ORIGINAL ARTICLE

IJPHY

PHOTOGRAMMETRIC QUANTIFICATION OF FORWARD HEAD POSTURE IS SIDE DEPENDENT IN HEALTHY PARTICIPANTS AND PATIENTS WITH MECHANICAL NECK PAIN

[1]Aliaa Rehan Youssef, PhD

ABSTRACT

Background: Forward head is a common postural fault of the cervical spine that can be assessed using the photogrammetry method. This is a valid, popular and feasible clinical method. Although forward head is primarily a sagittal plane postural fault, deviations in other planes may result in measurement errors when photos are captured from only one side. Therefore, the purpose of this study was to investigate whether forward head assessment by photogrammetry taken from the right (Rt) or left (Lt) sides of the body would differ.

Methods: One hundred thirty two healthy adults were assessed from standing and 90 were assessed from sitting positions. In addition, 41 patients with mechanical neck pain were assessed from standing and 56 from sitting positions. Three profile photos were captured from each side in standing and sitting positions. Photos were then digitized before they were analyzed using the kinovea software to measure the craniovertebral (CVA) and gaze angles.

Results: In healthy adults, the CVA was not significantly different across sides ($p>0.05$) whereas the gaze angle was different regardless of the testing position ($p <0.05$). For patients with mechanical neck pain, CVA differed in standing ($p <0.05$) but not in sitting position ($p >0.05$), whereas the gaze angle did not differ regardless of the testing position ($p >0.05$).

Conclusion: Measurement of CVA and gaze angles in sitting and standing is not consistent across sides, depending on the population tested. Assessors should be conservative and consider taking photos from both sides to assess the severity of forward head position using the photogrammetric method.

Keywords: Forward head posture, Photogrammetry, Craniovertebral angle, Gaze angle, Mechanical neck pain, postural faults.

Received 24th April 2016, revised 12th May 2016, accepted 26th May 2016

www.ijphy.org

10.15621/ijphy/2016/v3i3/100838

CORRESPONDING AUTHOR

[1]Aliaa Rehan Youssef, PhD

24 Mohammed Korium St.,
6th District, Nasr City,
Cairo, Egypt 11391

INTRODUCTION

Forward head posture (FHP) is the most common postural fault in the sagittal plane. It has been associated with neck pain and dysfunction[1-3], cervicogenic headache[4,5], carpal tunnel syndrome[6] and even an increased falling risk in the elderly[7]. Thus, quantifying the severity of FHP has been recommended for routine examination of the head and neck as well as the upper quadrant of the body[8,9].

Several assessment methods have been used such as observation[10,11] and the use of instruments including head posture and spinal curvature, electronic head posture[12] and Cervical Range of Motion[13]. Imaging such as plain radiographs and photography were also used[9,14–19].The use of photography, or photogrammetric method, to assess FHP has been reliable and sensitive[20]. It is a valid method that correlates well with radiographs[4,21]. Further, it is a simple, feasible and economic method that can be used in various clinical settings.

Photogrammetry requires capturing photographs in a standardized manner. Then, photographs are digitized for further analysis using a computer software[8,22]. Photo capture can be done either from sitting[23–25] or standing positions[16,17,24]. Literature has described photography captured from one side of the body[5,6,9,20,24,26–29]. However, due to the three dimensional nature of the spine, photos taken from one side only may result in measurements error, as side bending and rotation of the neck may alter the head position in the sagittal plane. Therefore, the purpose of this study was to detect whether photogrammetry of FHP in healthy subjects and patients with mechanical neck pain varies between the corresponding sides of the body.

METHODS

Participants:

This observational cross sectional study was approved and conducted in accordance with the guidelines of the local Ethics Committee. One hundred thirty two asymptomatic healthy male and female adult college students were recruited for this study (62 females and 70 males).

For the patient group, 56 female patients with mechanical neck pain were enrolled. The age range for all participants was 18 to 30 years old.

