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To Assess the Immediate Impact of Tying a Ponytail at Different Distances on Cranio-Vertebral Angle and Forward Head Translation

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ABSTRACT

Background: Non-specific Forward Head Translation (FHT) occurs due to any cervical spine dysfunction brought on by an imbalance in the muscles surrounding the cervical spine. Any rise or decline in the Craniovertebral (CV) angle is the most prevalent abnormality associated with FHT. The majority of women who knot ponytails frequently exhibit it. Forward head position can be evaluated using a variety of techniques. The study's objective is to assess the immediate changes in FHT and CV angle when hairs are knotted at different distances from the C7 vertebrae.

Methods: Ninety-three female participants between 18 and 30 years of age participated in the observational study. All participants were assessed for changes seen in Cranio-Vertebral (CV) angle and Forward Head Translation (FHT) due to tying a ponytail in the sagittal plane. The outcome measures employed were the photogrammetry method, assisted by the AI Posture Evaluation and Correction System (APECS) app, and the Tragus to Wall Distance (TWD) test.

Results: Chi-Square test was utilized to perform the data analysis, which showed statistically insignificant difference ($p.>0.05$) in both the outcome measures, i.e., when the hairs were tied at the top of the head, it showed more FHT and less CV angle, and when the hairs were kept open, it showed less FHT and more CV angle.

Conclusion: The present observational study demonstrated an immediate effect and significant difference in FHT and CV angle when tying a ponytail at several distances from the C7 vertebrae, as measured by the TWD test and the Photogrammetry Method.

Keywords: Ponytail, CV angle, FHT, APECS app, Photogrammetry Method, Tragus to Wall Distance test.

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INTRODUCTION

Neck pain or neck dysfunction is a common musculoskeletal problem that is characterized by soreness, pain, or discomfort in the region between the 11th thoracic vertebrae and the inferior edge of the occipital bone. The phrase "mechanical neck pain" refers to pain that arises from strain or tension on the components of the spinal column. Numerous factors, including adaptations to improper posture, sprains or strains of the muscles or ligaments, and changes in anatomical structures, can cause mechanical neck pain and restriction of cervical range of motion. This may worsen the inflammation, which can result in excruciating pain and muscular spasms [2].

The head is carried forward to the center of the shoulder in Forward Head Posture (FHP). The center of gravity shifts along with the head's forward displacement, causing the upper body to move backward and the shoulder to droop. The horizontal line is traced to the spinous process of the seventh cervical vertebra, and the line joining the spinous process of the C7 vertebra with the tragus of the ear intersects to form the CV angle. The angle is calculated using two recognized references: a horizontal line parallel to the ground that only goes through the spinous apophysis of the seventh cervical vertebra (C7) and another line that extends from the ear's swallow to C7. FHP may be indicated by an angle of less than 50 to 53 degrees. The disability increases as the CV angle decreases. Cranio Vertebral (CV) angle and neck discomfort were found to have a moderate to good negative connection. The r-value was -0.731 with a significance level of 0.01. Cervical flexion range and a lower CVA were found to be the predicting factors for the development of cervical pain, according to the findings by N.F. Mahmoud et al. (2019), who found that adults who experience neck pain exhibit higher FHP than those who do not. According to research on the relationship between forward head posture (FHP) and neck pain, a significant link exists between FHP and measures of neck pain in adults and older individuals. Additionally, adults with neck pain exhibit higher FHP than asymptomatic adults [6].

Due to these related issues, evaluating head posture has become more crucial in clinical settings for determining and creating treatment plans for patients with a decreased Cranio-Vertebral (CV) angle. The quality of life of females could be improved and the frequency of neck pain reduced by correcting an incorrect posture through education and therapy. In their three weeks of neck stabilization exercises, V. Kartik et al. (2022) discovered that it was efficacious in lowering pain, enhancing range of motion in the cervical spine, and restoring the reduced CV angle [3].

According to Tomas Gallego-Izquierdo et al. (2020), the smartphone app to evaluate forward head posture is a reliable and valid method of measuring the CV angle when standing. As such, it may be a useful evaluation tool in clinical practice [7].

