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ASSESSING CERVICAL PROPRIOCEPTION AND BALANCE TO MITIGATE FALLS AMONG ELDERLY INDIVIDUALS: A CROSS SECTIONAL STUDY

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Abstract

Introduction: *Cervical proprioception, is an essential component of physiological function and is critical in maintaining the equilibrium and functionality of the head and neck. Previous studies have suggested that the proprioceptive, visual and vestibular sensory systems interact to maintain dynamic stability during movement.*

Objectives: *The aim is to investigate the relationship between cervical proprioception and balance to mitigate falls among elderly individuals with cervical spondylosis.*

Methods: *This is a cross-sectional study, that was conducted in Liaquat National Hospital Karachi, Pakistan. For the collection of data convenience-based sampling was used. The estimated sample size was 133. Elderly individuals aged 65 years and older with confirmed diagnosis of cervical spondylosis, has history of fall and able to walk independently was included. While individuals with history of whiplash- associated disorder, neurological disorder, fracture, dislocation, inflammatory joint disease, fatigue syndrome, fibromyalgia, diabetic neuropathy, history of cervical spine surgery or trauma, central nervous system impairment, vestibular impairment, individuals unable to comprehend, follow study instruction and those taking sedating medication was excluded. Berge Balance Scale, Goniometer and Cervical JPE was used for the assessment of balance, cervical ROM and cervical proprioception. Data was analyzed using SPSS version 21.*

Result: *The study reveals that while most participants demonstrate moderate balance, right rotation ability significantly correlates with balance deficits.*

Conclusion: *The study highlights the critical role of cervical proprioception, particularly during rotational movements, in maintaining balance. Right cervical rotation errors exhibited the strongest negative correlation with balance, suggesting that accurate joint position sense during this movement is essential for stability. Left rotation also contributed to balance but to a lesser extent. Conversely, flexion and extension movements had minimal impact on balance.*

Overall, participants demonstrated moderate balance ability, but individuals with higher JPE, especially during right rotation, may face a greater risk of instability and falls. These findings emphasize the importance of targeting cervical

proprioception, particularly rotational movements, in balance training and rehabilitation programs, especially for populations prone to balance deficits.

INTRODUCTION

The global trend of population ageing is a significant phenomenon in the late 20th and early 21st centuries. According to the World Health Organization (WHO), the population of older adults, defined as people aged 60 or older, is growing at a rate of about 2.4%, and surpassing the general population's growth rate of 1.7% (1) (2). This increase in the elderly population is a global phenomenon. Pakistan currently has 12.13 million people over 65, and that figure is expected to rise to 18 million by 2050 (3).

As the world's population ages, the increasing incidence of fall and balance in the elderly is being recognized as an important threat to public health, prompting specific interventions from healthcare practitioners, particularly physiotherapists. The intricate connection that exists between cervical proprioception and functional balance has significant consequences for the musculoskeletal wellness of elderly people with cervical spondylosis(1).The aging global population has brought attention to a myriad of age-related health conditions that significantly impact the quality of life of elderly individuals. Among these, cervical spondylosis, a degenerative disorder affecting the cervical spine, is increasingly common among older adults, primarily as a consequence of aging (2).

The prevalence of cervical spondylosis has been reported to be approximately 3.3 cases per 1,000 individuals in the general population, highlighting its significance as a public health concern (2). The condition often manifests with various neurological and musculoskeletal symptoms, including neck pain, stiffness, and reduced mobility (2). A less commonly addressed yet critical outcome of cervical spondylosis is the impairment of proprioception, which refers to the body's capacity to perceive its position and movement (3).

Cervical spondylosis is often linked to impairments in cervical proprioception, which can disrupt the essential sensory feedback loop needed for maintaining balance. As a result, this disruption contributes to postural instability and an elevated risk of falls (2, 4). Therefore, older adults with cervical spondylosis face an increased risk of falling, leading to serious consequences such as fractures, reduced mobility, and a significant decline in overall quality of life (2, 4).

Cervical proprioception, an essential component of physiological function, is critical in maintaining the equilibrium and functionality of the head and neck (4). The complex network of proprioceptive sensors arranged in the cervical spine promotes the transfer of essential sensory information to the brain, which in turn controls the complex symphony of equilibrium, posture, and movement (1, 5).The intricate interactions of these sensory inputs maintain the body oriented in space and preserve its orientation in space, facilitating the seamless coordination of motions of the head, neck, and upper limbs (4). This complex sensory system is essential for negotiating the challenges of everyday life and is fundamental to maintaining balance and postural control throughout a range of activities (4, 6).