Healthy participants were excluded if they reported any previous history of musculoskeletal trauma, dysfunction or surgery over the past two years. Also, participants were excluded if they had uncorrected vision or hearing problems or respiratory disease. Initial screening was done to judge eligibility to participate in the study, then, a full verbal explanation of the purpose of the study and assessment procedure was given to participants. If a participant agreed to be enrolled in the study, an informed consent was signed.

For patients with mechanical neck pain, patients were excluded if they had any red or yellow flags, radiculopathy or other musculoskeletal deformity, diseases or dysfunction of the spine[30–32].

Photograph capturing:

First, adhesive markers were placed bilaterally on the tragus of the ear, and the calcaneocuboid joint of the foot. To capture images, a Fuji film digital camera (3 mega pixel) was mounted on a tripod that was placed at a distance of 100 cm from the subject's lateral foot. The height of the camera was adjusted based on the subject's height so that the camera was at the tragus level. An inclinometer was also used to verify the horizontal alignment of the camera. In addition, a plumb line was hung freely lateral to the tested subject to represent the true vertical line.

First, subjects were instructed to stand with the side of the trunk facing the camera and to look at a target fixed in front [33]. The researcher asked the subject to flex and extend the neck for a few times before assuming the standing resting posture. All participants were instructed, prior to photo capturing, to assume a relaxed resting posture while looking forward at the target with arm rested beside the body. Then, three sagittal plane photos were taken by the digital camera from each side and saved to a personal computer for further analysis. Repeated photographs aimed at reducing bias due to subject's tension during photography capturing as well as to overcome the difference between measurements because of postural swaying [34]. For photography in standing position, 132 healthy subjects and 41 patients with mechanical neck pain were assessed, whereas 90 healthy subjects and 56 patients with neck pain were assessed from sitting position using the same procedures. Digitized photographs were measured using the open access Kinovea software [7].

Assessment of FHP

To assess the severity of FHP, two postural angles were measured: the cranio vertebral angle (CVA) and the gaze angle (Figure 1). The CVA was measured as the angle between an imaginary line extending from C7 through the tragus, and the horizontal line [5]. The values for CVA are indicative of the position of the head relative to the trunk. The smaller the CVA, the greater the FHP. Gaze angle is the angle formed between a line drawn through the canthus of the eye and tragus of the ear and a horizontal line through the tragus of the ear. This angle describes the inclination of the head from the horizontal. It reflects the relative posture of the upper cervical spine with a greater gaze angle indicating a more extended position of upper cervical spine[7,8,15,28,35].

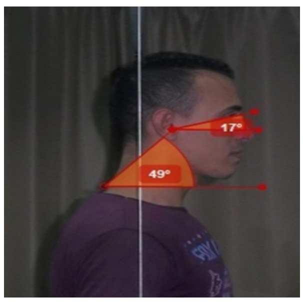

Figure 1: A profile photography showing the measurement of craniovertebral (lowermost angle) and gaze (uppermost angle) angles using the Kinovea software. A plumb line is hanged to represent the line of gravity

Statistical design:

The main outcome measure for this study was FHP severity as indicated by the CVA and the gaze angle measured from the right (Rt) and left (Lt) sides of the body.

The two angles were measured three times from each side and the average was calculated and used for further statistical analyses. Paired t-test was used to compare between angle values on the Rt and Lt in healthy as well as patients with mechanical neck pain. All statistical analyses were done using SPSS version 21.0 (IBM Inc., Chicago, IL, USA). The significance level was set at p<0.05. Also, agreement between the absolute values of the Rt and Lt sides was assessed using the Bland and Altman graphical method (-0.22°±6.6); with the difference between Rt and Lt sides measurements plotted (Y-axis) against the average of the two measures (X-axis)

RESULTS

For healthy subjects, CVA was not significantly different between the Rt and Lt sides in standing (p =0.45; 95% CI: -0.78, 0.35) and sitting (p =0.34; 95% CI: -0.51, 1.45) (Table 1).The mean difference ± 95% limits of agreement (LOAs) between Rt and Lt sides in standing was [36] and in sitting was (0.47°±9.35) (Table 2).