The most accurate and legitimate measure of FHP is the CV angle. One of the most comprehensive approaches utilizes photogrammetry technology and postural evaluation software, such as the AI Posture Evaluation and Correction technology (APECS), to analyze photos taken from a sagittal plane. This approach has several benefits, including being more accurate and dependable than visual evaluation alone, being reasonably quick, and easily preserving the image and values acquired. Photogrammetry is therefore regarded as the "gold standard" for determining head position [7]. Zahra Salahzadeh et al. (2019) also found that the photogrammetric approach had great inter- and intra-rater reliability to assess the head and cervical posture [8]. Since

they simplify the process of acquiring images and analyzing data and cut expenses, mobile apps like APECS have emerged as a viable substitute for photogrammetry systems [9]. According to the quality and accuracy of their photogrammetric results in extracting geometrical measurements (i.e., surface area and volume), Adel Alshibani et al. (2022) conducted a study. They compared Smartphone-Based Photogrammetry Assessment with a Compact Camera for Construction Management Applications. In contrast to compact cameras, this study evaluated the potential of smartphones as data collection devices. The geometrical estimates utilizing the smartphone camera were incredibly precise. Furthermore, the smartphone data had greater application and required less processing time and memory than the compact camera [10].

According to reports, the Tragus to Wall Distance Test (TWD) is a valid and reliable test for both intra- and intertester testing. Setting functional goals, re-evaluating the effectiveness of treatment plans, forecasting results, and figuring things out could all benefit from this evaluation. The "projection of the auricular cartilage of the ear, anterior to the external meatus" discharge criterion is known as the tragus. The tragus serves as an indicator to measure the displacement of the head with respect to the body in many of the techniques now utilized to evaluate forward head posture and kyphosis of the spine [11]. According to a systematic review by Richard W. Bohannon et al. (2018), the Tragus to Wall test is a straightforward, objective measure of forward flexed posture that has been validated and found to be reliable [12].

Due to its neatness, ponytails are particularly popular among female students. A postural deviation may result from tying a ponytail because it pushes our head in front of our center of gravity, putting undue strain on our neck [13]. In their research, Zainab Abbas et al.2022 discovered that individuals with high ponytails had the highest postural abnormalities, with forward head posture and rounded shoulders being prevalent in 56.8% and 55.7% of these females, respectively. As a result, a tight ponytail or bun can create cervicogenic headaches, which in turn cause postural abnormalities, including rounded shoulders and a forward head position [13].

Tying a ponytail creates a lot of tension on the cranial fascia, which leads to translation of the head in the forward direction, which in turn causes cervical extension. This

study is needed to check the immediate changes in the biomechanics of the cervical spine, which might lead to a postural Forward Head Translation (FHT) and a decrease in the Cranio-Vertebral (CV) angle in females. Hence, the study aimed to evaluate the immediate changes in CV angle and FHT when hair is tied at varying distances from the C7 vertebrae.

METHODOLOGY

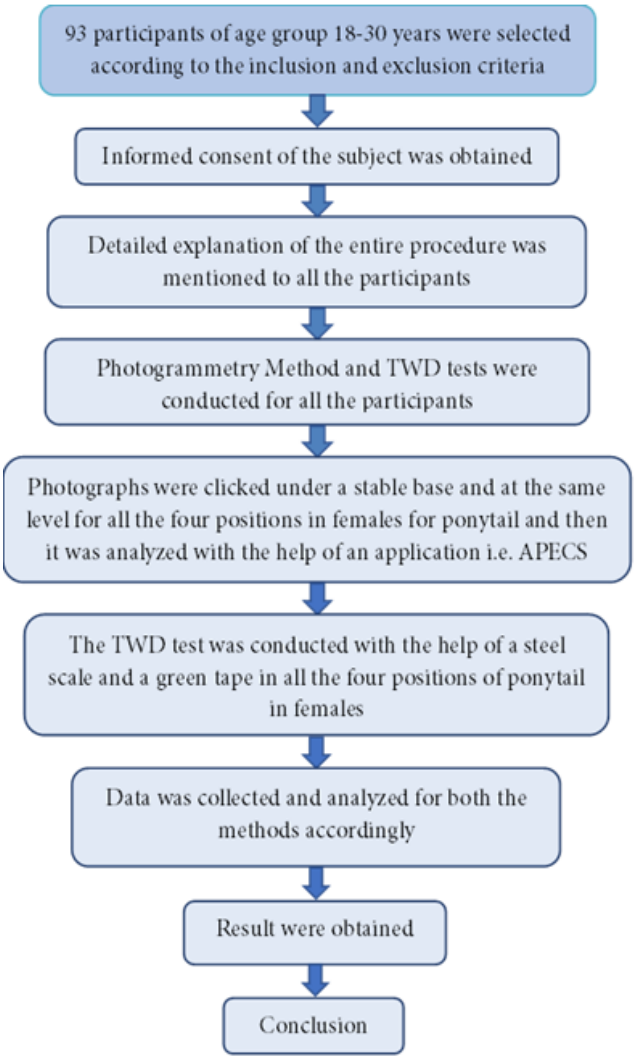
This observational study was carried out in the Kamrup Metro, Assam. The Institutional and Ethical Committee for Human Research at Assam Royal Global University authorized the study's methodology. Every step of the experimental process was described and documented. Participants were given a consent form and a data collection form. Data was collected from the Physiotherapy OPD of the Assam Royal Global University (RGU), Guwahati, Assam. Female students between 18 and 30 30years with hair length below the inferior angle of the scapulae were included in the study. Subjects with a history of whiplash injuries, fracture of the cervical vertebrae, previous history of significant trauma, chronic neck pain, and presence of FHP on postural observational analysis were excluded. The duration of the study was 6 to 8 months in 2022-2023. Sample size was estimated using Cochran's formula for a finite population, which is given by:

Where n is the sample size, z is the z-score (level of confidence; z = 95% = 1.96), p is the population proportion (p = 50%), N is the population size (N = 2350), and e is the margin of error (e = 10%). Therefore, the sample size was calculated as 93. The materials used for the study were a tripod stand, an iPhone, a rubber band, a steel ruler, and green tape (Figures 1 and 2). Outcome measures utilized were Photogrammetry (measurements in photographs, Figure 3) and the Tragus to Wall Distance test (TWD).

Figure 1: Tripod Stand

Figure 2: Steel scale, a rubber band, and green tape

PROTOCOL



PROCEDURE

1. Photogrammetry Method

The camera was positioned 150 cm from the subject in the photogrammetry method, and each subject's shoulder height served as the camera's height. The participants were instructed to determine their natural head position by progressively decreasing the angle while fully extending and flexing their necks until they reached a comfortable position. To improve reliability, the participants were asked to stand barefoot on a pre-fabricated outline of human feet. The participants were instructed to stand up and fix their gaze on an eye-level marker that was affixed to the front wall. To determine the CV angle, the subjects were asked to stand comfortably while being photographed from the lateral position. At this point, the acromion, the surface of the C7 spinous process, and the tragus of the ear were all marked. Four distinct pictures of a ponytail were then taken. Once all four pictures were acquired, they were added to the AI Posture Evaluation and Correction System (APECS) app to determine the CV angle for each picture separately [14].

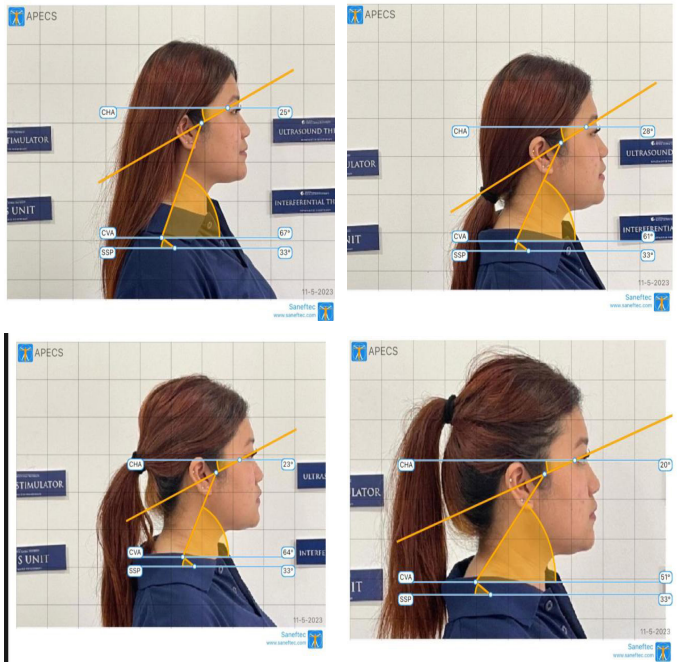


Figure 3: CV angle measurement for checking the immediate effect of tying ponytail at varying distances from C7 vertebrae with the help of an app, APECS.

