Age Movement	20–29 yr, N = 100	30–39 yr, N = 100	40–49 yr, N = 100	50–59 yr, N = 100
Flexion	60	58	59	53
SD	10.921	8.706	8.403	9.271
Extension	75	69	66	64
SD	10.336	10.347	9.709	10.298
Side flexion left	46	43	41	38
SD	7.500	6.406	7.740	7.975
Side flexion right	45	42	40	38
SD	7.466	7.091	8.388	8.055
Rotation left	78	79	79	71
SD	7.968	8.891	9.305	9.235
Rotation right	79	79	78	71
SD	6.632	8.604	9.690	8.294

ACROM indicates active cervical range of motion; SD, standard deviation.

TABLE 3. ANOVA Between the Different Subgroups of Age

Movement	Age-Year Decade	Average ACROM (°)	Difference (°)	*P*
Flexion	(20–29)/(30–39)	60/58	2	0.626
	(20–29)/(40–49)	60/59	1	0.944
	(20–29)/(50–59)	60/53	7	0.000
	(30–39))/(40–49)	58/59	−1	0.919
	(30–39)/(50–59)	58/53	5	0.009
	(40–49)/(50–59)	59/53	6	0.001
Extension	(20–29)/(30–39)	75/69	6	0.000
	(20–29)/(40–49)	75/66	9	0.000
	(20–29)/(50–59)	75/64	11	0.000
	(30–39)/(40–49)	69/66	3	0.431
	(30–39)/(50–59)	69/64	3	0.041
	(40–49)/(50–59)	66/64	2	0.681
Side flexion left	(20–29)/(30–39)	46/43	3	0.033
	(20–29)/(40–49)	46/41	5	0.000
	(20–29)/(50–59)	46/38	8	0.000
	(30–39)/(40–49)	43/41	2	0.266
	(30–39)/(50–59)	43/38	5	0.000
	(40–49)/(50–59)	41/38	3	0.108
Side flexion right	(20–29)/(30–39)	45/42	3	0.030
	(20–29)/(40–49)	45/40	5	0.000
	(20–29)/(50–59)	45/38	7	0.000
	(30–39)/(40–49)	42/40	2	0.256
	(30–39)/(50–59)	42/38	4	0.001
	(40–49)/(50–59)	40/38	2	0.233
Rotation left	(20–29)/(30–39)	78/79	−1	0.901
	(20–29)/(40–49)	78/79	−1	0.908
	(20–29)/(50–59)	78/71	7	0.000
	(30–39)/(40–49)	79/79	0	1.000
	(30–39)/(50–59)	79/71	8	0.000
	(40–49)/(50–59)	79/71	8	0.000
Rotation right	(20–29)/(30–39)	79/79	0	1.000
	(20–29)/(40–49)	79/78	1	0.878
	(20–29)/(50–59)	79/71	8	0.000
	(30–39)/(40–49)	79/78	1	0.916
	(30–39)/(50–59)	79/71	8	0.000
	(40–49)/(50–59)	78/71	7	0.000

Values in dark gray cells denote 20 to 30 years compared with other decades; light gray cells, 30 to 40 years compared with 40 to 50 years and with 50 to 60 years; white cells, 40 to 50 years compared with 50 to 60 years; black cells, significant values ($P \leq 0.05$).

ACROM indicates active cervical range of motion; ANOVA, analysis of variance.

TABLE 4. Results of the Linear Regression Analysis for Each Direction (Dependent Variable) for Age and Sex (Independent Variables)

Movement	*B* Value	*T* Value	*P*
Flexion			
Age	−0.180	−4.258	0.000
Sex	−0.023	−0.024	0.981
Extension			
Age	−0.350	−7.664	0.000
Sex	−1.835	−1.799	0.073
Side flexion left			
Age	−0.256	−7.719	0.000
Sex	−1.093	−1.476	0.141
Side flexion right			
Age	−0.256	−7.383	0.000
Sex	−0.892	−1.152	0.250
Rotation left			
Age	−0.207	−5.059	0.000
Sex	0.475	0.519	0.604
Rotation right			
Age	−0.254	−6.617	0.000
Sex	−0.223	−0.259	0.795

the fourth and fifth decade and fifth and sixth decade, depending on the movement direction. Apparently, during the period between 40 and 50 years, changes that occur lead to a significant decrease of ACROM. These changes could be related to osteoarthritic processes with consequences for the biomechanics of the neck. As a consequence of such osteoarthritic changes there could be a difference in the combination of the side flexion movement and the rotation movement. Flexion and extension can be performed 2 dimensionally. However, biomechanical studies have shown that side flexion and rotation are coupled movements, which means that side flexion cannot be performed without rotation and *vice versa*.[14,18] It is demonstrated in a 3-dimensional *in vitro* study that at least in the upper cervical spine the side flexion and rotation are coupled.[19] The coupling of movements possibly differs, depending on the initial dominant movement direction. However, we did not find significant left-right differences regarding rotation and side flexion, so the question arises to what extent the mechanical coupling of movements influences the ACROM. Furthermore, it is demonstrated that large differences exist in the orientation of joint surfaces and other asymmetries in the cervical spine.[20,21] These issues raise the problem of the definition of 3-dimensional neutral joint positions: in case of these asymmetries in joint surfaces a symmetric ROM seems less obvious. However, despite these studies we did not find asymmetries in ACROM of side flexion and rotation. Possibly, the persons in this study had no asymmetries in joint surfaces. The specimens in the joint asymmetry studies were of higher age (mean age, 80 ± 11 yr)[20] than our subjects of which the oldest persons were younger than 60 years. In case joint asymmetries are present in the current studied population, which is uncertain, such joint asymmetries might have less influence on the ACROM than expected. Clinically, these aspects may be important to consider for the interpretation of (normal) values as well as when attempting to restore mobility.