For patients with neck pain, CVA angle was significantly different between the corresponding sides in standing (p =0.01; 95% CI: 0.30, 2.35) but not in sitting position (p =0.17; 95% CI: -0.27, 1.51) (Table 1). CVA mean difference ± 95% LOAs in standing was (1.32°±6.49), whereas in sitting it was (0.62°±6.64) (Table 2).

Table 1: CVA and gaze angle measurement agreement between Rt and Lt sides: Mean Difference, 68% and 95% limits of agreement (LOA) are given

	Mean Difference (Accuracy)	68% LoA (Precision)	95% LoA
Normal Group			
CVA standing	-0.22	3.29	6.59
Gaze standing	-1.05	3.70	7.40
CVA sitting	0.47	4.66	9.35
Gaze sitting	-0.88	4.15	8.29
Neck pain Group			
CVA standing	1.32	3.25	6.49
Gaze standing	-0.76	2.90	5.80
CVA sitting	0.62	3.32	6.64
Gaze sitting	-0.58	4.01	8.03
LoA: Limits of agreement			

Regarding gaze angle, healthy subjects showed significant difference between corresponding sides in standing (p=0.001; 95% CI: -1.68, -0.41) and sitting (p =0.04; 95% CI: -1.75, -0.04) (Table 1).The gaze angle mean difference ± 95% LOAs in standing was (-1.05°±7.4) and in sitting it was (-0.88°± 8.3)(Table 2).

For patients with neck pain, the gaze angle showed a non-significant difference between the Rt and Lt sides in standing (p=0.10; 95%CI: -1.67, 0.16) and sitting (p=0.29; 95%CI: -1.65, 0.50) positions (Table 1). In standing, the mean difference ± 95%LOA between the two sides in standing was (-0.76°±5.80) and in sitting it was (-0.62°± 8.03) (Table 2).

Table 2: CVA and gaze angle: descriptive statistics, P-value, as well as 95%CI.

			Mean ± SD	Range	P-value	95% CI
Healthy Subjects	Standing (n= 132)	Rt CVA	46.4 ± 5.1	33.0 – 58.0	0.45	- 0.78 – 0.35
		Lt CVA	46.6 ± 5.3	32.0 – 59.0		
		Rt Gaze	16.9 ± 5.3	3.7 – 28.3	0.001*	- 1.68 – -0.41
		Lt Gaze	17.9 ± 5.6	3.0 – 30.0		
	Sitting (n= 90)	Rt CVA	46.7 ± 5.4	34.3 – 62.0	0.34	- 0.51 – 1.45
		Lt CVA	46.2 ± 5.9	33.0 – 65.0		
		Rt Gaze	17.7 ± 5.5	5.0 – 30.0	0.04*	- 1.75 – -0.04
		Lt Gaze	18.5 ± 5.4	6.7 – 30.7		
Patients with Mechanical Neck Pain	Standing (n= 41)	Rt CVA	45.3 ± 4.6	31.3 – 55.3	0.01*	0.30 – 2.35
		Lt CVA	44.0 ± 4.8	30.3 – 51.7		
		Rt Gaze	16.1 ± 5.3	4.0 – 25.0	0.10	-1.67 – 0.16
		Lt Gaze	16.8 ± 5.1	4.3 – 29.0		
	Sitting (n= 56)	Rt CVA	45.4 ± 6.2	30.7 – 56.0	0.17	- 0.27 – 1.51
		Lt CVA	44.8 ± 5.9	30.0 – 55.0		
		Rt Gaze	15.2 ± 4.7	6.0 – 23.7	0.29	-1.65 – 0.50
		Lt Gaze	15.8 ± 5.3	5.7 – 26.7		

* indicate significant difference between right and left sides (p<0.05)
Rt: Right; Lt: Left; CVA: Craniovertebral angle

DISCUSSION

This is a comparative cross sectional study. The main outcome measure was the difference in CVA and gaze angles measured from the Rt and Lt standing and sitting positions. Healthy participants and patients with mechanical neck pain were assessed. The CVA was significantly different across sides in standing position in patients with mechanical neck pain, whereas the gaze angle significantly differed across sides in both sitting and standing in healthy participants.

