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Correlation between the Degree of Forward Head Posture and Hamstring Muscles Tightness in Non-Specific Neck Pain

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ABSTRACT
Introduction: Anterior translation, also recognized as Forward Head Posture (FHP), is a pathology that happens when the head moves forward from the vertical line of gravity. FHP can cause significant problems, such as fascial stretching at the lower cervical level, shortening of the upper cervical segment, hamstring tightness, and back fascial limitation at the hamstring and calf muscles levels.

Aim of this study: This study aimed to determine the correlation between forward head posture and hamstring, calf muscles tightness.

Methods: The study involved 84 university students of both sexes, with a mean age of 21.96 ± 2.25 years for males and a mean age of 22.05 ± 2 years for females, and a mean BMI of 22.32 ± 1.68 kg/m^2 for males and a mean of 22 ± 1.7 kg/m^2 for females. The sample size included only those with a craniovertebral angle (CVA) measurement of less than 49^0, which was determined using the photogrammetry method. The study was conducted to establish the degree of correlation among FHP and hamstring-calf muscles by using the active knee extension test (AKE test), as well as the passive straight leg raise test (PSLR) for hamstring muscles tightness using the ankle dorsiflexion with the knee extended (ADFKE), in addition to ankle dorsiflexion with the knee flexed (ADFKF) for calf muscles tightness.

Results: There was a weak significant direct correlation (r=0.300, p=0.034) between CVA and right hamstring tightness as measured by PSLR in males with a normal BMI.

Conclusion: Forward head posture (FHP) weakly correlates with hamstring tightness in males with normal BMI, therefore treatment program should include hamstring muscles stretching.

Keywords: Craniovertebral angle (CVA), Forward head posture (FHP), Hamstring muscle tightness, Flexibility, Calf muscles tightness.

INTRODUCTION

The spinal deformity most commonly observed is FHP, occurring when the head is translated in front of the vertical line of gravity in the sagittal plane by 5 cm[1]. It is known that the prevalence of FHP in computer-based workers is 66%, and an increasing number of teenagers worldwide are using electronic devices for extended periods, which can cause musculoskeletal pathologies such as reduced postural control, forward translation of the body's center of gravity (COG), and impaired balance [2]. Continuous usage of smartphones and laptops can also lead to malalignment of the head and neck [3].

The cervical lordotic curve is mandatory for efficient mastication, breathing, vocalization, eye movement, gaze, tolerating compressive loads, mimicking stress on the vertebral end plate, and absorbing shocks during walking and running. Loss of normal cervical curvature affects all of these functions [4].

Young adults with FHP may experience chronic neck pain, a reduction in the normal curve of the neck, and radicular symptoms for the upper limb due to anterior translation of COG, flexion, stretching of the lower cervical spine, and disc pathology [5]. Static balance control is affected more significantly by FHP than dynamic balance control because of the overall activity of posture maintenance muscles [6]. FHP negatively impacts the autonomic nervous system's functions and disrupts cervical sensorimotor control [7]. Chronic tension headaches (CTTH), which can be extremely incapacitating, are a common symptom of FHP, inducing postural abnormalities. The degree of FHP affects the severity of both CTTH, muscle shortening and increases myofascial trigger point activity (MTrPs). Addressing FHP is essential for preventing these long-term effects [8].

The hamstring muscles are a group of three muscles, semimembranosus, semi-tendinosis, along with biceps femoris. The hamstring muscles are two-joint muscles located at the posterior thigh that cross both the hip and knee joints, allowing for hip extension and knee flexion [9]. However, studies have shown that there is a high prevalence of 68% among college students who have a hamstring score of 30^0 to 45^0 on the AKET test, which is considered a moderate tightness, who are between the ages of 18 to 25 years [10]. Extended periods of sitting during work can cause tightness in the hamstrings for 90% of the population, and 85.75% of office workers who work for 6-8 hours a day experience hamstring tightness. This can greatly decrease flexibility in the hamstring muscles as time goes on [11].