2. Tragus to Wall Distance Test (TWD) test (Figure 4)

A steel scale was used to measure the distance between the tragus of the ear and the wall. To prevent errors, the therapist maintained the Occiput to Wall (OWD) distance at 10 cm for each sample. The individuals were then instructed to stand on the green tape with their heels at the edge, with the therapist using the tape at a distance of 10 cm from the wall. To increase the BOS, both feet were positioned 30 cm apart. The test was then carried out in four distinct locations, meaning that the distance was first measured with the hair open, then with the ponytail tied close to the occiput, and finally measured once more. Subsequently, the test was performed in four distinct positions: first, the distance was measured in open hairs; next, the distance was measured when the ponytail was tied close to the occiput; finally, the distance was measured when the ponytail was tied close to the eye's canthus; and finally, the distance was measured when the ponytail was tied at the scalp. As a result, samples with a greater distance between the tragus of the ear and the wall in any of the four positions were deemed to be in an inappropriate position, meaning they had more FHT, than samples with a smaller distance between the two, meaning they had less forward head translation. Less FHT will indicate a greater CV angle, and more FHT will indicate a smaller CV angle [15].

Figure 4: FHT measurement to assess the immediate effect of tying a ponytail at varying distances from the C7 vertebrae using the TWT test.

RESULTS

The present study assessed the immediate impact of tying a ponytail at varying distances from the C7 vertebrae, including 93 participants allocated to a single group. For all the participants, CVA and FHT were analyzed separately. All the participants were compared based on the two outcome measures, namely the Photogrammetry Method (PM) and the Tragus to Wall Distance (TWD) test.

STATISTICAL ANALYSIS

The analysis of data collected about baseline characteristics and outcome measures was performed utilizing the SPSS software (version 27.0) through the following statistical techniques.

- Significance was assessed at 5% level of significance, with a p-value less than 0.05 considered a statistically significant difference.
- The tables and graphs were created using the MS-EXCEL and MS-WORD tools. Analysis of descriptive statistics: Frequency and percentage analyses were used to describe different study variables.
- Chi-Square test as a non-parametric test for CV angle and FHT analysis has been used for checking the efficacy of tying ponytail in females.

Thus, the observational analysis of the baseline demographic data for all participants revealed no difference, indicating that both methods were homogeneous in nature.

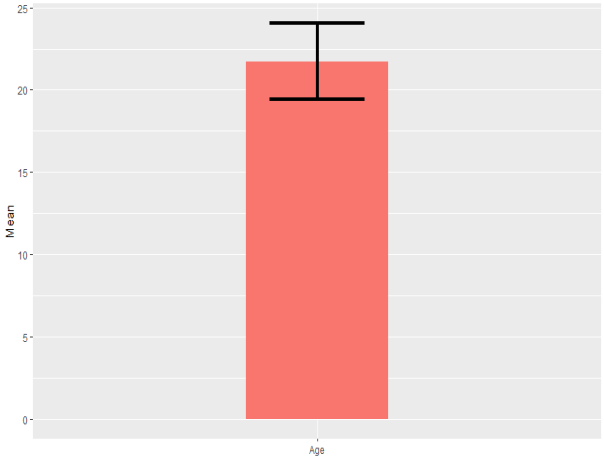
DEMOGRAPHIC PROFILE

Age, gender, height, weight, and body mass index were among the baseline demographics collected. No

statistically significant difference in demographic features was found when the baseline values of all 93 participants were evaluated. Therefore, it can be concluded that the study population was homogenous.

Age distribution

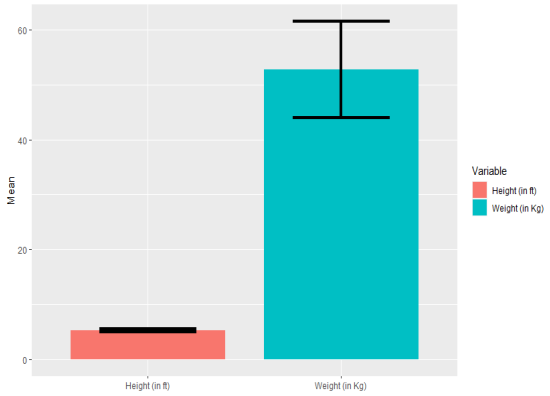
The age of the participants in the study was between 18 and 30 years. The overall mean standard deviation of age of subjects in the study was 21.73+2.33 years. No statistical significance was observed in the analysis.



