International Journal of Science and Research (IJSR)
ISSN: 2319-7064
Impact Factor 2024: 7.101

Effect of Quadriceps Angle and BMI On Static and Dynamic Balance in Young Adults: A Correlational Study

Battala Veerendra Kumar[1], Dr. V. Srikumari[2], Dr. K. Madhavi[3]

[1]BPT Intern, SVIMS College of Physiotherapy, Tirupati, A. P., India
Email: *bathalaveerendrakumar959[at]gmail.com*

[2]Ph. D, Associate Professor, SVIMS College of Physiotherapy, Tirupati, A. P., India
Corresponding Author Email: *vadlamudi_jyo[at]yahoo.com*

[3]Ph. D, Professor, Principal. SVIMS College of Physiotherapy, Tirupati, A. P., India
Email: *konetigiri.madhavi[at]ap.gov.in*

Abstract: ***This observational, analytical study explored the correlation between Quadriceps angle (Q - angle) and Body Mass Index (BMI) on static and dynamic balance, with a focus on injury risk and performance, in young males aged 10–16 years. The study enrolled 150 participants, excluding individuals with conditions that could affect balance, such as prior lower limb injuries, obesity and vestibular disorders. Measurements of Q - angle, BMI, and balance (static and dynamic) were conducted using standardized clinical tests. Statistical analyses assessed the relationships between variables, with significance levels set at $p < 0.05$ and $p < 0.01$. The results demonstrated a weak yet statistically significant positive correlation between Q - angle and static balance ($r = 0.186$, $p = 0.022$) as well as dynamic balance ($r = 0.242$, $p = 0.003$), suggesting a marginal influence of Q - angle on balance. In contrast, BMI showed no significant correlation with static ($r = - 0.008$, $p = 0.926$) or dynamic balance ($r = 0.024$, $p = 0.768$). These findings highlight the potential use of Q - angle in balance assessments and lower extremity injury prevention strategies, while BMI appears to exert minimal influence on balance in this population. The study emphasizes the importance of biomechanical evaluations in understanding injury risk and optimizing performance.***

Keywords: Q - angle, Body Mass Index, static balance, dynamic balance, injury prevention

1. Introduction

The Quadriceps angle (Q - angle) is a critical measure in assessing lower extremity alignment, representing the direction of the quadriceps muscle vector in the frontal plane. It provides a comprehensive overview of proper anatomical alignment and knee kinematics of the lower extremity (1). The quadriceps angle, commonly referred to as the Q - angle, is a critical biomechanical parameter in the assessment of lower extremity alignment and function. The Q - angle is formed by the intersection of two lines: one drawn from the anterior superior iliac spine (ASIS) to the centre of the patella, and the other from the centre of the patella to the tibial tuberosity. This angle reflects the pull of the quadriceps muscle relative to the patella and tibia, influencing knee joint mechanics and potentially contributing to various musculoskeletal disorders (6).

The Q - angle is typically measured with the patient in a standing position to simulate weight - bearing conditions. A goniometer is commonly used for this purpose, with the axis placed over the centre of the patella and the arms aligned with the ASIS and tibial tuberosity. Normal values for the Q - angle vary but generally range from 8° to 17°. This angle is significant because it affects the tracking of the patella during knee flexion and extension. An abnormal Q - angle can alter the distribution of forces across the knee joint, potentially leading to patellofemoral pain syndrome, chondromalacia patellae, and an increased risk of anterior cruciate ligament (ACL) injuries. A higher Q - angle can result in greater lateral pull on the patella, contributing to malt racking and increased stress on the lateral patellar facet and surrounding structures (6). Horton and Hall (1989) reported that females generally have higher Q - angles than males, which may partly explain the higher incidence of patellofemoral pain and ACL injuries among female athletes. They suggested that the wider pelvis in females leads to a greater lateral pull on the patella, contributing to the increased Q - angle (5) (6).