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Poor ergonomic chair design when sitting can negatively affect back pain and tightness in the hamstring muscles. This is due to the loss of the lumbar lordotic curve, which affects pressure distribution and can cause nerve impingement in 75% of patients. It's important to understand that tightness in the hamstring muscles plays a significant role in low back pain (LBP) [12]. Patients suffering from LBP often experience tightness in one or both legs, which is often caused by the hamstring muscles being attached to the ischial tuberosity, which leads to gait abnormalities [13]. When the hamstring loses flexibility, it can cause neuro-musculoskeletal changes and symptoms that result in decreased strength, stability, and endurance [10]. These consequences can induce recurrent injuries and affect psychosocial aspects [13]. Extended periods of sitting can result in tightness of the hamstrings [11]. It is important to note that computer-based workers and smartphone users have a significantly high prevalence of 66% of subjects with FHP [2]. The connection between FHP and hamstring tightness arises from the back fascial line connecting the suboccipital muscles, the back muscles of the spine, and the back muscles of the thigh and leg (hamstring as well as calf muscles) [14]. An RCT study compared proprioceptive neuromuscular facilitation (PNF) and sustained stretch (SS) for hamstring tightness and found that releasing tension through a back fascial line improves FHP and its corresponding measurement angle CVA, that is the indicator of FHP [15, 16].

The calf muscles are composed of the gastrocnemius, soleus, as well as plantaris, with the gastrocnemius having two heads that form the Achilles tendon with the soleus [17]. Studies have shown that calf muscle tightness is prevalent in 44% of normal adults [18].

The calf muscle is responsible for plantar flexing of the foot at the ankle joint and helps extend the tibia during closed kinetic chain motion, along with the gluteus maximus [19]. However, if the calf muscle becomes shortened, it can significantly limit the range of dorsiflexion and knee extension, leading to plantar fasciitis and heel pain [20]. Furthermore, calf muscle tightness can significantly impact an individual's balance and gait [21].

The triceps surae is a crucial component of the superficial back fascial line that connects with the hamstring and extends upward to the entire backline, incorporating essential components such as the sacrotuberous ligament, sacrolumbar fascia, erector spinae, epicranial, galea aponeurotica, as well as frontalis muscles [14].

Forward Head Posture (FHP) can cause the lower cervical area to experience fascial stretching and the upper cervical segment to shorten [6], leading to tightness in the hamstrings, posterior rotation of the pelvis, flattening of the lumbar curve [12], and limitations in the back fascia at the hamstring and calf level. Our study clarifies this correlation and the necessity to detect it.

PATIENTS AND METHODS:

Between November 2022 and May 2023, we conducted a cross-sectional correlation study to examine the relationship among FHP and hamstring-calf muscles. We recruited 84 male and female university students aged 18 to 30, with BMIs ranging from 18 to 24.9 kg/m^2, through spoken and written advertisements.

Inclusion criteria: The study included adult individuals aged from 18 to 30 years [22]. The participants had a CVA of less than 49^0 and experience neck pain, chronic non-specific neck pain. The neck disability index was greater than 5 points [23]. The participants had not been engaged in any sports or athletic routine for more than 2 years [22].

The exclusion criteria: Participants with moderate or severe scoliosis [23]. Vascular syndromes such as vertebrobasilar insufficiency, history of neurological (Guillain-Barre, peripheral neuritis) or orthopedic disorders (osteoporosis, osteoarthritis), progressive neurological deficits, history of lumbar and cervical herniated intervertebral discs with spinal stenosis, cervical spine history of trauma, fracture, congenital anomalies, or surgical intervention, history of lower extremity fracture and surgery with malunion prevalence of serious pathology such as rheumatoid arthritis, ankylosing spondylitis, malignancy, infection and inflammatory disorders. Additionally, participants with leg length discrepancy and a BMI less than 18 or greater than 24.9 kg/m^2 [(24)].