Although a standardized measurement protocol was used, the results of the study might be influenced by movement of the upper thoracic spine. To resemble the clinical situation as much as possible we decided to accept this possible bias.

Furthermore, we have not taken in account posture abnormalities, for example, scoliosis or thoracic or cervicothoracic hyperkyphosis.

For future research we recommend to perform the same study on people with neck complaints, to determine in what amount there is a significant difference in ACROM between healthy people on the 1 hand and people with neck complaints on the other.

➢ Key Points

- ❑ Generating normal values for ROM of the cervical spine in asymptomatic persons.
- ❑ To confirm normal values for active ROM of the cervical spine in other studies.

- ❑ Discussing the clinical relevance of active ROM of the cervical spine
- ❑ Confirmation that sex has no influence on the active ROM of the cervical spine.

Acknowledgments

The authors thank their colleagues S. M. Duchateau, S. M. L. Coumans, C. M. J. Dreezens, N. J. M. T. Rosier, and J. A. J. Engbersen for their contribution in the measurements, and J. Geraets for his contribution in the statistical analyses.

References

1. Bot SD, van der Waal JM, Terwee CB, et al. Incidence and prevalence of complaints of the neck and upper extremity in general practice. *Ann Rheum Dis* 2005;64:118–23.
2. Borghouts JAJ, Koes BW, Bouter LM. The clinical course and prognostic factors of non-specific neck pain: a systematic review. *Pain* 1998;77:1–13.
3. Borghouts J, Janssen H, Koes B, et al. The management of chronic neck pain in general practice. A retrospective study. *Scand J Prim Health Care* 1999;17:215–20.
4. Agarwal S, Allison GT, Singer KP. Reliability of the spin-T cervical goniometer in measuring cervical range of motion in an asymptomatic Indian population. *J Manipulative Physiol Ther* 2005;28:487–92.
5. Pool JJ, Hoving JL, de Vet HC, et al. The interexaminer reproducibility of physical examination of the cervical spine. *J Manipulative Physiol Ther* 2004;27:84–90.
6. de Koning CH, van den Heuvel SP, Staal JB, et al. Clinimetric evaluation of active range of motion measures in patients with non-specific neck pain: a systematic review. *Eur Spine J* 2008;17:905–21.
7. Capuano-Pucci D, Rheault W, Aukai J, et al. Intratester and intertester reliability of the cervical range of motion device. *Arch Phys Med Rehabil* 1991;72:338–40.
8. Fletcher JP, Bandy WD. Intrarater reliability of CROM measurement of cervical spine active range of motion in persons with and without neck pain. *J Orthop Sports Phys Ther* 2008;38:640–5.
9. Nilsson N, Christensen HW, Hartvigsen J. The interexaminer reliability of measuring passive cervical range of motion, revisited. *J Manipulative Physiol Ther* 1996;19:302–5.
10. Rheault W, Albright B, Byers C, et al. Intertester reliability of the cervical range of motion device. *J Orthop Sports Phys Ther* 1992;15:147–50.
11. Tousignant M, de Bellefeuille L, O'Donoughue S, et al. Criterion validity of the cervical range of motion (CROM) goniometer for cervical flexion and extension. *Spine (Phila Pa 1976.)* 2000;25:324–30.
12. Tousignant M, Boucher N, Bourbonnais J, et al. Intratester and intertester reliability of the Cybex electronic digital inclinometer (EDI-320) for measurement of active neck flexion and extension in healthy subjects. *Man Ther* 2001;6:235–41.
13. Youdas JW, Carey JR, Garrett TR. Reliability of measurements of cervical spine range of motion– comparison of three methods. *Phys Ther* 1991;71:98–104.
14. Trott PH, Pearcy MJ, Ruston SA, et al. Three-dimensional analysis of active cervical motion: the effect of age and gender. *Clin Biomech (Bristol, Avon.)* 1996;11:201–6.
15. Hole DE, Cook JM, Bolton JE. Reliability and concurrent validity of two instruments for measuring cervical range of motion: effects of age and gender. *Man Ther* 1995;1:36–42.
16. Yukawa Y, Kato F, Suda K, et al. Age-related changes in osseous anatomy, alignment, and range of motion of the cervical spine. Part I: radiographic data from over 1200 asymptomatic subjects. *Eur Spine J* 2012;21:1492–8.
17. Hilton A, Armstrong R. Stat Note 6: *post hoc* ANOVA tests. *Microbiologist* 2006;34–6.
18. Mimura M, Moriya H, Watanabe T, et al. Three-dimensional motion analysis of the cervical spine with special reference to the axial rotation. *Spine (Phila Pa 1976.)* 1989;14:1135–9.
19. Cattrysse E, Provyn S, Kool P, et al. Reproducibility of kinematic motion coupling parameters during manual upper cervical axial rotation mobilization: a 3-dimensional *in vitro* study of the atlanto-axial joint. *J Electromyogr Kinesiol* 2009;19:93–104.
20. Cattrysse E, Provyn S, Gagey O, et al. *In vitro* three-dimensional morphometry of the lateral atlantoaxial articular surfaces. *Spine (Phila Pa 1976.)* 2008;33:1503–8.
21. Cattrysse E, Barbero M, Kool P, et al. 3D morphometry of the transverse and alar ligaments in the occipito-atlanto-axial complex: an *in vitro* analysis. *Clin Anat* 2007;20:892–8.