The photogrammetric method has a high interrater (ICC=0.75-0.89) and intrarater (ICC=0.91-0.99) reliability in assessing FHP [18]. Further, it has a good validity compared to radiographs. It has a strong correlation with the angles measured using Low Density X-ray images (LODOX) (R-values of at least 0.84)[37]. When FHP was assessed using radiographs and photographs; no differences were found between the two methods assessing CVA[4]. Thus, photogrammetry has been recommended as a method that is clinically feasible, cost-effective, time-efficient, and non-invasive with no exposure to ionizing irradiation [37].

In previous studies, the CVA and gaze angles measured from profile pictures were taken from the Rt side[17,24,29], Lt side [18,20,26,28,38] or dominant upper limb side[9,39], without justifying which side should be chosen. Thus, this study was the first to compare side effect on measurement of FHP.

In this study, the mean CVA significantly differed only in standing position in patients with mechanical neck pain with a mean difference of 1.3°. Neck pain has been shown to impair standing balance[40,41]. This was attributed to distraction, increased anxiety or sensorimotor changes [40]. Further, neck pain is usually associated with shortening of extrinsic neck muscles such as the sternocleidomastoid and scaleni muscles[42–44]. When these muscles act unilaterally, they flex, rotate and side bend the neck. Such combined movement involves more than one anatomical plane, and thus, may contribute to the minor difference seen between the right and left sides in those patients population.

On the other hand, CVA was consistent across sides in healthy participants in standing and sitting positions. Yet, average CVA in healthy individuals and patients with neck pain was 45 and 46°, respectively. These values are below the known 48-50° cutoff for this age population[5,45].However, this cutoff has been identified using different measuring methods and approximately seven decades ago. Life style has changed dramatically in the past few years, with the extensive use of smart technologies such as cellular phones and tablets as well as with general reduction of active life style. Recent studies reported similar range to that of the current study, even in younger populations. For example, Ruivo et al. (2015) reported an average CVA of 47.9°(± 4.8) in 275 adolescents, aged between 15 and 17 years old and assessed from standing position[39]. Also, Fard and his colleagues tested fifty healthy adults between the age of 19 and 30 in standing position and reported a CVA angle ranged from 39.5 to 55.5° [46], which is close to the range reported in this study. Further, a relatively high prevalence (25%) of FHP (decreased CVA) was reported in Chinese high school students [47]. Also, a few studies reported a lower mean CVA than that reported in this study[1,23,38].

Regarding CVA agreement between the two sides in healthy participants during standing position, the mean difference was less than 0.5°. The closer the mean difference to zero, the less systematic bias exists between measurements. This reflects a high accuracy in measurement of the two sides[48,49]. It should be noted that the variability (68% LOA) between the measurements of the two sides was relatively small (≈3.29°); which represents around 6% of the reported normal CVA angle of 50°. This was also true for sitting, where the mean difference was small (0.47°) as well as the variability (4.66°). Small variability reflects higher precision, or how close the measured values are to each other[48, 49].

The CVA agreement between the Right and Left sides in patients with mechanical neck pain was similar to that seen in healthy participants. There was a high accuracy between the corresponding side as denoted by the small mean difference in standing (1.32°) and sitting (0.62°). The narrow differences reflected by the 68% LOAs between the sides reflects small variability or high precision (3.25° for standing and 3.32° for sitting, both are less than 10% of normal value)[48,49].

In this study, gaze angle ranged between 3° and 30° in standing and between 5° and 30° in sitting. Changes in gaze angle in association with FHP are still controversial. For example, Kang et al. (2012) reported that FHP is associated with decreased CVA and increased gaze angle [7], whereas Raine and Twomey (1997) found that gaze angle was not related to alteration in CVA[28].

