JOURNAL OF BIOMEDICAL INVESTIGATION (JBI) VOLUME 12 NUMBER 2: JULY-AUGUST 2024

ASSOCIATION BETWEEN CRANIOVERTEBRAL ANGLE AND THE RISK OF FALLS AMONG COMMUNITY-DWELLING OLDER ADULTS IN SELECTED COMMUNITIES IN OYO STATE, NIGERIA

Authors:
Tabiti, Omotayo O[1*]; Oyeniran, I.D[1]; Ojoawo, A.O[2]; Akodu, A.A. [3]; Adeleke J.O.[2]

Authors Affiliations:
[1]Department of Physiotherapy, College of Health sciences Bowen University, Iwo, Nigeria
[2]Department of Physiotherapy, College of Health sciences, Obafemi Awolowo University, Ile-Ife, Nigeria,
[3]Department of Physiotherapy College of Medicine, University of Lagos, Nigeria

***Corresponding author:**
Omotayo Olorunsogo Tabiti
Email: tabititayo@gmail.com, omotayo.tabiti@bowen.edu.ng,

Received: 20/7/2024; accepted for publication 31/8/2024

ABSTRACT

Background: Reduced craniovertebral angle (< 49^0) i.e. forward head posture is the most common type of postural abnormality seen in older adults which result from displacement of the vertical line of the body's centre of gravity.

Aim: This study was designed to determine the association between the craniovertebral angle (head posture) and risk of falls of community dwelling older adults in Oyo state.

Materials and Methods: This was a cross-sectional study in which consecutive sampling was used to recruit 195 participants (97 females, 98 males). Universal goniometer and adapted Time-up-and-go test were used to measure the participant's craniovertebral angle (CVA) and risk of fall respectively. Chi square test was used to determine the level of association between variables while Mann Whitney U test was used to determine the difference between the two age groups/. Alpha level was set at < 0.05

Results: The mean CVA of the participants was 36.10±6.80 degrees with 186 (95.40%) participants having CVA <49° (forward head posture). There was a significant association between craniovertebral angle and risk of fall (p=0.001) of the participants and there was also a significant difference in craniovertebral angle and the risk of fall between the two age groups (p=0.001) and (p=0.001) respectively.

Conclusion: The outcome of this study revealed that prevalence of forward head posture was high and there was significant association between the craniovertebral angle and the risk of fall of the geriatric population.

Keywords: *Craniovertebral angle, risk of fall, community-dwelling, older adults*

INTRODUCTION

Ageing can be defined as a complex dynamic process featured by a progressive reduction of physiological function[1]. Changes in aging occur in all organs of the body and affect the working of all body systems[2]. Postural malalignments are the deviation from the standard alignment, which result from changes of the musculoskeletal system during the aging process, and various body segments such as head, neck, shoulders, thoracic and lumbar spine may be affected by this deviations[3] Postural malalignments among aging adults are often attributed to age-associated changes, and at times to sex-associated differences[4] These age-associated postural changes may be attributed to age-related biological and physiological changes, functional or pathological causes, or a combination of these changes[4]

In forward head posture (FHP), the head projects forward from the median plane and appears to be stationed anterior to the body, and this condition is regarded as the most common postural malaligment[5] .It is generally described as a ventral position of the head in relation to the vertical line of the body's center of gravity[6] .This situation occurs due to alteration in the postural

alignment and challenge of using normal strategies for balance control during activities of daily living especially in older adults[7] .A change in the function of these cervical muscles as a result of improper positioning of the head adversely affects the movement and balance control [8] . Forward head posture alters the center of gravity of the body that results in mechanical changes related to postural control in the torso and every joint. The body usually make effort to adapt to these changes by altering its balance control mechanisms; these adaptations reduce balance ability while performing various activities and increment in the risk of falling and musculoskeletal injury[5].