The Q - Angle's Role in Balance and Stability are widespread. It affects knee alignment and can influence the distribution of forces across the knee joint. A higher Q - angle can lead to knee valgus, where the knees collapse inward during activities such as walking or running. This misalignment can affect the patellar tracking mechanism, potentially leading to patellofemoral pain syndrome and other knee - related issues. Research has shown that individuals with a higher Q - angle may exhibit altered gait patterns, including increased knee abduction and decreased efficiency in force transmission. These changes can affect overall balance and stability, leading to compensatory movements that increase the risk of injury. During dynamic activities, such as sports or high - impact exercises, a high Q - angle can exacerbate biomechanical stresses on the knee. This can lead to increased strain on the ligaments and surrounding tissues, potentially contributing to conditions such as anterior Body Mass Index (BMI).

BMI (Body Mass Index) is a numerical value derived from a person's weight and height. It is a screening tool used to categorize individuals into weight categories, such as underweight, normal weight, overweight, and obese, which may indicate potential health risks. BMI is classified into categories according to the World Health Organization (WHO): Underweight Less than 18.5, Normal weight 18.5 -

24.9, Overweight 25 - 29.9, Obesity (Class I) 30 - 34.9, Obesity (Class II) 35 39.9, Extreme Obesity 40 and above.

Relationship Between BMI and Balance such that it can affect an individual's postural stability and balance. In Underweight (Low BMI), Lower muscle mass and reduced bone density can compromise balance. Individuals may have poor physical strength, leading to instability. Normal BMI Ideal weight often correlates with better muscle strength and joint flexibility, promoting balance. In case of Overweight and Obesity (High BMI) Excess body weight can alter the centre of gravity, increasing the risk of falls Overweight individuals may have reduced agility and impaired coordination. Joint stress, particularly in the knees and ankles, can further disrupt balance.

The interplay between Q - angle and BMI remains understudied, particularly regarding their combined impact on static and dynamic balance. This study investigates these relationships, with potential implications for injury prevention and performance optimization in young adults.

2. Literature Survey/ Problem Definition

The need for investigating the effect of the Q - angle on static and dynamic balance in young adults is underscored by the significant role that balance plays in both everyday activities and athletic performance (4). The Q - angle, a measure of knee alignment, has been associated with various knee pathologies and injuries, particularly in active populations. For instance, a higher Q - angle can contribute to altered knee mechanics and increased risk of knee injuries such as anterior cruciate ligament
(ACL) tears and patellofemoral pain syndrome, conditions prevalent among young athletes (Huston & Greenfield, 2021). While much research has focused on the relationship between the Q - angle and injury risk, less attention has been given to how it specifically affects static and dynamic balance (4) (15). Given that balance is crucial for maintaining stability during both stationary postures and dynamic movements, understanding how variations in the Q - angle influence these aspects could provide valuable insights for injury prevention and performance enhancement. This is particularly relevant for young adults, who are frequently engaged in high - impact activities and sports, where balance deficits can significantly impact performance and increase the likelihood of injury (8).

Furthermore, addressing this research gap could lead to more effective clinical interventions and preventive strategies tailored to individuals with abnormal Q - angles. By elucidating the relationship between the Q - angle and balance, clinicians and sports professionals can develop targeted assessment and training programs aimed at improving balance and reducing injury risk. This includes integrating Q - angle assessments into routine evaluations and implementing specific exercises or orthotic devices designed to correct alignment and enhance stability (Smith et al., 2023) (5). Ultimately, understanding the Q - angle's effect on balance can contribute to better management of knee health, optimized athletic performance, and enhanced overall functional stability in young adults (12). This study aims to address this gap by examining the relationship between Q - angle and balance measures, which can help predict and prevent potential musculoskeletal injuries in the future.

Objectives of the study:

- To determine the correlation between Q - angle and static balance in young adults.
- To assess the relationship between Q - angle and dynamic balance in young adults.
- To evaluate the potential of Q - angle as a diagnostic tool for predicting lower extremity injuries.