Procedures:

1-photogrammetry for CVA, measurement of FHP assessment:

It is mandatory to determine forward head posture (FHP) with accuracy, and the craniovertebral angle (CVA) is a reliable and valid indicator. Measuring the CVA through lateral photography is not only easy but also accurate, with an excellent interclass correlation coefficient of ICC=0.88. This method was commonly used and is noninvasive when compared to the gold standard X-ray. The photograph has been taken by a Samsung A72 mobile camera with 64 megabits mounted on a tripod 50 cm away from the subject, capturing the plastic pointer at the tragus of the ear and the C7 spinous process [25]. To measure the CVA, a line has been drawn C7 spinous process to the tragus of the ear and another line parallel to the ground from the C7 spinous process and calculate the intersecting angle between them, which is uploaded to AutoCAD software, which is a reliable and valid program for geometry analysis, using a Lenovo Z51 laptop for analyzing CVA [26]. The CVA ranges from 53.3^0-56.8^0, and any measurement less than 49^0 indicated FHP. A range of 46.9^0-49^0 represented mild FHP, while 40.7^0-43.2^0 was classified as moderate to severe FHP [25]. Figure (1) demonstrated the proper technique for capturing the photograph. Individuals were instructed to perform flexion and extension of their head and neck twice, then in a neutral stance with a plumb line hanging from the ceiling in front of their ankle joint. This line serves as a guide for vertical alignment in the photograph [25].

FIGURE (1): CVA assessment.

ASSESSMENT OF HAMSTRING TIGHTNESS:

1-active knee extension test (AKET):

During the experiment, the individuals were in a supine-lying position, and one of their hips was secured in a neutral position using a belt. The other hip was then flexed at a 90-degree angle, and the knee joint was gradually extended till the individual experienced pain or discomfort. To measure the range of motion, a digital goniometer was utilized, with the stationary arm attached to the individual's thigh using a Velcro strap and the fulcrum fixed at the lateral knee joint line. The movable arm of the goniometer moved with the participant's leg to accurately measure the angle of active knee extension. A normal measurement is less than 20^0 of knee extension, while mild tightness is indicated by a measurement of 21^0-30^0, 31^0-40^0 is considered moderate, and > 40^0 is observed as severe tightness [27].

2-Passive straight leg raise test (PSLRT):

The individuals were asked to lie on their backs while one leg was secured by a belt. The examiner then extended the knee of the examined leg and gently flexed the hip joint until the participant felt a sensation of tightness, stretching, or pain. The angle at which this occurred was recorded. Angles of 79^0 or higher were considered normal, while angles below 79^0 indicated a degree of tightness. The stationary arm was fixed horizontally to the table, and positioned laterally to the trunk, while the fulcrum was secured at the greater trochanter of the femur. The movable arm was used to move the thigh towards the lateral condyle of the femur [28].

Assessment of calf muscle tightness:

1-Ankle dorsiflexion with the knee extended (ADFKE):

The participants were requested to lie on their backs with their legs extended and actively move their ankles upwards while keeping their feet in a neutral position. A digital goniometer was used to measure the degree of ankle movement. The goniometer's fixed arm was positioned parallel to the middle of the outer surface of the leg, whereas the movable arm was positioned in the direction of the fifth toe. The fulcrum was placed at the lateral malleolus. A range of 10^0 or more degrees of upward movement was considered normal, while less than 10^0 indicated tightness in the calf muscles [29].

2-Ankle dorsiflexion with knee flexed (ADFKF):

The procedure used in the study was similar to the one described in ADFKE, with one difference, participants were instructed to bend their knee joint at a 90^0. A dorsiflexion of 15^0 or more was considered normal, while anything less indicated tightness in the calf muscles. The use of a digital goniometer was demonstrated to be a reliable and valid way of assessing the range of motion. In fact, it showed similar inter- and intra-reliability as a traditional universal goniometer [29].

Ethical considerations: The study was approved by The Ethical Committee (P.T.REC/012/004177) of the Faculty of Physical Therapy, Cairo University. Before participating, we provided each participant with information about the scope and procedures of the study and informed consents were obtained. To ensure confidentiality, we de-identified all collected data using numeric IDs.

Statistical analysis

Data were expressed as mean± SD. Unpaired t-test was used to compare between subjects characteristics of the two groups. MANOVA was used to compare between measured variables of different BMI and gender. Person correlation coefficient relation used to determine the relation between the degree of FHP and the degree of hamstring muscles tightness in individual with chronic non-specific neck pain. Statistical package for the social sciences computer program (version 20 for Windows; SPSS Inc., Chicago, Illinois, USA) was used for data analysis. *P* less than or equal to 0.05 was considered significant. The data have been checked for outliers, homogeneity of variance, as well as the assumption of normality. All outcome measures were normally distributed, according to Shapiro-Wilk and Kolmogorov-Smirnov tests for normality, so MANOVA was used for comparison between males and females, and the Pearson correlation coefficient relation was utilized to determine the relation between measured variables.