The head-neck complex is equipped with a highly intricate proprioceptive system, which plays a pivotal role in regulating head posture and balance (7). In this context, proprioception, often equated with kinesthesia, refers to the perception of body segment positions and movements (16). This intricate sensory function relies predominantly on afferent signals stemming from muscle spindles and skin receptors, supplemented to a lesser extent by receptors situated in capsules, ligaments, and joint facets(8). Remarkably, the neck muscles, including the deep vertebral and occipital-vertebral muscles, exhibit a notable density of muscle spindles

comparable to muscles governing precise movements, such as those controlling eye and hand motions(9). Any disruptions in cervical afferent inputs, their subsequent integration into sensorimotor processes, or impairments in the motor output to neck muscles, including spindle fibers, can lead to deviations in neck position sense(10).Such deviations can pose significant challenges to balance, as evidenced in conditions like cervicogenic dizziness (11, 12).

The process of cervical sensorimotor control is intricate and involves integrating various sensory inputs, including visual, vestibular, and cervical proprioceptive information (13, 14). This complex system ultimately leads to the execution of motor programs by the cervical muscles to maintain head posture, balance, and cervical joint stability (13, 14). Identifying and addressing disruptions in cervical sensorimotor control is crucial as they can result in a range of negative consequences (7, 15). Dysfunctional motion patterns that result from these disruptions can impact the patient's quality of life and lead to long-term health issues (15). Therefore, healthcare providers need to devise effective strategies to assess and treat disruptions in cervical sensorimotor control to minimize their adverse effects on patients' well-being (7, 15).

Cervical proprioception, in combination with the visual and vestibular systems, is vital for maintaining bodily balance and posture by providing necessary afferent proprioceptive inputs to optimize motor control and refine muscle activation patterns (16). The cervical spine contains a significant number of muscle spindles, contributing to a complex proprioceptive system that governs neck reflex mechanisms (17). These reflexes are essential for maintaining balance, coordinating head and eye movements, and achieving equilibrium both statically and dynamically (18). The process of cervical sensorimotor control is intricate and involves the integration of various sensory inputs, including visual, vestibular, and cervical proprioceptive information (13, 14). This complex system ultimately leads to the execution of motor programs by the cervical muscles to maintain head posture, balance, and cervical joint stability (13, 14). Identifying and addressing disruptions in cervical sensorimotor control is crucial, as they can result in a range of negative consequences (7, 15). Dysfunctional motion patterns that result from these disruptions can impact the patient's quality of life and lead to long- term health issues (15). Therefore, healthcare providers need to devise effective strategies to assess and treat disruptions in cervical sensorimotor control to minimize their adverse effects on patients' well-being (7, 15).

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However, as time passes, age-related changes occur, which may call cervical proprioception into question (1, 7). Gradually declining neck muscle and joint function combined with changes in the interpretative capacity of the central nervous system pave the way for an anticipated decline in proprioceptive severity (7). This reduced sensitivity to proprioceptive cues may create a chain of detrimental events, such as impaired postural control and a higher probability of slips and falls (1, 7). This provides an important reminder of the intricate interconnections that maintain human physiology and the fragility associated with ageing (7). Elderly people struggle with keeping balance while carrying out everyday tasks since they have

difficulties in cervical proprioception and cervical spondylosis
(7).The sensations received from the cervical muscles, tendons, and joints are essential for coordinating movements and sustaining the head and neck when performing everyday tasks (7, 19). Cervical joint position sense (JPS) is an essential component of proprioception. It primarily reflects ascending afferent input from cervical muscle, disc, capsule, and ligament receptors (58). Disruptions in cervical afferent input can cause impaired cervical JPS. This impairment is commonly measured as cervical joint position error (JPE)(59).

The most widely used method for assessing cervical joint position error (JPE) is the active motion angle reconstruction test (60). This test requires participants to relocate either a neutral or a predefined target head position without visual feedback, as determined by the researchers. The accuracy of this assessment is quantified by measuring the distance between the center of the target and the participant's final head position (60).

The target used in this test is calibrated for a patient positioned 90 cm away. At this distance, a 7 cm error from the center of the target corresponds to a 4.5-degree angular error, as calculated using the inverse tangent function (arctan(7 cm/90 cm) = 4.5 degrees)(7). This relationship between the linear distance error and the angular error is dependent on the fixed distance between the participant and the target (7).