Graph 1: Age distribution

Body Mass Index

The overall height and weight means and standard deviations in the study were 5.23 ± 0.24 and 52.81 ± 8.76, respectively. When BMI data were analyzed, 25.8% of participants were underweight, 63.4% of participants were normal, 6.5% of participants were overweight, and 4.3% of participants were considered obese.



Graph 2: Height and Weight distribution

OUTCOME MEASURES

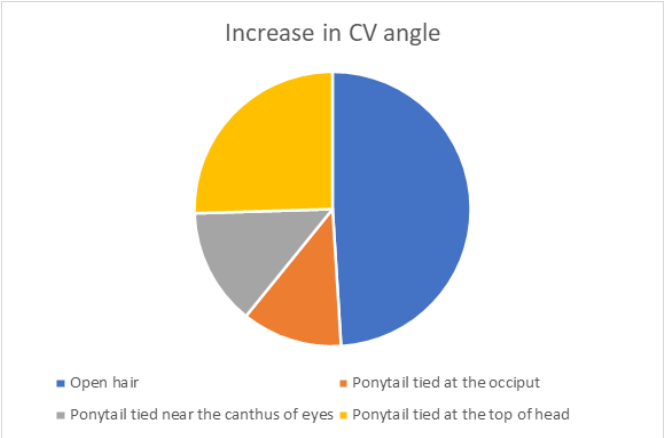
Photogrammetry Method:

Increase of CV angle:

Here, a 53.80% change was seen when the hairs were open, a 12.90% change was seen when the hairs were tied at the occiput, a 15.10% change was seen when the hairs were tied near the canthus of the eye, and a 28.00% change was seen when the hairs were tied at the top. Thus, a chi-square test suggests that the number of participants for whom the CV angle increases is significantly higher for open hair (53.80%) and significantly lower for ponytail tied at the occiput (18.30%), with a p-value < 0.001.

Table 1: Increase in CV angle

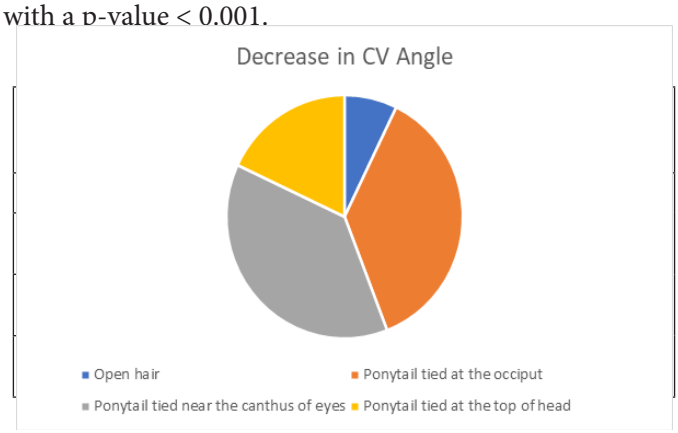
Type of ponytail	Number of cases	Percentage (out of 93 participants)	p-value
Open hair	50	53.80%	<0.001
Ponytail tied at the occiput	12	12.90%	
Ponytail tied near the canthus of the eye	14	15.10%	
Ponytail tied at the top of the head	26	28.00%	



Graph 3: Increase of CVA

Decrease in CV angle.

Here, an 8.60% change was seen when the hairs were open, a 44.10% change was seen when the hairs were tied at the occiput, a 45.20% change was seen when the hairs were tied near the canthus of the eye, and a 21.50% change was seen when the hairs were tied at the top. Thus, a chi-square test suggests that the number of participants for whom the CV angle decreases is significantly lower for open hair (8.60%) with a p-value < 0.001.