Further, gaze angle values reported in literature are quite variable. For example, Raine & Twomey (1997)found that gaze angle measured from standing photography ranged from 1° to 15° [28]. The upper range reported was lower than that of the current study. However, in the Raine and Twomey study, participants' age ranged from 17-83 years, which is a wide and quite different age range compared to that of the current study. Also, Kang and his colleagues (2012) reported gaze angle measured in sitting and ranging from 19° to 21°, with the lower range much greater than that of the current study[7]. However, their population age range also differed from that of the current study (33 to 37 years). Difference in gaze angle across sides could be attributed to testing position, and whether a target was fixed. To minimize variability related to measurement, in this study a fixed target was standardized in all measurements.

Healthy participants showed differences in gaze angle across sides, regardless of the testing position. On the other hand, patients with mechanical neck pain did not show any differences in either testing position. It is not clear why differences existed in healthy subjects and not patients with mechanical neck pain. However, with the controversial results about gaze angle changes with FHP and considering the complex nature of neck pain and it associated compensatory postural changes in the three cardinal planes; a 3D kinematic analysis could help explaining why changes in gaze angle of healthy people but not in patient populations.

For gaze angle agreement, healthy subjects assessed in standing showed almost double the mean difference reported for CVA measurements, indicating lower measurement accuracy of gaze angle. This was associated with a high variability (≈3.70°) that exceeded 13% of the upper reported range of 30° indicating lower precision. In sitting position, the mean difference value was considerable (≈ 1°) compared to that of the CVA. Further, variability as evident by 68% LOAs (≈4.15°) continued to be high denoting low precision. Thus, a more precise method for quantifying gaze angle should be considered before final conclusions about differences across sides could be drawn.

In patients with mechanical neck pain, the gaze angle measured in standing and sitting showed a relatively small difference (less than 1° degree) compared to that measured in healthy participants. Yet, variability continued to be high in standing (≈2.90°) and sitting (≈4.01°) questioning this method precision for measuring gaze angle.

Despite the novel findings of this study, a few limitations exist. This study used surface markers, which may result in measurement error due to skin movement. Also, patients with mechanical neck pain were all females. Future studies are encouraged to include patients from both genders and different age groups and occupations.

CONCLUSION

Photogrammetric quantification of forward head position by measuring craniovertebral and gaze angles may differ across sides depending on the population tested. For gaze angle, healthy adults may show differences across sides, whereas the craniovertebral angle may differ across sides in patients with mechanical neck pain.

REFERENCES

[1] Lau KT, Cheung KY, Chan KB, Chan MH, Lo KY, Chiu TTW. Relationships between sagittal postures of thoracic and cervical spine, presence of neck pain, neck pain severity and disability. *Man Ther*. 2010;15(5):457-462.

[2] Diab A A, Moustafa IM. The efficacy of forward head correction on nerve root function and pain in cervical spondylotic radiculopathy: a randomized trial. *Clin Rehabil*. 2012;26(4):351-361.

[3] Yip CHT, Chiu TTW, Poon ATK. The relationship between head posture and severity and disability of patients with neck pain. *Man Ther*. 2008;13(2):148-154.

[4] Visscher CM, De Boer W, Lobbezoo F, Habets LLMH, Naeije M. Is there a relationship between head posture and craniomandibular pain? *J Oral Rehabil*. 2002;29(1992):1030-1036.

[5] Watson DH, Trott PH. Cervical headache: an investigation of natural head posture and upper cervical flexor muscle performance. *Cephalalgia*. 1993;13(4):272-284.

[6] De-la-Llave-Rincón AI, Fernández-de-las-Peñas C, Palacios-Ceña D, Cleland J a. Increased forward head posture and restricted cervical range of motion in patients with carpal tunnel syndrome. *J Orthop Sports Phys Ther*. 2009;39(9):658-664.

[7] Kang J-H, Park R-Y, Lee S-J, Kim J-Y, Yoon S-R, Jung K-I. The effect of the forward head posture on postural balance in long time computer based worker. *Ann Rehabil Med*. 2012;36(1):98-104.

[8] Silva AG, Punt TD, Sharples P, Vilas-Boas JP, Johnson MI. Head posture assessment for patients with neck pain: Is it useful? *Int J Ther Rehabil*. 2009;16(1):43-53.