RESULTS

Table (1) and figure (2) revealed the gender percentage, and figure (3) revealed the mean values of age of males that were 21.96 ± 2.25 years and that of females were 22.05 ± 2 (p-value=0.830). The mean values of BMI of males were 22.32 ± 1.68 and that of females were 22 ± 1.7 kg/m^2 (p-value=0.417). The mean values of CVA as shown in figure (4) of males were 43.19 ± 7 and that of females were 41.56 ± 8.2^0 (p-value=0.272).

TABLE (1): Demographic data

Measured variable	Group A
Males (N) Females (N)	50 34
Age (years) Males Females p-value	21.96 ± 2.25 22.05 ± 2 0.830
BMI (kg/m^2) Males Females p-value	22.32 ± 1.68 22 ± 1.7 0.417
CVA (degrees) Males Females p-value	43.19 ± 7 41.56 ± 8.2 0.272

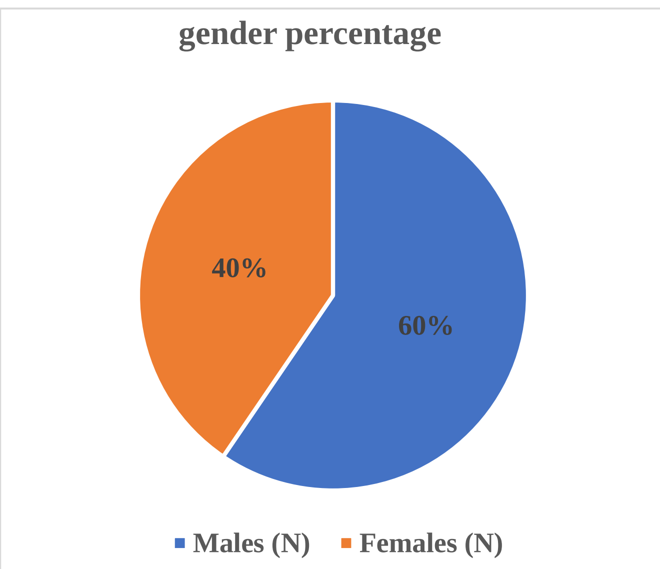

Figure (2): Gender percentage of males and females

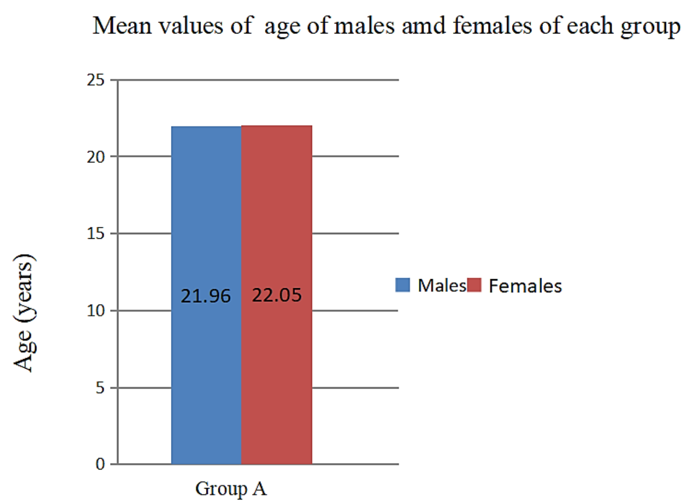

Figure (3): Mean values of subjects' age.