By utilizing this calibrated target system, the active motion angle reconstruction test provides a standardized and objective means of evaluating an individual's cervical proprioception. The angular error, derived from the linear distance between the target center and the participant's final head position, serves as a quantitative measure of their ability to accurately sense and reproduce a specific head orientation (61). This assessment approach allows researchers and clinicians to gain insights into the integrity of the sensorimotor system responsible for maintaining proper head and neck positioning, which can be impaired in various musculoskeletal and neurological conditions (60, 61). The angle of cervical after each JPE attempt can be measured through goniometer.

During an evaluation of head position sense, the variable that is measured is the difference between the initially established reference point position, which is either a neutral or target position, and the position that subjects achieve while attempting to match the target position(8, 51). This difference is measured in degrees (°) and is referred to as the Joint Position Error (JPE) (52).The JPE test is commonly used to test the cervical proprioception (51, 53, and 54).

Lately, there has been a growing emphasis on assessing cervical proprioception in older individuals dealing with cervical spondylosis. One of the most commonly used techniques for evaluating neck proprioception is the head reposition accuracy (HRA) test (55). This test measures an individual's capability to return their head to a specific position without using visual cues after movement (56). The HRA test consists of two commonly employed versions: repositioning to the neutral head position (NHP) and repositioning into a target head position (THP) (56, 57). The NHP test assesses the person's ability to actively reposition their head to a self-selected neutral position (55). Meanwhile, the THP test evaluates the individual's capacity to actively reposition their head to a predetermined target position (55).

Various studies have shown impaired cervical proprioception, indicated by increased repositioning errors in individuals with different neck syndromes like cervical spondylosis compared to those without symptoms (7, 60). These findings suggest a potential somatosensory dysfunction, leading to difficulties in processing information necessary for maintaining balance (60). Additionally, compromised proprioception

significantly affects postural stability across a range of health conditions (19).

While ageing is associated with an overall decline in balance (1, 6), the well-established proprioceptive system in the cervical spine collaborates with the vestibular and visual systems to maintain proper posture and equilibrium (6). The preservation of balance and stability is crucial for overall health, and cervical proprioception, or the perception of position and movement of the head and neck plays a vital role in this process. The cervical spine contains numerous proprioceptive receptors that provide important feedback to the central nervous system regarding the head's spatial orientation (20). However, as the body ages, it undergoes several changes, such as cervical spine degeneration, particularly cervical spondylosis, and loss of muscle strength, which can have a negative impact on cervical proprioception (20, 21). This decline in cervical proprioception with age can result in impaired balance and an increased risk of falls in older adults with cervical spondylosis (1, 20, 21). Therefore, it is crucial to consider these age-related changes to enhance balance and stability in older adults with spondylosis (1, 20).

Balance is the capacity of an individual to maintain their body position or restore the center of mass efficiently. In optimal posture, this can be achieved with minimal muscle effort or postural sway (22). The significance of a well-functioning balance system is evident in its role in aiding clear vision during movement and automatically adjusting posture based on activity demands. Achieving balance involves the intricate coordination of sensorimotor control systems, incorporating sensory input (vision, proprioception, and the vestibular system), processing this input, and generating motor responses in the muscles of the head, eyes, trunk, and limbs. These muscles are crucial for maintaining posture in humans (1, 23). Balance is a multifaceted concept influenced by various factors.

Research indicates a strong link between diminished cervical proprioception and poorer balance performance, as assessed by tests like the Berg Balance Scale and Timed Up-and-Go test (23). The decline in cervical proprioceptive acuity with age contributes to increased postural sway and reduced limits of stability, especially when the cervical spine is subjected to torsional positions that challenge the proprioceptive system(20, 22). The aging process significantly impacts the body's ability to maintain balance, leading to a higher risk of falls among the elderly when faced with activities requiring static or dynamic balance (24). Research indicates that globally, 28-35% of falls occur in individuals aged 65 years or older, with this percentage increasing with age (25). Specifically, the fall rate for those aged 75 years or above is reported to be around 40%(26).

Balance issues are commonly linked to various conditions such as impaired vision, hearing difficulties, vestibular problems, neuropathies like diabetic neuropathy, and a range of chronic diseases including cerebral disorders, cerebrovascular issues, and cervical spondylosis and other spinal cord disorders (27). Psychological factors, dementia, high blood pressure, postural hypotension, diabetes, heart conditions, and joint problems like arthritis and muscular weakness also contribute to balance impairments (28). Many of these conditions are prevalent in the aging population, increasing the risk of falls and related injuries among the elderly with cervical spondylosis (27, 28).