Fall injuries in the elderly is a major public health concern with the aging population; the resulting consequences, makes up one of the most common and serious problems facing our older adults population and falls are the second leading cause of unintentional injuries, deaths and the thirteenth leading cause of Years Lived with Disability worldwide[9] . Approximately 28–35% of people aged ≥65 years have been estimated to have history of fall at least once yearly[10]. Immobility, loss of independence, poor quality of life, mortality, hospitalization and early entry to long-term care facilities are the results of falls in the older adults[11]. In the elderly age is one of the risk factors for falls and fall-related injuries increase with age, with a rise in the risk of fracture, especially in the hip joint >50% of the cases [12] . Females older adults have higher falls than males older adults with females >70 years old being more susceptible to bone fractures, this is probably due to the bone density changes associated with menopause[13]. Factors such as the activities of daily living ability, obesity, physical activity habits, poor living conditions, and environmental factors are closely related to the risk of falls among the geriatric population[14].There have been studies on the correlation between head posture and postural balance in community-dwelling older adults who use Dentures, others are on female older adults with vertebral fracture[21,27] ; others have compare cervical ROM and proprioception between fallers and non-fallers and assess parameters that lead to fall risk among healthy older adults[33], others correlation between forward head posture and neck pain among office workers, others are effect of forward head posture on postural balance among computer workers and also among young adults[34], these were all studies conducted in either developed or developing countries of Europe, Asia etc. However, with the increase of forward head posture at an alarming rate across all ages especially older adults, this postural malalignment might posed as a risk factor to functional mobility and risk to fall in the elderly in Africa, whose rate of fall for example Nigeria was 25.3% and 41.3% for rural and urban older adult dwellers respectively coupled with poor uneven surface road and poor lightening etc[35]. A search through literature has shown a dearth of published studies in Africa especially low income countries in West Africa like Nigeria that have assess the association between forward head posture a major intrinsic risk factor to fall in the older adults hence the need to embark on this study. This study results might reveal the proportion of altered

head posture, and its degree of association to the risk of falls among the elderly. We hypothesized that there will be no significant association between craniovertebral angle(head posture) and the risk of fall among community-dwelling older adults. The aim of the study was to determine the degree of association between forward head posture and risk of fall among the elderly. This study addresses a significant public health issue - the risk of falls in older adults, which is a leading cause of morbidity and mortality in this population. By investigating the association between craniovertebral angle and fall risk, the study contributes valuable information to preventive strategies in geriatric care, the need for planning of head posture corrective exercises, lifestyle modification and educating on the relevance of proper head posture as a coping strategy to minimize fall risk in geriatric population.

MATERIALS AND METHODS

Research setting and study design

This was a cross-sectional survey of 195 elderly individuals (aged 65 years and above) resident who were consecutively recruited from three local government areas (Ido, Ibadan, Ogbomoso North and Ogbomosho South) Local in Oyo state of Western Nigeria. To avoid bias random sampling was used to select the communities from each local government area of Oyo state the largest state in south-west Nigeria[20]. The communities were mainly Apete, Agbede and Isale Afon. Invitations were extended to prospective participants through leaders from community and community associations. The Town halls of each community was the location for the data collection.

Inclusion criteria

Participants included in this study were consenting older male and female adults aged ≥65 years[15] residing in the aforementioned communities in Oyo State .

Exclusion criteria

Older adults residing in the aforementioned communities with neurological disorders such as Parkinsons' disease, dementia and musculoskeletal dysfunction that can affect assessment of the craniovertebral angle (head posture) and risk of fall of the participants were excluded from the study.

Sample size

Sample size was used to determine the amount of people that were recruited for this study. The formula for calculating is given below:

$$n = \frac{Z_{1-\alpha/2}^2 p(1-p)}{d^2}$$

where $Z_{1-\alpha/2}^2$ is a standard value of 1.96

p is the expected proportion in population – where p is 15%(Fejer et al, 2006)

d is precision = 0.05

$$n = \frac{(1.96)^2\ 0.15(1-0.15)}{(0.05)^2} = 195$$ participants.

A total of 195 participants were involved in this survey.

Procedure for data collection

Prior to commencement of this study, Ethical approval was obtained from Bowen

University Teaching Hospital, Health Research and Ethics Committee (BUTH-HREC-855). A written informed consent was obtained from participants after they have read, complete and sign the informed consent form prior to their participation, appropriate data collection methods and storage such as substituting codes for participants identifiers and encrypting data in order to achieve data confidentiality and participant anonymity in the study.