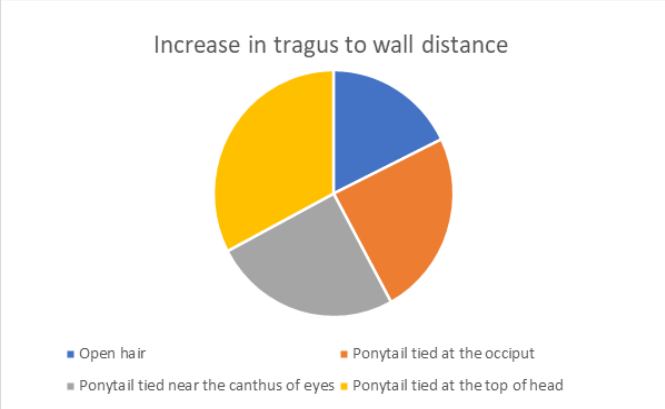
Graph 4: Decrease of CVA

Tragus to Wall Distance Test: Increase in TWD test.

Here, a 20.40% change was seen when the hairs were open, a 28.00% change was seen when the hairs were tied at the occiput, a 29.00% change was seen when the hairs were tied near the canthus of the eye, and a 37.60% change was seen when the hairs were tied at the top. Thus, a chi-square test suggests that the number of participants for whom the TWD increases is significantly higher for ponytail tied at the top of the head (37.60%) and significantly lower for open hair (20.4%), with a p-value < 0.001.

Table 3: Increase in TWD test

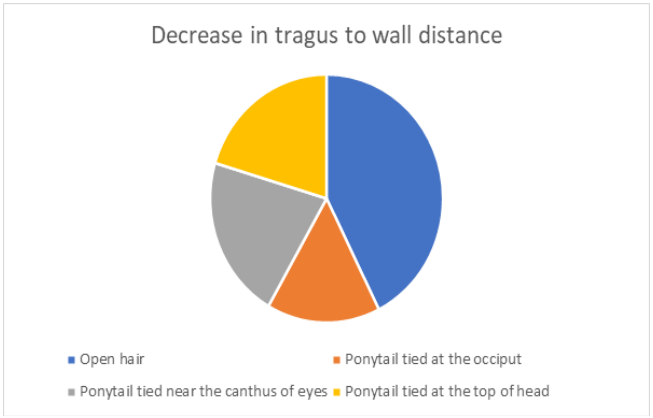
Type of ponytail	Number of Participants	Percentage (out of 93 participants)	p-value
Open hair	19	20.40%	<0.001
Ponytail tied at the occiput	26	28.00%	
Ponytail tied near the canthus of the eye	27	29.00%	
Ponytail tied at the top of the head	35	37.60%	



Graph 5: Increase in TWD test

Table 4: Decrease in TWD test:

Type of ponytail	Number of cases	Percentage (out of 93 participants)	p-value
Open hair	46	49.50%	<0.001
Ponytail tied at the occiput	17	18.30%	
Ponytail tied near the canthus of the eye	23	24.70%	
Ponytail tied at the top of the head	22	23.70%	



Graph 6: Decrease in TWD test

Decrease in the TWD test:

Here, a 49.50% change was seen when the hairs were open, an 18.30% change was seen when the hairs were tied at the occiput, a 24.70% change was seen when the hairs were tied near the canthus of the eye, and a 23.70% change was seen when the hairs were tied at the top. Thus, a chi-square test suggests that the number of participants for whom the TWD decreases is significantly higher for open hair (49.50%) and significantly lower for Ponytail tied at the occiput (18.30%), with a p-value < 0.001.

Cross-table of decrease in TWD test and increase in CV angle:

To test whether there is a significant difference between the decrease in TWD and the increase in CV angle for the four different ponytail types, a chi-square test was performed. The p-value 0.981, which is more than 0.05, suggests that there is no significant difference between them. Both methods are performing similarly.

Table 5: Cross-table of decrease in TWD test and increase in CV angle:

		Increase in CV Angle				Total (out of 93 Participants)	Chi-square	p-value
		Open hair	Ponytail tied at the occiput	Ponytail tied near the canthus of the eye	Ponytail tied at the top of the head			
Decrease in TWD	Open hair	26	6	7	11	46	2.515	0.981
	Ponytail tied at the occiput	8	3	3	3	17		
	Ponytail tied near the canthus of the eye	14	3	2	8	23		
	Ponytail tied at the top of the head	11	3	3	7	22		
Total (out of 93 Participants)		50	12	14	26	93		

The p-value 0.981 > 0.05 suggests that there is no significant difference between them. Both methods are performing similarly.