Falls represent the foremost contributor to fatal injuries among the elderly, resulting in a decline in functional autonomy and a diminished quality of life, encompassing emotional distress, isolation, and decreased mobility, all of which impose a substantial burden on society (24).Around 30% of individuals aged 65 years and above living in the community experience at least one fall annually, with approximately 15% encountering two or more falls within the same

timeframe(29).The repercussions of a fall extend beyond physical injury, potentially instigating a fear of falling that can trigger activity limitations or heightened reliance on others (30).

Several researchers have investigated the risk factors for fall-related injuries. Furthermore, falls and fall-related injuries appear to be risk factors for increased healthcare utilization and functional decline(33). Understanding the specific risk factors that contribute to falls with consequences is essential for developing targeted interventions to mitigate the burden on individuals and healthcare systems(28). By addressing the underlying factors that increase the likelihood of falls leading to adverse outcomes, healthcare providers can implement more effective strategies to promote the well-being and independence of older adults and other populations at risk (32).

Falls are a usual and serious health concern for elderly individuals with balance issues and cervical spondylosis, posing a greater risk to their overall well-being (34). The natural ageing process increases susceptibility to falls when individuals get older, potentially lowering the standards of life for older adults (34). According to research, the annual incidence of falls among adults over the threshold of 65 ranges between 24% and 40%(35). As life expectancy rises, it becomes more essential to identify nuanced differences among older people and comprehend the changing needs and challenges they face in their later years(36).Following a fall, a substantial proportion of older adults experience notable repercussions, including a reduction in participation in leisure activities, decreased social connections, and diminished self-confidence(36). These limitations in exercise and social engagement lead to a decrease in overall quality of life, fostering a sense of loss of autonomy and increased reliance on others among the elderly(37). Consequently, an incident of a fall is a watershed moment for many older adults, indicating a possible turning point in their psychological and physical health(38). It is predicted that without effective preventive measures, the number of injuries due to falls will significantly increase by 2030(38, 39).

Falls are a prevalent and concerning geriatric syndrome, associated with heightened mortality and morbidity among the elderly population(32). A fall is defined as an unintentional change in position resulting in an individual coming to rest on a lower level(28). Globally, the prevalence of falls among the elderly population ranges from 18% to 33%, with 6% to 15% of individuals experiencing recurrent falls (40, 41). More specifically, statistics indicate that 28% to 35% of those aged 65 and above, and 32% to 42% of those over 70 years old, experience falls annually(40, 41).

In developing countries, the reported annual incidence of low fall rates varies, with 19.3% in China, 22.4% in the United Kingdom, and 20% in Japan (42). In Pakistan, the National Injury Survey has reported an incidence rate of 8.85 fall-related injuries per thousand individuals annually (43). These alarming statistics underscore the significant burden that falls place on the elderly population, their families, and healthcare systems worldwide (43).

While aging is an inevitable physiological process, various health and mental conditions can exacerbate the risk and consequences of falls among the elderly (44). Factors such as cognitive impairment, chronic diseases, medication use, and physical frailty can all contribute to an increased susceptibility to falls and their associated negative outcomes (44). Addressing these underlying risk factors through comprehensive geriatric assessments, targeted interventions, and the implementation of fall prevention strategies is crucial to mitigate the substantial impact of falls on the well-being and independence of the aging population (45).

As individuals advance in age, their physiological systems undergo a multitude of changes that can significantly impact their overall health and

functional abilities (69). Among these transformations, the domains of sensory perception, proprioception, and balance play a particularly pivotal role in maintaining postural stability and preventing falls, which have emerged as a prevalent concern among aging populations worldwide (70).

The aging process is accompanied by a gradual decline in various physiological systems, including the visual, vestibular, and somatosensory systems, all of which are integral to the maintenance of balance and postural control (69). As individuals grow older, they may experience diminished visual acuity, reduced proprioceptive feedback from the joints and muscles, and impaired vestibular function, which can collectively compromise their ability to effectively integrate sensory information and generate appropriate motor responses to maintain stability (69).

Furthermore, the aging process is often accompanied by the development of chronic health conditions, such as musculoskeletal disorders, neurological diseases, and cardiovascular problems, all of which can further exacerbate balance impairments and increase the risk of falls (72). Factors like muscle weakness, joint stiffness, and impaired cognitive function can also contribute to the deterioration of balance and postural control in the elderly with cervical spondylosis (69).

Karachi, one of the world's most densely populated cities, is currently confronting the challenges posed by its rapidly aging population. It is, therefore, crucial to gain a comprehensive understanding of the factors that contribute to the deterioration of balance and the heightened risk of falls within this senior demographic with cervical spondylosis (71).