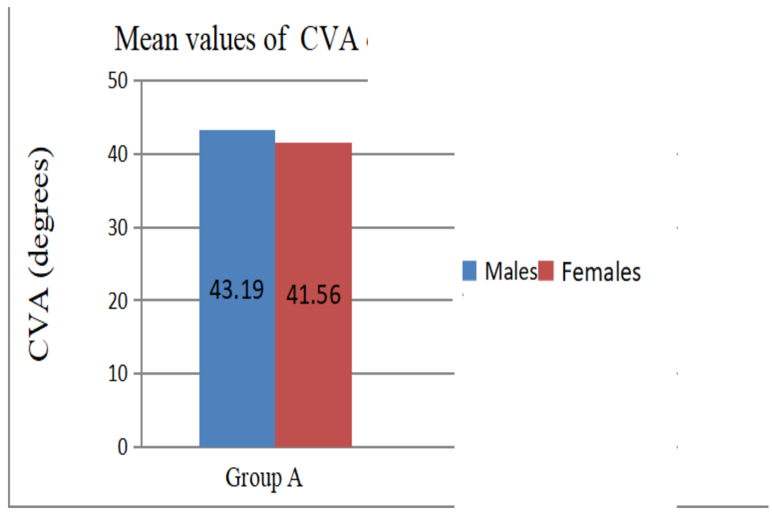

Figure (4): mean value of CVA of males and females.

As shown in table (2), and figure (5) in males of normal BMI, there was a significant direct weak correlation between CVA and right hamstring tightness by PSLR (r= 0.300) (p=0.034). No statistically significant difference between CVA and RT hamstring muscle tightness by AKET (r=-0.142, p= 0.324), and LT hamstring muscle tightness by AKET and PSLR tests respectively (r=-0.089, p= 0.540) (r=0.131 p=0.364). There was no statistically significant difference between CVA and RT gastrocnemius and soleus muscles tightness (r= 0.228 p=0.111) (r= 0.057, p=0.692) respectively. There was no statistically significant difference between CVA and Lt gastrocnemius and soleus muscles (r=0.204, p= 0.154), (r=0.066 p=0.648) respectively.

TABLE (2): Pearson correlation between the degrees of FHP AND MEASURED variables in males with normal BMI

N= 50		Right AKE	Left AKE	Right PSLR	Left PSLR	Right ADFKE	Left ADFKE	Right ADFKF	Left ADFKF
CVA	r value	-0.142	-0.089	0.300	0.131	0.228	0.204	0.057	0.066
	p-value	0.324	0.540	0.034*	0.364	0.111	0.154	0.692	0.648