Cross-table of increase in TWD test and decrease in CV angle:

To test whether there is a significant difference between the increase in TWD and the decrease in CV angle for the four different ponytail types, a chi-square test was performed. Thus, the p-value 0.996, which is more than 0.05, suggests that there is no significant difference between them. Both methods are performing similarly.

Table 6: Cross-table of Increase in TWD and decrease in CV angle:

		Decrease in CV Angle				Total (out of 93 Participants)	Chi-square	p-value
		Open hair	Ponytail tied at the occiput	Ponytail tied near the canthus of the eye	Ponytail tied at the top of the head			
Increase in TWD	Open hair	2	7	8	5	19	1.592	0.996
	Ponytail tied at the occiput	3	12	12	6	26		
	Ponytail tied near the canthus of the eye	2	12	14	4	27		
	Ponytail tied at the top of the head	3	16	15	7	35		
Total (out of 93 Participants)		8	41	42	20	93		

The p-value 0.996 > 0.05 suggests that there is no significant difference between them. Both methods are performing similarly.

DISCUSSION

This present study observed that postural deviation was present in females who wore ponytails. Almost everywhere, including homes and schools, tying ponytails are commonly used nowadays. The participants in this study were between the ages of 18 and 30 on average. All of the data are homogeneous in character, as evidenced by the statistical analysis that showed no statistical significance between FHT and participant age. This may be because university-aged individuals are more likely than others to wear ponytails for extended periods. According to our current study, there is a significant correlation between the immediate effect of wearing a ponytail with FHT for a prolonged period of time and the development of forward head posture, which results in an exaggerated anterior curve in the lower cervical vertebra and an exaggerated posterior curve in the upper thoracic vertebra.

According to a study by Vinodhkumar Ramalingam et al. (2019), 67% of 188 university students exhibited forward head position, although 58.5% of students reported being unaware of it [16]. The frequency of forward head posture was 63.96% among 197 students from four Pakistani universities, as reported in a study by Naz A et al. (2018) [17]. The current study was conducted to determine the prevalence of posture deviation in the female population of the age group 18-30 years. It concluded that 73.5% of the female population is affected by postural deviation due to the immediate effect of tying a ponytail. A previous study by Vinodhkumar Ramalingam et al. (2019) suggests that a change in the biomechanics of the cervical spine leads to postural deviation. This aggravates when there is excessive pressure on the neck extensors [16]. According to the same study, wearing a ponytail results in FHP, or head-on-trunk misalignment. It raises the thoracic spine's kyphosis and creates rounded shoulders and increased lordosis of the lower cervical spine16. According to reports, FHP typically causes shortening of the SCM muscle in addition to the cervical extensor muscles, which include the splenius and upper trapezius. These musculoskeletal diseases alter the equilibrium of the muscles surrounding the neck. FHP also results in weakness of the scapular retractors, including the middle fibers of the trapezius, and the cervical flexor muscles. The length of a muscle affects its capacity to produce force. A muscle's capability to produce force is reduced as it shortens or lengthens in relation to its resting state. A muscle's capacity to produce force is diminished as it is shortened or lengthened in relation to its resting state. Stated differently, changes in muscle length impact muscular activity, and this is linked to the stability of the force-length connection. The cervical spine will experience more stress and less stability as a result of this imbalance [18].

One of the several VDT (Visual Display Terminals) syndromes, the forward head syndrome, is frequently observed in women who wear ponytails and work for extended periods of time in a fixed position. Participants' head and neck postures were evaluated by taking lateral photos, after which the cervical curve angle and CV angles were measured. This approach has been widely used in earlier research [14]. The upper cervical vertebra experiences an extension moment as a result of the head's protrusion in an anterior direction and an elevated CV angle. Under both static and dynamic circumstances, this results in a shift of COG toward the anterior direction. These findings imply that these decreased activities are linked to a decreased capacity to produce force and are caused by changes in muscle length brought on by FHP [19]

According to a study by Zainab Abbas et al. (2022), women who wear their hair in a ponytail or bun experience postural deviations [13]. This issue needs to be addressed immediately, as if left unattended, the pain and posture will deteriorate. Numerous studies recommended lowering the height of high ponytails and reducing the amount of time spent wearing them. The cervical structure is under less strain when the tight ponytail and bun are loosened, which results in improper posture [13]. The immediate impact of tying a ponytail, however, has been assessed in this study at different distances from the C7 vertebrae. In this study, FHP was measured and determined when a ponytail was knotted at different distances using CV angle and TWD. There was not a significant difference between the angular

values of the 93 samples for CV angle and TWD in cm; the p-value was greater than 0.05.