[9] Ruivo RM, Pezarat-Correia P, Carita AI. Cervical and shoulder postural assessment of adolescents between 15 and 17 years old and association with upper quadrant pain. *Brazilian J Phys Ther*. July 2014; 18(4):364-71.

[10] Silva AG, Punt TD, Johnson MI. Reliability and validity of head posture assessment by observation and a four-category scale. *Man Ther*. 2010;15(5):490-495.

[11] Aitken A. Reliability of Visual Assessment of Forward Head Posture in Standing. 2008:1-82.

[12] Lau HMC, Chiu TTW, Lam T-H. Measurement of craniovertebral angle with Electronic Head Posture Instrument: Criterion validity. *J Rehabil Res Dev*. 2010;47(9):911-918.

[13] Garrett TR, Youdas JW, Madson TJ. Reliability of measuring forward head posture in a clinical setting. *J Orthop Sports Phys Ther*. 1993;17(3):155-160.

[14] Ferrario VF, Sforza C, Germanò D, Dalloca LL, Miani A. Head posture and cephalometric analyses: an integrated photographic/radiographic technique. *Am J Orthod Dentofacial Orthop*. 1994;106(3):257-264.

[15] Chansirinukor W, Wilson D, Grimmer K, Dansie B. Effects of backpacks on students: measurement of cervical and shoulder posture. *Aust J Physiother*. 2001;47(2):110-116.

[16] Dunk, Nadine M., Jennifer Lalonde and JPC. Implications for the use of postural analysis as a clinical diagnostic tool: reliability of quantifying upright standing spinal postures from photographic images. *J Manipulative Physiol Ther*. 2005;28(6):386-392.

[17] Dunk NM, Chung YY, Compton DS, Callaghan JP. The reliability of quantifying upright standing postures as a baseline diagnostic clinical tool. *J Manipulative Physiol Ther*. 2004;27(2):91-96.

[18] Gadotti IC, Armijo-Olivo S, Silveira A, Magee D. Reliability of the craniocervical posture assessment: Visual and angular measurements using photographs and radiographs. *J Manipulative Physiol Ther*. 2013;36(9):619-625.

[19] Murphy M, Hides J, Russell T. A Digital Photographic Technique for Knee Range of Motion Measurement : Performance in a Total Knee Arthroplasty Clinical Population. *Open J Orthop*. 2013;3:4-9.

[20] Gadotti, I. C., & Biasotto-Gonzalez DA. Sensitivity of clinical assessments of sagittal head posture. *J Eval Clin Pract*. 2010;16(1):141-144.

[21] Grimmer-Somers K, Milanese S, Louw Q. Measurement of cervical posture in the sagittal plane. *J Manipulative Physiol Ther*. 2008;31(7):509-517.

[22] Gadotti IC. Measurement properties of the sagittal craniocervical posture photogrammetry (Doctoral dissertation, University of Alberta). 2010.

[23] Fernández-de-las-Peñas C, Alonso-Blanco C, Cuadrado ML, et al. Forward head posture and neck mobility in chronic tension-type headache: a blinded, controlled study. *Cephalalgia*. 2006;26(3):314-319.

[24] Pownall PJ, Moran RW, Stewart AM. Consistency of standing and seated posture of asymptomatic male adults over a one-week interval: A digital camera analysis of multiple landmarks. *Int J Osteopath Med*. 2008;11(2):43-51.

[25] Nam SH, Son SM, Kwon JW, Lee NK. The Intra- and Inter-rater Reliabilities of the Forward Head Posture Assessment of Normal Healthy Subjects. *J Phys Ther Sci*. 2013;25(6):737-739.

[26] Moradi N, Maroufi N, Bijankhan M, et al. Intrarater and Interrater Reliability of Sagittal Head Posture: A Novel Technique Performed by a Physiotherapist and a Speech and Language Pathologist. *J Voice*. 2014 Nov;28(6):842.e11-6.