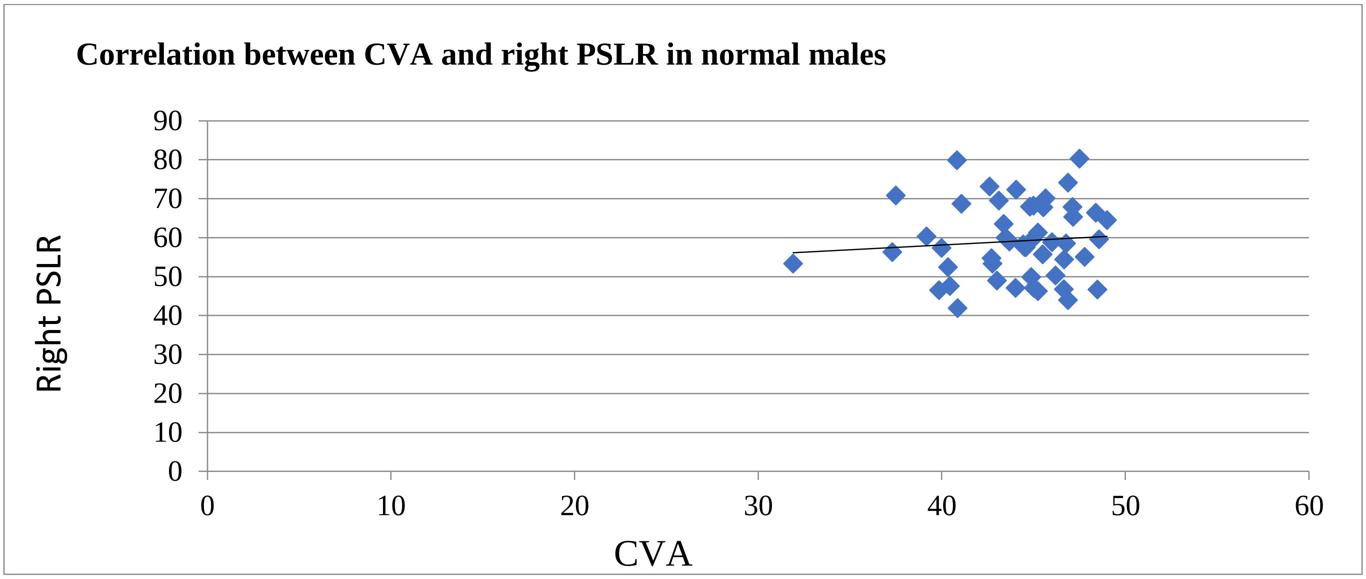

Figure (5): Correlation between CVA and right PSLR in normal males

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As shown in table (3), in females of normal BMI, there was no statistically significant difference between CVA and RT hamstring muscles by AKET and PSLR tests (r=-0.141, p=0.426) (r=0.318, p=0.067) respectively, and no statistically significant difference between CVA and Lt hamstring muscles by AKET and PSLR tests (r=-0.038, p=0.831), (r=0.176, p=0.321) respectively. There was no statistically significant difference between CVA and RT gastrocnemius and soleus muscles (r= 0.145, p=0.412), (r=-0.060, p=0.734) respectively. There was no statistical significance difference between CVA and Lt gastrocnemius and soleus muscles (r= 0.045, p= 0.799) (r=-0.008, p=0.966) respectively.

Table (3): Pearson correlation between the degrees of FHP AND MEASURED variables in females with normal BMI

		Right AKE	Left AKE	Right PSLR	Left PSLR	Right ADFKE	Left ADFKE	Right ADFKF	Left ADFKF
CVA	r value	-0.141	-0.038	0.318	0.176	0.145	0.045	-0.060	-0.008
	p-value	0.426	0.831	0.067	0.321	0.412	0.799	0.734	0.966

DISCUSSION

The study found a significant correlation between the CVA and PSLR test in males with a normal body mass index (BMI), and CVA is the indicator of FHP. This means that subjects with FHP had a reduction in CVA, which also was correlated with a decline in flexibility of their hamstring muscles. On the other hand, subjects without FHP had an increase in CVA, which was correlated with an increase in flexibility of their hamstring muscles.

This finding is consistent with **Jeong *et al.*** [16] who recommended restoring hamstring flexibility in subjects with FHP. That study concluded that to enhance CVA and reduce tone in the cervical extensors, PNF and sustained stretching (SS), help transmit the force of the hamstring to the pelvis as well as the spine. While the exact reasons for these results are unclear, it's possible that enhanced upright posture as a result of an altered superficial backline could also be a contributing factor.

A program that focuses on relaxing the hamstrings helps alleviate headaches, as headache is one of the main symptoms of FHP, and supports the results of this study, this is because shortened hamstrings can contribute to poor posture and FHP, which is a common cause of headaches. Therefore, the Hamstring Relaxation (HR) program may be a more effective treatment for headaches than physiotherapy for the cervical region only, as it reduces the degree of FHP [30].

A histological analysis study discovered the connections of fascia and evidence of a myodural bridge between the dura and suboccipital muscle [15]. Suboccipital muscles according to **Myers** [14], are connected to the superficial back fascial line. Tight hamstrings can produce backward pelvis rotation, reducing the lumbar lordotic curve and increasing kyphosis, ultimately resulting in FHP due to the effects of gravity [3]. Stretching the lower cervical fascia and increasing tension shortening of the upper myodural bridge can develop headaches caused by the effects of the line of gravity anterior translation [15].

It's imperative to understand that fascia envelops each muscle, blood vessel, as well as nerve in the human body, establishing vital connections between bones, organs, and muscles, and creating an extensive network throughout the body [31]. Researchers have unequivocally discovered the continuity of the fascial chain in both upper and lower extremities, based on the principle of tensegrity [31, 32].