Research instruments

i. Universal goniometer (Locally made, Nigeria): The universal goniometer was used to measure the craniovertebral angle of the participants in degrees.

ii.Time up and go test: The adapted TUG test from BOOMER score was used as a performance based test to measure the risk of fall of the participants.

Measurements of head posture and risk of falls

The assessment tool for measuring craniovertebral angle (head posture) and risk of fall were universal goniometer and BOOMER score respectively. The Universal goniometer is a simple measuring device comprising of a protractor and two arms attached to the protractor, one of which is fixed to the protractor and the other arm is movable at the fulcrum which is the center of the protractor. A large universal goniometer having 12-inch arms and full-circle plastic body was used for quantifying the craniovertebral angle and Time-up-and-Go test which was adapted from Balance Outcome Measure for Elder Rehabilitation (BOOMER) scale was used to assess the functional mobility and the fall risk of the participants. For the Head posture measurement:

The craniovertebral angle is measured in degrees as the point of intersection between a horizontal line passing through the spinous process of C7 and the diagonal line passing through the tragus of the ear to meet the spinous process of C7. The spinous process of C7 is taken as a reference landmark as it can be easily located by palpation, the tragus is taken as another reference point as it is visible and it moves in direct relation to the skull. To quantify the craniovertebral angle (head posture),The participants were made to sit on a backless chair and place their hands on their knees and they were instructed to look at points that are horizontal to their vision, the fulcrum of a universal goniometer was placed in line with the C7 vertebrae, with the immovable arm positioned horizontal to the C7 landmark and the moveable arm running parallel to the tragus of the ear, two trials were taken in order to mitigate the potential for measurement error.For this study, craniovertebral angle < 49 degrees were regard as abnormal craniovertebral angle (forward head posture) while those >49 degrees was normal craniovertebral angle. For the risk of fall measurement; the Time up and go test adapted from Balance Outcome Measure for Elder Rehabilitation (BOOMER) scale was used. Time Up and Go test: a sturdy armchair with a backrest was placed at the end of the balcony of their place of residence. On the floor a piece of tape 3 m long was placed away from the front edge of the chair. Participants were given instruction about the task which

entails walking at their normal pace rather than a rapid speed and they were timed with a stop watch as they sit in the chair with their back against the backrest and arms resting on the chair armrests. To carry out the TUG test participants were instructed to stand up out of the sturdy chair, walk 3m, turn around, walk back to the chair, and sit down. Participants were instructed to: "stand up on the word 'go,' walk to the tape, turn around, walk back to the chair, and sit down." The timing of the TUG test began at the word "go," and ended when the participant was seated[16,17].

Data Analysis

Descriptive statistics of mean, standard deviation, frequency and percentages was used to summarize the data obtained. Inferential statistics of Chi square test was used to determine the significant association between craniovertebral angle sand risk of fall of the participants. Chi square test was used to determine the significant association between craniovertebral angle and risk of fall and the selected socio-demographic and anthropometric variables (gender, occupation, educational status and BMI respectively) of the community-dwelling older adults. Mann Whitney U test was to determine the significant difference between head posture craniovertebral angle (head posture) and risk of fall and the two the age groups of the participants. All statistical analysis were conducted using Statistical Package for Social Sciences (SPSS) 23.0 (IBM Corp., Armonk, NY, USA). Level of significance (α) was set at 0.05.

RESULTS

Socio-demographic and Anthropometric profiles of the study participants

One hundred and ninety-five (195) older adults (50.30% females, 49.7% males with mean age= (68.93 ±6.25years). One hundred and one (51.80%) had tertiary level of education . Six (3.10%)of the participants were underweight, One hundred and thirty-one 131 (67.20%) participants were normal weight (Table 1). One hundred and eighty-six (186) participants had a craniovertebral angle of less than 49 degrees (95.40%), nine participants had a craniovertebral angle that was ≥49 degrees (4.60%). Participants who had a craniovertebral angle of less than 49 degree were considered to have an abnormal craniovertebral angle (forward head posture) and participants who had a craniovertebral angle of ≥49 were considered to have a normal craniovertebral angle. One hundred and sixteen, 116 (59.00%) of the participants had a moderate risk of fall (Table 2).

Differences in craniovertebral angle and static balance and risk of fall between the two age groups.