[27] Braun BL. Postural differences between asymptomatic men and women and craniofacial pain patients. *Arch*

Phys Med Rehabil. 1991;72(9):653-656.

[28] Raine S, Twomey LT, Raine and Lance T. Twomey S. Head and shoulder posture variations in 160 asymptomatic women and men. *Arch Phys Med Rehabil*. 1997;78(11):1215-1223.

[29] Harrison AL, Barry-Greb T, Wojtowicz G. Clinical measurement of head and shoulder posture variables. *J Orthop Sports Phys Ther*. 1996;23(6):353-361.

[30] Rubinstein SM, van Tulder M. A best-evidence review of diagnostic procedures for neck and low-back pain. *Best Pract Res Clin Rheumatol*. 2008;22(3):471-482.

[31] Misailidou V, Malliou P, Beneka A, Karagiannidis A, Godolias G. An evidence-based clinical guideline for the diagnosis and treatment of cervical radiculopathy from degenerative disorders. *J Chiropr Med*. 2010;9:49-59.

[32] Binder A. The diagnosis and treatment of nonspecific neck pain and whiplash. *Eura Medicophys*. 2007;43(1):79-89.

[33] Kuo Y-L, Tully E a, Galea MP. Video analysis of sagittal spinal posture in healthy young and older adults. *J Manipulative Physiol Ther*. 2009;32(3):210-215.

[34] Verma SK, Maheshwari S, Gautam SN, Prabhat K, Kumar S. Natural head position: key position for radiographic and photographic analysis and research of craniofacial complex. *J Oral Biol Craniofacial Res*. 2012;2(1):46-49.

[35] McEvoy MP, Grimmer K. Reliability of upright posture measurements in primary school children. *BMC Musculoskelet Disord*. 2005;6(1):35.

[36] Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. *Lancet*. 1986;327(8476):307-310.

[37] Van Niekerk S-M, Louw Q, Vaughan C, Grimmer-Somers K, Schreve K. Photographic measurement of upper-body sitting posture of high school students: a reliability and validity study. *BMC Musculoskelet Disord*. 2008;9:113.

[38] Salahzadeh Z, Maroufi N, Ahmadi A, et al. Assessment of forward head posture in females: Observational and photogrammetry methods. *J Back Musculoskelet Rehabil*. 2014;27(2):131-139.

[39] Ruivo RM, Pezarat-Correia P, Carita AI. Intrarater and interrater reliability of photographic measurement of upper-body standing posture of adolescents. *J Manipulative Physiol Ther*. 2015;38(1):74-80.

[40] Vuillerme N, Pinsault N. Experimental neck muscle pain impairs standing balance in humans. *Exp brain Res*. 2009;192(4):723-729.

[41] Field S, Treleaven J, Jull G. Standing balance: a comparison between idiopathic and whiplash-induced neck pain. *Man Ther*. 2008;13(3):183-191.

[42] Bryden L. The influence of posture and alteration of fun ion upon the craniocervical and craniofacial regions. *craniofacial Dysfunct pain Man Ther Assess Manag oxford butterworth- heinemann*. 2001:179-203.

[43] Kendall F, McCreary E, Provance P, Rodgers M, Romani W. Muscles: Testing and Function, with Posture and Pain. *LWW; Fifth Ed*. 2005.

[44] Dalton E. Strategies to Address Forward Head Posture,part one. *massage Mag*. 2006.

[45] Cureton Jr TK. Bodily Posture as an Indicator of Fitness. *Res Quarterly Am Assoc Heal Phys Educ Recreat*. 1941;12(2):348-367.

[46] Fard B, Ahmadi A, Maroufi N, Sarrafzadeh J. Evaluation of forward head posture in sitting and standing positions. *Eur Spine J*. 2015.

Citation

Rehan Youssef, A. (2016). PHOTOGRAMMETRIC QUANTIFICATION OF FORWARD HEAD POSTURE IS SIDE DEPENDENT IN HEALTHY PARTICIPANTS AND PATIENTS WITH MECHANICAL NECK PAIN. *International Journal of Physiotherapy,* 3(3), 326-331.