3. Methodology

The study was an observational analytical investigation that included 150 young healthy male individuals aged 10 - 16, selected through convenience sampling based on specific inclusion and exclusion criteria. The inclusion criteria were male participants aged 10 - 16, corresponding to students in classes 4 - 10, with a normative BMI for their age. The exclusion criteria included any previous lower limb injuries, musculoskeletal surgeries (such as those involving the spine, hip, knee, ankle, and foot), obesity with a BMI exceeding 1.2, patellar bursitis, chondromalacia, osteoarthritis of the knee or hip, achilles tendinitis, and vestibular or visual impairments like nystagmus and vertigo.

The procedure involved testing the participants' dominant leg, determined by a ball - kicking test. All tests were performed barefoot, with participants closely supervised to ensure safety. The tests were halted at any sign of safety concerns, such as tachycardia or increased blood pressure.

Tests:
Q angle was measured in standing (as shown in Fig.1) Three landmarks were identified: anterior superior iliac spine (ASIS), centre of the patella and tibial tuberosity. For marking patellar midpoint, the borders of patella were palpated and outline was drawn. The point joining the maximum vertical and transverse diameters of patella was marked as the midpoint of patella. The point of maximum prominence at the anterior upper end of tibia was noted as the tibial tuberosity. The fulcrum of the goniometer was placed on the centre of the patella; the moving arm was directed to the ASIS and the stationary arm to the tibial tuberosity. The angle created by the intersection of these 2 lines is the Q angle.

Figure 1: Markings on the knee joint for measuring Q Angle

The Stork Balance Test (as shown in Fig.2) assessed participants' ability to maintain balance on one leg, which is essential for evaluating overall balance and postural stability. Participants removed their shoes, placed their hands on their hips, and positioned the non - supporting foot against the inside knee of the supporting leg. After a minute of practice, they raised the heel to stand on the ball of the supporting foot. The stopwatch started as the heel lifted from the floor and stopped if the participant moved hands off the hips, the supporting foot swiveled or moved, the non - supporting foot lost contact with the knee, or the heel touched the floor. The best time of three attempts was recorded, with scores ranging from poor (less than 10 seconds) to excellent (over 50 seconds).

Figure 2: Stork Test

Figure 3 - Functional Reach Test

In the Functional Reach Test, participants stood next to a wall without touching it, with a measuring tape fixed at shoulder height. They extended their arm forward at a 90 - degree angle from the body, marking the initial position of the fingertips. They then reached forward as far as possible without stepping or losing balance, and the final position of the fingertips was recorded. The difference between the initial and final fingertip positions was measured to represent the "functional reach." This test is used to assess stability and the risk of falls, particularly in older adults and those with neurological conditions, with normal values varying by age and sex; young adults typically reach 14 - 16 inches (35 - 40 cm), while older adults may reach 10 - 12 inches (25 - 30 cm).