This study's findings have significant implications for physiotherapy professionals in terms of designing and implementing personalized rehabilitation programs for elderly individuals and enhance the well- being of the elderly population in Karachi (73). By identifying and addressing specific deficits in cervical proprioception and functional balance, physiotherapists can enhance the effectiveness of treatments and improve the overall quality of life for these individuals (21). This approach is crucial in enhancing the standard of care for elderly individuals with cervical spondylosis managing balance and fall issues, as well as improving cervical proprioception (72).

The study's findings are particularly relevant in the context of Karachi Pakistan, where the elderly population is growing rapidly and faces significant challenges in accessing healthcare services (73). The integration of evidence-based physiotherapy practices into healthcare systems can help address these challenges and improve the overall health outcomes for elderly individual with cervical spondylosis (72, 73).

1. Background

The aging global population has brought increasing attention to age-related health conditions, with falls posing a significant public health issue among older adults. Cervical spondylosis, a prevalent degenerative disorder in elderly individuals, is often associated with impaired cervical proprioception— our body's ability to sense movement and position of the head and neck. This impairment compromises the sensory feedback crucial for balance, leading to postural instability and heightened fall risk in affected individuals.

Globally, approximately 28-35% of people aged 65 and older experience falls annually, a statistic that worsens with advancing age. Falls in elderly individuals are associated with severe outcomes such as fractures, loss of independence, and decreased quality of life. In Pakistan, particularly in densely populated areas like Karachi, the growing elderly population faces additional challenges, as healthcare access may be limited for managing conditions like cervical spondylosis and its complications.

Addressing cervical proprioceptive deficits through targeted interventions may reduce fall risk and improve quality of life for older adults with cervical spondylosis, thereby contributing valuable insights for physiotherapy practices and fall prevention efforts in similar populations.
This study aims to assess the relationship between cervical proprioception and balance in elderly individuals with cervical spondylosis. Findings are expected to inform targeted interventions to mitigate fall risk, potentially guiding rehabilitation approaches to improve functional stability in this vulnerable group.

2. Significance of the problem

Previous studies have extensively explored the risk factors for falls in the elderly population, but little research has been conducted on cervical proprioception and its relationship between impaired balance and postural control which increased the risk of fall, in the population of Karachi. Therefore, we aim to investigate how cervical proprioception may affect balance in the elderly population with cervical spondylosis.
This research will provide assistance to the Physical Therapists or Rehabilitators on how rehabilitation of the cervical region in elder individuals with impaired cervical proprioception can enhance balance and postural control and prevent the risk of falls.

3. Objective of the study

The study aim to investigate the relationship between cervical proprioceptive function and the incidence of falls in elderly individuals with cervical spondylosis.

4. Hypothesis

Null Hypothesis (H_0):

H_0 : There is no significant relationship between cervical proprioception and balance to mitigate falls among elderly individuals.

Alternative Hypothesis (H_1):

H1 : There is a significant relationship between cervical proprioception and balance to mitigate falls among elderly individuals.

5. Operational Definitions

Cervical proprioception: Cervical proprioception refers to the body's perception of the position and movement of the neck in space(20). It is a crucial component of the nervous system that helps maintain balance, posture, and coordinate head movements (5, 74).

Cervical joint position error (JPE): Cervical JPE refers to the inaccuracy in your ability to sense your head and neck's position in space relative to a neutral position (60). It essentially measures how well your body's internal sensors match the actual position of your neck (60, 74).

Cervical Joint Position Error Test (JPE Test):Cervical JPE test is used to assess cervical proprioception(5). This test measures your ability to return your head to a neutral position after moving it, while blindfolded (60). A higher cervical joint position error indicates reduced precision in your neck's positional awareness (60, 74).

Balance: Balance refers to the ability to maintain postural stability and control body position both statically and dynamically (24). It involves the integration of sensory information from the visual, vestibular, and somatosensory including proprioceptive systems to coordinate muscle responses and maintain the body's center of mass over its base of support (16)

Berge Balance scale (BBS): BBS is used to assess an individual's functional mobility and risk of falls (75, 76). It's particularly helpful for evaluating balance in older adults and people with conditions that can affect balance, such as stroke, Parkinson's disease, and multiple sclerosis. It consists of 14 specific tasks that a healthcare professional scores on a scale of 0 to

4(76). Zero indicates the lowest level of function, and 4 represents the highest level of function.

2. Methodology

2.1 Study Design

This is a cross-sectional study.