Mann Whitney U test was to determine the significant difference between head posture (craniovertebral angle) and Risk of fall and the two the age groups of the participants. There was a significant difference between craniovertebral angle and risk of fall and the two age groups (p= 0.001) and (p= 0.001) respectively (Table 3).

Association between head posture (craniovertebral angle) and risk of fall of the participants.

Chi-square test was used to determine the level of association between craniovertebral angle and risk of fall among the participants.

There was a significant association between craniovertebral angle and risk of fall (p= 0.001) (Table 4). **Association between craniovertebral angle (head posture) and selected sociodemographic and anthropometric variables.**

Chi-square test was used to determine the association between craniovertebral angle and selected socio-demographic variables of the participants. There was no significant association between cranovertebral angle and gender (p= 0.547), educational levels (p= 0.353), occupation (0.014) and BMI (p= 0.510) (Table 5).

Table 1: Socio-demographic and anthropometric profiles of the participants

Variable	Categories	Frequency	Percentage
Educational level	Primary	15	7.7
	Secondary	41	21.0
	Tertiary	101	51.8
	None	38	19.5
Gender	Male	97	49.7
	Female	98	50.3
Occupation	Professionals	94	48.2
	Unskilled	51	26.2
	Traders	25	12.8
	Unemployed	25	12.8
Age	65-75	157	80.5
	76-86	38	19.5
BMI	Underweight	6	3.1
	Normal weight	131	67.2
	Overweight	55	28.2
	Obese	3	1.5

Table 2: Craniovertebral angle (head posture) and Risk of fall (TUG) of participants

Variables	Categories	Frequencies(n)	Percentage (%)
Craniovertebral angle	Abnormal	186	95.40
	Normal	9	4.60
Risk of fall(TUG)	Poor	2	1.00
	Fair	39	20.00
	Moderate	116	59.50
	Excellent	38	19.50

Table 3: Differences in craniovertebral angle and risk of fall between the two age groups.

Variables	Mean rank		U	P
	65-75	76-86		
Craniovertebral angle	112.79	36.88	660.500	0.001*
Risk of fall (TUG)	114.46	29.99	398.500	0.001*

*Significant at P≤ 0.05

Table 4: Association between head posture (craniovertebral angle) and Risk of fall (TUG) of the participants.

VARIABLE	Craniovertebral angle	
	x^2	P value
Risk of fall (TUG)	20.638	0.001*

*Significant at P≤ 0.05

Table 5: Association between Craniovertebral angle (head posture) and selected sociodemographic and arthropometric variables.

Variable	Craniovertebral angle	
	x^2	p-value
Occupation	2.466	0.482
Educational level	2.121	0.548
BMI	3.664	0.300
Gender	0.106	0.745

*Significant at P< 0.05

DISCUSSION

This study was designed to investigate the association between craniovertebral angle and risk of fall among community-dwelling older adults in selected communities (Apete, Agbede and Isale Afon) in Oyo State, Nigeria. Majority of the participants in this study were within 60-75 age group. The mean age of the participants in the study was 68.93 years with a standard deviation of 6.25 years though the mean age is lower than that of the study done by[18] , who reported a mean age of 78.31 with a standard deviation of 6.42 years. Majority of the participants involved in this study were females. This is not surprising as females have longer life expectancy than males[19] .The current study is similar to the finding from the study by where more than half of the participants involved in the study were females[20]. In this study, the mean BMI was 23.3 with majority of the participants classified as normal weight. This is similar to who reported a mean of 24.76 with majority of the participants classified as normal weight[21]. This is in contrast to a previous studies reported a mean BMI of 26.9 with majority of the participants classified as overweight[22]. As such, the lower BMI in the current study may be as a result of the socio-economic status of the participants in the area of study.

The mean of the participants' craniovertebral angle (CVA) in this study was 36.1 degrees which is in contrast to previous studies who reported the mean CVA as 48.9 and 42.38 respectively[18]. The current finding may be as a result of methods of measurement of CVA in this present study, which may have also influenced the outcome. Findings from this study indicates that there was no significant association in craniovertebral angle and gender (p=0.745). This is similar to previous studies by [23,24] who reported that craniovertebral angle is not associated with gender. There was significant difference between craniovertebral angle (head posture) and the age groups of the participants (p=0.001) respectively. Lansade demonstrated a significant deterioration of cervical proprioceptive abilities with increasing age[33]. Proprioception refers to the process impulses relayed by afferent receptors such as peripheral muscles, capsules, ligaments and joints is processed in the central nervous system. Somatic afferent information from the upper cervical spine, converges with vestibular and visual inputs on central nervous system nuclei involved in processing and integration of postural balance inputs[33].