Figure 3: Functional Reach Test

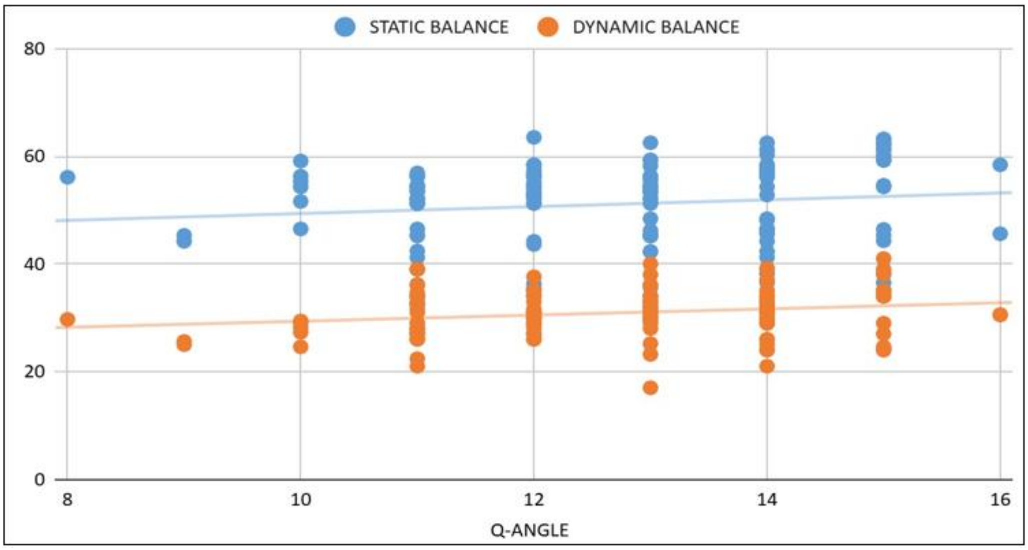
4. Results

Table 1: Descriptive Statistics

	Mean	Std. Deviation
BMI	20.71	2.92
Q - angle	12.69	1.554
Static Balance	50.9	7.633
Dynamic Balance	30.903	4.2557

Table 2: Nonparametric Correlations between Q angle and Static Balance and Dynamic Balance

	Variables	Correlation Coefficient	Significance (p - value)	Interpretation
Q Angle	Static Balance	0.186	0.022	Weak positive correlation, significant
	Dynamic Balance	0.242	0.003	Weak positive correlation, significant

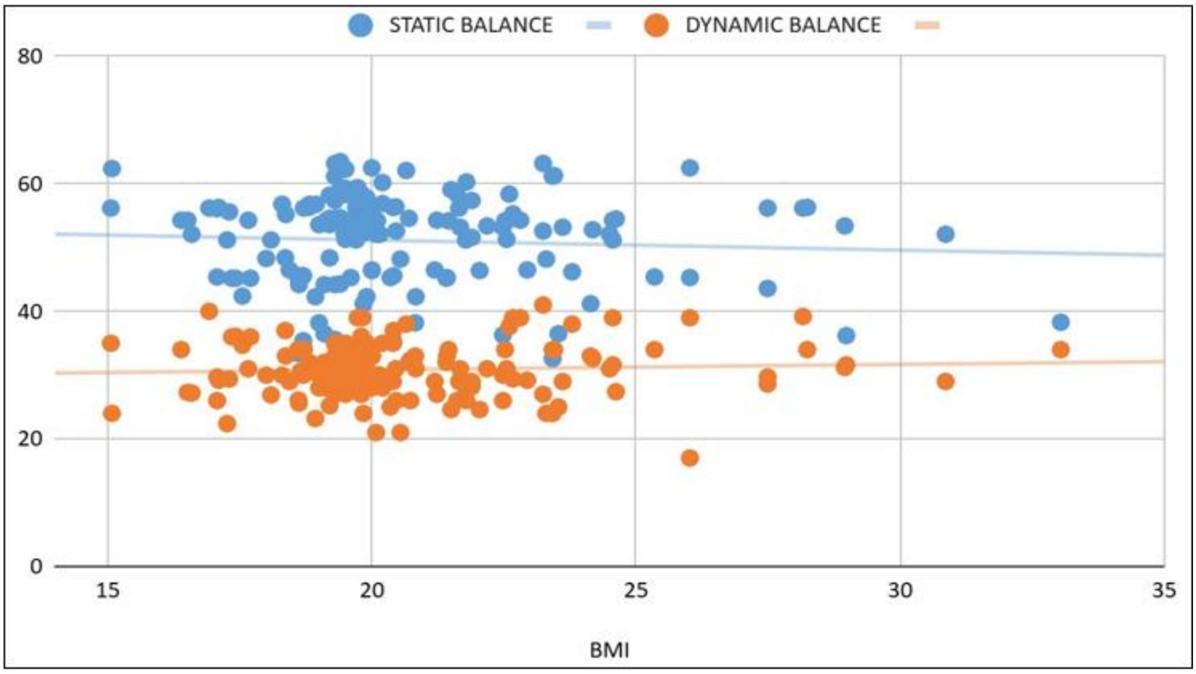


Graph 1: Scatter plot graphical representation depicting the relation between Q angle and Static and Dynamic Balance