2.2 Study Population/Settings

The study will focus on individuals aged 65 and older, drawing participants from the outpatient department (OPD) and Physiotherapy Department at Liaquat National Hospital and Medical College (LNMC), as well as senior citizens within the LNH community in Karachi, Pakistan. A purposive sampling approach will be utilized to ensure participants are representative of the elderly population receiving routine medical and physiotherapy care.

2.3 Sampling Technique

Convenience Based Sampling.

2.4 Sample Size

Sample size of 133 has been calculated through WHO sample size calculator using prevalence of cervical spondylosis from the previously conducted researches.

2.5 Study Duration

The study started on 6 March 2024; the research topic was approved by the research supervisor on 24 April 2024; and the synopsis was submitted on 23 May 2024. The data collection started from 12 August 2024 till 31 August, and the collected data was submitted on 3 September 2024. The project write-up was started in September, and the introduction, literature review, and methodology were submitted on October 1, 2024. Data analysis and result write up were submitted on 15 October 2024. Research discussion along with conclusion was submitted on October 29, 2024, and the final research project was submitted on November 9, 2024 in Soft copy and hard copy of The entire test typically takes about 15-20 minutes to complete (75-77)
the final research project was submitted on 13 November 2024.

2.6 Inclusion Criteria

1. Elderly individuals aged 65 years and older.
2. Confirmed diagnosis of cervical spondylosis (x-ray, limited ranges).
3. History of falls or assessed fall risk using standardized tools (e.g., Berg Balance Scale).
4. Able to walk independently with or without assistive devices.

2.7 Exclusion Criteria

1. Individuals with history of whiplash-associated disorder and neurological disorder.
2. Individuals with fracture, dislocation and inflammatory joint disease.
3. Individuals with history of cervical spine surgery or trauma.
4. Individuals with central nervous system impairment such as paresthesia and vestibular impairment such as vertigo, dizziness.
5. Individuals unable to comprehend and follow study instruction.
6. Individuals with chronic fatigue syndrome, fibromyalgia and diabetic neuropathy.
7. Individuals taking sedating medication.

2.8 Study Parameters

Berge balance Scale (BBS): Tool utilized to assess a patient's capacity to maintain balance safely through a set of predefined activities. It comprises 14 items, each rated on a five-point scale from 0 to 4, where 0 represents the lowest function level and 4 the highest (81). The purpose of the BBS is to objectively determine a patient's ability or inability to safely balance during a series of predetermined tasks (81, 82). BBS score of 56 suggests functional balance, 45 indicates higher risk of falling and score of 49 or less indicates risk of fall particularly who have had stroke (83). The amount of change needed to be 95% confident of a true change in the BBS score depends on the patient's initial score. Patients with higher initial

scores 45-56 require a smaller change 4 points to be confident of a true change, 5points if they score within 35–44, while those with lower initial score 25-34 require larger change 7points to be confident of a true change (83). The intra-rater relative reliability was found to be 0.98, with a 95% conference interval (CI) (81-83).

Goniometer: Goniometer is an instrument that either measures an angle or allows an object to be rotated to a precise angular position (64, 65).The goniometer demonstrates excellent validity and reliability, with intrarater ICC values ranging from 0.997 to 0.998, standard errors of the mean between 1.15 and 1.48, and smallest detectable differences from 3.19 to 4.09 (65). For interrater reliability, the ICC is 0.994, standard error of the mean is 2.11, and smallest detectable difference ranges from 5.85 to 6.95 (64).

Cervical JPE test: Cervical JPE test is a clinical tool used to evaluate cervical proprioception by assessing an individual's ability to accurately reposition their head to a target position after active neck movements without visual feedback (7).It is crucial for assessing sensorimotor control in individuals with and without neck pain, providing valuable insights into neck proprioception deficits and aiding in rehabilitation and research efforts (60). The cervical Joint Position Error (JPE) test demonstrates good to excellent reliability, with intra-rater reliability higher for the laser pointer device (ICCs = 0.682–0.774), inter-rater reliability is generally above 0.70 And had moderate to good validity (ICCs > 0.614) (60, 61).

3. Result.

2.9 Ethical Considerations

The study will ensure ethical compliance by obtaining approval from the relevant research ethics committee prior to commencing the data collection process. Additionally, informed consent will be obtained from all the participants before they are included in the study.

2.10 Data Collection Procedure

Questionnaires in hard copy was distributed to gather relevant information, and a qualified professional conduct a cervical Joint Position Error (JPE) assessments to evaluate proprioception. The responses from the questionnaires and the results of cervical JPE assessments was systematically recorded, ensuring confidentiality and adherence to ethical guidelines.