This is similar with the finding from the study by[17], who reported that age is associated with head posture (craniovertebral angle) as the older the age, the severe the forward head posture. The finding of the current study is in contrast with previous studies that reported that age has no relationship with craniovertebral angle[6,23],. Craniovertebral angle was shown to have no significant association with occupations of participants (p=0.482) implying that participants nature of job is not associated to the value of craniovertebral angle. This is in contrast to previous studies that suggested that occupation was shown to have an effect on craniovertebral angle [25,26]

The finding may be as a result of the method of measurement of craniovertebral angle adapted in this study. There was no significant association between craniovertebral angle and educational status of the participants (0.548), implying that educational status is not a factor that is related to the size of FHP. This may be caused by lack of education on proper ergonomics as it concerns proper head posture even though most of the participants have tertiary level of education (n=101). It was also observed that craniovertebral angle had no significant association with all BMI classifications (p=0.300) implying that body mass index is not an associated factor to the size of head posture, which may be as a result of majority of the participants being normal weight. This corresponds to the findings from the following studies by [22, 27]. They noted that craniovertebral angle has no effect with BMI classifications which is consistent with the findings of the current study.

In this study there was a significant association between craniovertebral angle and Risk of fall (p=0.001). This could possibly mean that abnormal craniovertebral angle (forward head posture) can predispose one to impaired balance thereby leading to the risk of fall because postural control requires accurate sensory integrations of neck proprioceptive inputs and appropriate motor responses to the displacement of the centre of gravity (COG) which is altered in elderly with forward head posture. Forward head posture causes reduced vestibular and proprioceptive functions, which are crucial sensory inputs for postural control and it also alters the COG of the body that lead to mechanical modifications related to postural control of the body while the body attempts to adapt to these changes by altering its balance control mechanisms; these adaptations decrease balance ability while performing different activities and increase the risk of falling and musculoskeletal injury[8] .This corresponds to a study by which reported that forward head posture was significantly associated with risk of fall among older adults[28]. This is also consistent to[10], which reported that abnormal craniovertebral angle or forward head posture has a greater effect on balance which also concurs to the study by[29].However, in a study by[30], there was no statistically significant effect of forward head posture(craniovertebral angle <50 degrees) on an individual's balance. The findings of the current study may be as a result of poor head posture adopted over the years thereby leading to the displacement of the vertical line of the centre of gravity. This situation can thereby lead to risk of fall of the participants. It may also be as a result of age-associated changes in posture which is attributed to age-related biologic and physiological changes which could cause difficulties in using normal strategies for balance control during daily activities. Panzer reported that abnormal posture, vestibular impairment contributed to abnormal biofeedback, function of maintaining balance. It might change torque required to maintain posture which is associated with reduced balance controlling ability[34]

This study had some limitations like any other study being a cross-sectional study we couldn't establish a temporal

relationship(causative effect) between forward head posture and risk of falls variables which may limit the generalization of the results and also inability to control confounding factors that influence cranio-cervical posture such as psychological situation, thoracic and lumbar spine position and those that affect balance such as polypharmacy, poor visual acuity, musculoskeletal symptoms. Therefore we suggest that the study findings should thus be interpreted with caution. However, the sample size was calculated using established scientific formula and also, the tools (Universal goniometer and adapted BOOMER scale) used in this study are already validated as instrument suitable for the assessment of the indicated variables. Together, these added to the strength of the study and we hope that some level of generalization could still be made from our findings.

CONCLUSION

The outcome of this study revealed that forward head posture (abnormal craniovertebral angle) is very high among older adults in this study with a rate of 95.4%. There was significant association between head posture (Craniovertebral angle) and risk of fall and occupation of the elderly in this study. There was a significant difference in head posture and risk of fall between the two age groups of participants respectively.