Few studies have examined the direct impact of ponytail tying on postural deviation. The study found that the immediate tying of a ponytail at the top of the head, close to the canthus of the eye, at the occiput, and at the open hairs caused changes in the CV angle and FHT of 40±64 degrees and 5.5±13 cm, 41±64 degrees and 2.5±13 cm, 34±69 degrees and 4±13.5 cm, 36±68 degrees, and 4.5±13.5 cm, respectively. Open hair is therefore regarded as the most essential posture that benefits the musculoskeletal system and does not change the cervical spine's biomechanics.

A study by Eriksson EM et al. (2000) found that normal populations have relatively wide ranges of cranio-vertebral angles (35–60 degrees) [15]. However, the typical range of cranio-vertebral angles in this investigation was 50-70 degrees; patients with moderate-severe FHP and minor FHP had reduced ranges of 34-43 degrees and 46.9-49.1 degrees, respectively. This demonstrates unequivocally that even those without neck pain have a little FHP, which can be evaluated on a digital photo using APECS software. Since the APECS app can differentiate between normal head posture and FHP in the angle-based measurement on a digital image, this is the only study that, to our knowledge, shows high sensitivity of the photogrammetry method while tying ponytail at multiple distances from C7 vertebrae [19]. Presenting normative data about the digital posture assessment of healthy young females conducted using the mobile app APECS and assessing its repeatability were the objectives of the current study. The APECS app has already been utilized in research to assess postural behaviors associated with particular ergonomic studies. In earlier investigations, the double square method was used to measure the prolonged shoulders, and the photogrammetry method, a contemporary technique for evaluating forward head posture, was employed [19].

However, as our primary goal in this study was to measure the distance between the shoulder and the tragus of the ear, a steel scale was used to measure the prolonged shoulder, and the value of OWD was taken as a constant, i.e., 10 cm, for all samples to prevent errors. The angle measures a smaller angle (less than 49.9 degrees) when the forward head posture continues to exaggerate. According to this study, it is significant that students are aware of the altered head and shoulder posture that occurs due to faulty postures attained while tying a ponytail at different levels of the head. To our knowledge, this is the first study to utilize the PM and TWD tests to quantify the head and neck posture assumed when tying a ponytail at various distances from the C7 vertebrae. Photographs of the cervical spine's location in the sagittal plane have been a valuable source of information for clinical or research purposes regarding posture measures for the past thirty years. Therefore, photogrammetry has been proven to be a more reliable measurement tool for assessing head and cervical posture during ponytail tying compared to the TWD test, due to the limited literature support.

CONCLUSION

This study demonstrated immediate effect and significant difference in FHT and CV angle while tying a ponytail at several distances from the C7 vertebrae, which was measured by the TWD test and the Photogrammetry Method.

LIMITATION

1. Occiput to wall distance (OWD) was considered as an arbitrary value, i.e., 10 cm for all 93 samples.
2. Hair length, i.e., only below the inferior angle of scapulae, was considered.
3. Age group, i.e, 18-30 years.
4. The study was conducted only for college-going students of RGU.
5. Limited literature support regarding tying ponytail affecting cervical posture.
6. Only the sagittal plane was considered.

RECOMMENDATIONS

1. CV angle and FHT can also be checked in the frontal or coronal plane.
2. For checking the immediate effect of tying a ponytail, further studies on the TWD test can be done by considering any other arbitrary value of OWD, either 5cm, 15cm, 20cm, etc.
3. The study can be done in different geographic regions of the country in a heterogeneous group of the population.
4. The future study can discuss the importance of strengthening the neck and upper back musculature.
5. In future studies, the BMI of the samples can also be calculated to check postural deviation.
6. In future studies, cervicogenic headache should be studied, which occurs due to abnormal posture of the cervical spine.

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