2.11 Data Analysis Procedure

We use SPSS version 21 in our study. Inferential statistics such as pre post independent sample T test will be conducted to examine the relationship between cervical proprioception and balance to mitigate falls in elderly individuals with cervical spondylosis.

Table 1: Cervical Joint Position Error Testing

Cervical Movement	JPE Degree (Error)
Flexion	4
Extension	4
Left Rotation	6
Right Rotation	>8

Interpretation:
The highest cervical joint position error (JPE) degree occurs during **right rotation** (>8 degrees), followed by **left rotation** (6 degrees). Errors during **flexion** and **extension** are comparatively lower (4 degrees each).

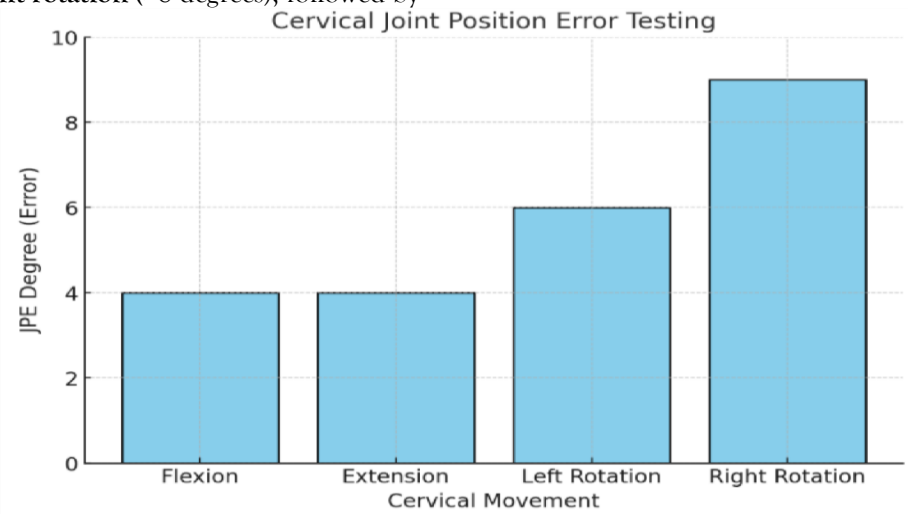
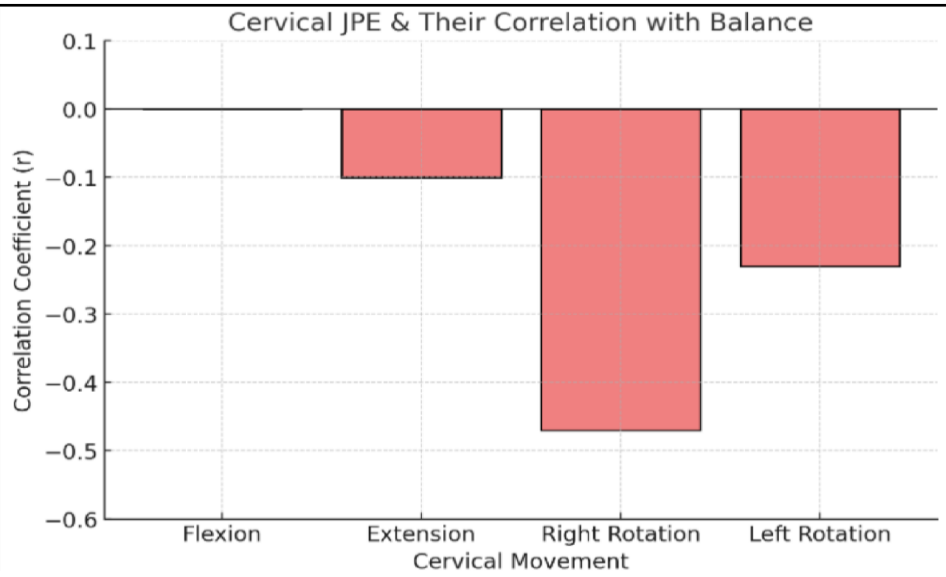


Table 2: Cervical JPE & Their Correlation with Balance

Cervical Movement	Correlation Coefficient (r)
Flexion	~0.00
Extension	~-0.10
Right Rotation	~-0.47
Left Rotation	~-0.23

Interpretation:
• Right cervical rotation shows a strong negative correlation with balance scores ($r = -0.471$, $p < 0.001$), indicating that greater error during right rotation significantly impacts balance negatively.
• Left cervical rotation has a moderate negative correlation ($r = -0.231$, $p = 0.05$), also affecting balance.
• Errors in flexion and extension have minimal or weak correlations with balance.