Recommendations

Based on the findings of this study, it is recommended that:

1.There is need for future research to investigate the causative(temporal) relationship that exist between head posture and risk of fall and also adopt a computerized method of measurement of CVA to minimize error of measurement among a larger and diverse populace.

2.Sensitizations of clinicians during geriatric rehabilitation, on the association that exist between head posture and risk of fall will help them in the planning of help posture corrective exercises and educating of the elderly on proper head posture as a coping strategy to minimise fall risk in geriatric population.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not for- profit sectors"

Acknowledgement

The authors thank all community-dwelling older adults in the selected areas in Oyo state who participated in this study.

Declaration of conflicting interests

The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article

REFERENCES

Colloca G, Di Capua B, Bellieni, A, Fusco D, Ciciarello F, Tagliaferri L, Valentini V, Balducci L. Biological and functional biomarkers of aging: definition, characteristics, and how they can impact everyday cancer

treatment. Current Oncology Reports.2020;(22):1-12.

Kenig J. Oncogeriatrics (part 2). Normal and pathological ageing. NOWOTWORY J Oncol. 2019; 69: 146–149.

Jang HJ, Hughes LC, Oh DK, Kim SY. Effects of corrective exercise for thoracic hyperkyphosis on posture, balance, and well-being in older women: a double-blind, group-matched design. Journal of geriatric physical therapy.2019; 42(3):E17-E27.

Kauffman TL, Barr JO, Moran ML. Geriatric rehabilitation manual. 2nd Ed. Elsevier Health Sciences; 2007.

Lee KJ, Han HY, Cheon SH, Park SH, Yong MS. The effect of forward head posture on muscle activity during neck protraction and retraction. Journal of Physical Therapy Science. 2015;27(3): 977-979.

Salahzadeh Z, Maroufi N, Ahmadi A, Behtash H, Razmjoo A, Gohari M, Parnianpour M. Assessment of forward head posture in females: observational and photogrammetry methods. Journal of back and musculoskeletal rehabilitation. 2014; 27(2):131-139.

Schenkman M, Morey M, Kuchibhatla M. Spinal flexibility and balance control among community-dwelling adults with and without Parkinson's disease. The Journals of Gerontology Series A: Biological Sciences and Medical Sciences. 2000;55(8):M441-M445.

Lee JH. Effects of forward head posture on static and dynamic balance control. Journal of physical therapy science. 2016;28(1):274-277.

Song BH, Choi YH and Cha, Y.J, (2019): Comparison of Effects of Different Myofascial Meridians Methods on Pain and Postural Control of College Students with Forward Head Posture. Journal of the Korean Society of Physical Medicine. 2019;14(1):15-23.

Hu X, Qu X. Pre-impact fall detection. J Biomedical engineering online. 2016;(15):1-16.

Jeon MY, Jeong H, Petrofsky J, Lee H, Yim J. Effects of a randomized controlled recurrent fall prevention program on risk factors for falls in frail elderly living at home in rural communities. Medical science monitor. International medical journal of experimental and clinical research. 2014;(20):2283.

Rimland JM, Abraha I, Dell'Aquila G, Cruz-Jentoft A, Soiza R, Gudmusson A, Petrovic M, O'Mahony D, Todd C, Cherubini A. Effectiveness of non-pharmacological interventions to prevent falls in older people: a systematic overview. The SENATOR Project ONTOP Series. PloS one. 2016;11(8)e0161579.

Stewart WJ, Kowal P, Hestekin, H. et al. Prevalence, risk factors and disability associated with fall-related injury in older adults in low- and middle-incomecountries: results from the WHO Study on global AGEing and adult health (SAGE). BMC Med. 2015;13:147.

Akosile CO, Ngwu NP, Okonkwo UP. et al. Neighborhood safety, fall indices, physical activity level and social participation restrictions from a population of community-dwelling older adults in Nsukka, Enugu State, Nigeria. BMC Geriatr 2023;23: 358.

Scherbov S, Sanderson WC. New Approaches to the Conceptualization and Measurement of Age and Ageing. In: Mazzuco, S, Keilman, N. (eds) Developments in Demographic Forecasting. The Springer Series on Demographic Methods and Population Analysis. 2020; 49.