Myofascial meridians define that the hamstrings on the back side of the human body are linked by the superficial backline which runs from the gastrocnemius muscle through the hamstrings and attaches to other muscles including the Sacrotuberous ligament, thoracolumbar fascia, erector spinae, iliocostalis, cervical suboccipital muscles, epicranial, galea aponeurotica, as well as frontalis muscles [14]. This myofascial meridian, known as the superficial backline, is responsible for transmitting tension from the head or gastrocnemius to other muscles [33].

It must be emphasized that a prior study has shown that tightness and contraction in the hamstring muscle can lead to neck and shoulder pain. The reason behind that is also the myofascial chain's superficial backline that connects the neck to the lower extremities, as well as the soft tissue in the cervical spine that connects the dura along with suboccipital muscle fascia[15]. It was demonstrated that performing hamstring stretching exercises significantly improved cervical range of motion (ROM) [34].

This study supports the conclusion drawn by **Jeong *et al.*** [24] that reducing the tone of suboccipital muscles, either through passive fascial treatment or active movements, can lead to a reduction in the tone of knee flexors (hamstring muscles) and an increase in the amplitude of hip flexion. This, in turn, can improve the SLR test score, which exactly supports what was discovered in this study. The suboccipital muscle inhibition (SMI) technique and craniocervical flexion exercise (CCFE) program, which are passive and active programs respectively have been found to improve results in the SLR test, popliteal angle (PA), CVA, as well as cervical range of motion (CROM). They are both beneficial in enhancing hamstring flexibility in patients with neck pain, with immediate results.

The current study discovered a weak significant correlation among males. This could be explained by a previous study that reported reductions in the ROM of the cervical spine due to structural changes in the cervical soft tissue and muscles inactivity. This can result in increased connective tissue density, as well as shortening and fibrosis of the muscles and collagen tissue [24].

On the other hand, FHP can impact the curvature of the spine in the thoracic [35] and lumbar regions more than the pelvic or hamstring areas [12]. This phenomenon was more prevalent in females in this study, with no significant correlation observed in them. A previous study has attributed this to a mechanical malalignment in the cervical and thoracic [35], or lumbar region [12]. Manual therapy of the cervicothoracic junction has been found to significantly impact the craniovertebral angle (CVA) and cervical mobility. It is also well known in the treatment of FHP that clinics commonly employ strengthening exercises for the deep flexors and stretching of the suboccipital muscles.

Performing the craniocervical flexion exercise (CCFE) can activate the deep neck flexor muscles, which can improve your posture when sitting for long periods, and the soft tissue in the cervical area links the dura matter along with sub-occipital muscle fascia, contributing to this improvement [24]. However, prolonged sitting can cause tightness in the hamstring and calf muscles, which means that it may coexist with FHP but is not necessarily the cause of or not correlated with some other populations [11].

A systematic review concluded that there is 1a level of evidence that suggests describing therapeutic exercises may improve CVA but 1b level of evidence that suggests therapeutic exercises can't improve CVA. This result confirms what was found in this correlation study since some patients needed to have hamstring stretching for tightness involvement before treatment. Furthermore, there is 1b level evidence indicating when given exercise recommendations, patients with FHP have a moderate improvement in cervical pain [36].

The insignificant correlation between the CVA and the hamstring muscle flexibility of females can be explained by the fact that women are generally more flexible than men across a wide range of age groups and educational attainment levels [37].

We found that there was an insignificant correlation between FHP and calf muscles tightness among males and females with normal BMI, which may be related to the fact that the hamstring fascia is longer than the calf fascia, so the more the affection and relation are at the hamstring level [14].

Limitation:

During the three-trial learning period, the AKE test is likely to result in dynamic hamstring stretching which could be the reason for the insignificant correlation observed with the active knee extension test.

CONCLUSION

The study revealed that there was a significant direct weak correlation between FHP and tightness in the hamstring muscles among males with a normal BMI. The more the reduction in CVA, the more the FHP, and the more the decline in the flexibility of their hamstring muscles. Physical therapists should examine hamstring muscles for tightness in patients with FHP for stretching exercises or myofascial release to get maximum improvement of FHP treatment.

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- **Conflict of interest:** No conflict of interest.

- **Recommendations:** a large number of participants with FHP above 30 years old, desk workers, social workers, and heavy workers with neck pain must be included. Also, Assessment of the CVA at a sitting posture.

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