RESULT ANALYSIS:

Right Cervical Rotation and Balance

- A significant negative correlation ($r = -0.471$, $p < 0.001$) was observed.
- Higher joint position error (JPE) in right cervical rotation was strongly associated with poorer balance.
- Indicates that cervical proprioception during right rotation is critical for maintaining stability.

Left Cervical Rotation and Balance

- A moderate negative correlation ($r = -0.231$, $p = 0.05$) was identified.
- Errors in left cervical rotation also negatively affected balance but to a lesser extent than right rotation.
- Highlights the role of both sides of cervical rotation in balance maintenance.

Flexion and Extension Movements

- Flexion showed minimal correlation with balance ($r \sim 0.00$).
- Extension exhibited a weak negative correlation ($r \sim -0.10$).
- Proprioceptive accuracy in these movements appears less influential on balance compared to rotation.

Overall Joint Position Error (JPE)

- Right cervical rotation showed the highest JPE (>8 degrees), followed by left rotation (6 degrees).
- Errors in flexion and extension were relatively low (4 degrees each).
- Rotational movements were more error-prone and impactful on balance. **Moderate Balance Ability of Participants**
- Most participants displayed moderate balance ability despite variability in JPE across movements.
- Those with higher errors in right rotation may face an increased risk of balance impairments.

4. Discussion:

4.1 Comparison with existing Research

The current study aimed to assess cervical proprioception and balance to mitigate falls among elderly individuals. the findings of our study showed the balance scores and the ability to right rotation with a negative relationship of Pearson 0.471 significant at 0.000. These stronger correlations made the current study to imply that higher rotation ability is likely to reduce balance scores suggesting deficits in balance control. Our study aligns with previous findings that emphasize a significant relationship between proprioception deficits and increased fall risk in the elderly.

With the knowledge from previous studies, such as the one conducted by Reddy, Cervical spondylosis subjects showed statistically significant large JPEs in all the directions tested suggesting impaired cervical proprioception due to degenerative changes in cervical spine. (1)

While prior studies have identified cervical proprioception's role in balance maintenance, this study notably highlights right rotation as a strong indicator for fall susceptibility advancing the focus on specific movement pattern within cervical function. A recent study has surfaced that further supports the findings of our research that right cervical rotation plays a crucial role in maintaining cervical proprioception. (2)

The findings support existing literate that suggests tailored rehabilitation targeting proprioceptive improvements could mitigate fall risks in populations with cervical spondylosis.

4.2 Limitations

This study presents several limitations;

- As a cross-sectional design, it captures only a momentary association between cervical proprioception and balance without establishing causation.
- The sample size, while sufficient, may not represent broader populations with diverse cervical impairments.
- Additionally, the absence of longitudinal data restricts insights into changes in proprioception and balance over time, and reliance on self-reported fall histories may introduce recall bias.
- The limited duration of the study may have constrained data depth, and assessments conducted in controlled environments may not accurately reflect dynamic real-world conditions.

4.3 Strength of the Study

Conversely, the study's strengths include isolating right cervical rotation as a significant proprioceptive deficit linked to fall risk, enhancing clinical interventions.

Utilizing multiple objective measurements adds specificity to proprioceptive evaluations and identifies crucial correlations relevant to fall prevention. The robust statistical methods employed further bolster the reliability of the findings.

4.4 Weakness of the Study

The study relies on participants' memory for fall history, which can introduce recall bias. Objective tracking methods, like wearable sensors, would capture real-time data on falls and could reduce this potential bias, enhancing result reliability.

5. Conclusion

The study highlights the critical role of cervical proprioception, particularly during rotational movements, in maintaining balance. Right cervical rotation errors exhibited the strongest negative correlation with balance, suggesting that accurate joint position sense during this movement is essential for stability. Left rotation also contributed to balance but to a lesser extent. Conversely, flexion and extension movements had minimal impact on balance.

Overall, participants demonstrated moderate balance ability, but individuals with higher JPE, especially during right rotation, may face a greater risk of instability and falls. These findings emphasize the importance of targeting cervical proprioception, particularly rotational movements, in balance training and rehabilitation programs, especially for populations prone to balance deficits.

5.1 Recommendations

- Developing targeted rehabilitation programs focusing on improving cervical rotation.
- Conducting longitudinal studies to explore interactions between cervical proprioception and balance over time.
- Incorporating dynamic balance assessments that simulate real-life scenarios. Utilizing objective fall tracking methods to enhance data reliability and minimize recall bias.

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