Kuys SS, Morrison G, Bew PG, Clarke J, Haines TP. Further validation of the balance outcome measure for elder rehabilitation. Archives of physical medicine and rehabilitation. 2011; 92(1):101-105.

Kear BM, Guck TP, McGhaha AL. Timed Up and Go (TUG) Test: Normative Reference Values for Ages 20 to 59 Years and Relationships With Physical and Mental Health Risk Factors. Journal of Primary care Community Health. 2017; 8(1): 9–13.

Nemmers TM, Miller JW, Hartman MD. Variability of the forward head posture in healthy community-dwelling older women. Journal of geriatric physical therapy. 2009; 32(1):10-14.

Crimmins EM, Shim H, Zhang YS, Kim JK. Differences between men and women in mortality and the health dimensions of the morbidity process. Clinical chemistry. 2019; 65(1):135-145.

Quek J, Pua YH, Clark RA, Bryant AL. Effects of thoracic kyphosis and forward head posture on cervical range of motion in older adults. Manual therapy. 2013; 18(1),:65-71.

Bae Y. and Park Y. Head posture and postural balance in community-dwelling older adults who use dentures. Medicina. 2020;56(10):529.

Antony R, 2022. Normal craniovertebral angle range in asymptomatic Black South African females: a pilot study (Doctoral dissertation) https://openscholar.dut.ac.za/

Naz A, Bashir MS, Noor R. Prevalance of forward head posture among university students. Rawal Med Journal. 2018; 43(2):260-2.

Mahmoud NF, Hassan KA, Abdelmajeed SF, Moustafa IM, Silva AG. The relationship between forward head posture and neck pain: a systematic review and meta-analysis. Current reviews in musculoskeletal medicine. 2019;12(4):562-577.

Akodu AK, Akinbo, SR, Young QO. Correlation among smartphone addiction, craniovertebral angle, scapular dyskinesis, and selected anthropometric variables in physiotherapy undergraduates. Journal of Taibah University Medical Sciences. 2018;13(6):528-534.

Keerthana B, Lavanya P, Preetha S. craniovertebral angle measurements among dental practitioners. PalArch's Journal of Archaeology of Egypt / Egyptology, 2020;17(7):1818-1825. Retrieved from

https://archives.palarch.nl/index.php/jae/article/view/1423

Fard BS, Ahmadi A, Maroufi N, Sarrafzadeh J. Evaluation of forward head posture in sitting and standing positions. European Spine Journal. 2016 ;(25): 3577–3582

Ziebart C, Gibbs JC, McArthur, C, Papaioannou A, Mittmann N, Laprade J, Kim S, Khan A, Kendler, DL, Wark JD, Thabane L. Are osteoporotic vertebral fractures or forward head posture associated with performance-based measures of balance and mobility?. Archives of osteoporosis. 2019;14:1-10.

Migliarese S and White E. Review of forward-head posture and vestibular deficits in older adults. Current Geriatrics Reports. 2019; 8:194-201.

Kerry C. Reliability of measuring natural head posture using the craniovertebral angle. Irish Ergonomics Review, 2003;37.

Shaghayeghfard B, Ahmadi A, Maroufi N, Sarrafzadeh J. Evaluation of forward head posture in sitting and standing positions. European spine journal. 2016; 25:3577-3582

Guohao L, Xiong Z, Weiji W, Tracey W.The relationship between forward head posture, postural control and gait: A systematic review. Gait Posture. 2022;98:316-329

Mettelinge TR, Desimpelaere P, Cambier D. Cervical mobility and cervical proprioception in relation to fall risk among older adults: a prospective cohort study. Eur Geriatr Med. 2023; 14(3): 447–453.

Kang JH, Park RY, Lee SJ, Kim JY, Yoon SR, Jung KI.The Effect of The Forward Head Posture on Postural Balance in Long Time Computer Based Worker .Ann Rehabil Med. 2012; 36(1): 98–104.

Darshana J , Sukhada P, Manasi D. Effects of forward head posture on postural balance in young adults. Int. J. Adv. Res. 7(6), 136-146

Atoyebi O, Elegbede O, Babatunde O, Adewoye K, Parakoyi D. Prevalence and risk factors for falls in urban and rural older adults in Ekiti State, Nigeria.Ghana Med J. 2021;55(4):265–272.