As shown in Table 2 and Graph 1, there is a weak positive correlation between the Q - Angle and static balance, with a correlation coefficient of 0.186, which is statistically significant at the 0.05 level (p = 0.022). This suggests that as the Q - Angle increases, static balance may slightly improve. There is a weak positive correlation between the Q - Angle and dynamic balance, with a correlation coefficient of 0.242, which is statistically significant at the 0.01 level (p = 0.003). This indicates that as the Q - Angle increases, dynamic balance may also slightly improve.

Table 3: Nonparametric Correlations between BMI and Static Balance and Dynamic Balance

	Variables	Correlation Coefficient	Significance (p - value)	Interpretation
BMI	Static Balance	-0.008	0.926	Very weak negative correlation, not significant
	Dynamic Balance	0.024	0.768	Very weak positive correlation, not significant



Graph 2: Scatter plot graphical representation depicting the relation between Q angle and Static and Dynamic Balance

As shown in Table 3 and Graph 2, there is a very weak and non - significant negative correlation between BMI and static balance, with a correlation coefficient of - 0.008 (p = 0.926). This suggests that BMI has no meaningful relationship with static balance. There is a very weak and non - significant positive correlation between BMI and dynamic balance, with a correlation coefficient of 0.024 (p = 0.768). This indicates that BMI has no meaningful relationship with dynamic balance.

5. Discussion

The study revealed a weak negative correlation between Q - angle, BMI, and static and dynamic balance among participants. It indicated that an increase in either Q - angle or BMI correlates with a slight decline in balance performance. Despite identifying these correlations, the strength of the associations was minimal, suggesting that neither Q - angle nor BMI significantly influences balance on their own.

The Q - angle, an anatomical measurement reflecting the alignment of the femur and tibia, is integral to the biomechanics of the lower limb. The study's findings suggest that a larger Q - angle could subtly impair balance by destabilizing the knee joint and altering the distribution of load across the lower limb. This effect is more pronounced during dynamic activities that require rapid adjustments in posture and limb coordination. However, the variability among individuals and the weak overall correlation indicate that compensatory factors such as muscle strength in the quadriceps and hamstrings, proprioception, and neuromuscular control might mitigate the adverse effects of a larger Q - angle on balance.

Similarly, BMI, which indicates body mass relative to height, was found to have a marginal impact on balance. This relationship suggests that while increased BMI could theoretically challenge balance by shifting the center of mass upward and complicating postural control, the actual effect is relatively insignificant. This might be due to less demand on dynamic control mechanisms during static balance tasks, while during dynamic balance activities, the additional inertia requiring balance control is more noticeable. Nevertheless, individuals with higher BMI may compensate through improved proprioception, strategic postural adjustments, or increased muscle strength, contributing to the weak correlation observed.

The study emphasizes the multifactorial nature of balance, highlighting that Q - angle and BMI are among several factors that contribute to balance but are not dominant on their own. Effective balance control involves complex interactions between neuromuscular coordination, muscle strength, and sensory inputs such as vision and proprioception. These elements, along with external factors like footwear, surface stability, fatigue, and psychological aspects like confidence, play significant roles in determining balance performance, often overshadowing the anatomical and body composition measures.

In clinical and practical contexts, understanding the limited impact of Q - angle and BMI on balance can guide more effective strategies for injury prevention, particularly in athletic and active populations. While higher Q - angles or BMI may indicate a slight increase in the risk of balance - related injuries, such as ankle sprains or falls, it is crucial to focus on enhancing overall neuromuscular control and strengthening the lower limbs. In rehabilitation settings, patients with altered Q - angles or high BMI would benefit from targeted exercises focusing on core stability, proprioception, and strengthening of the lower limbs to counteract balance impairments. Similarly, training and conditioning programs that emphasize dynamic stability through exercises like single - leg squats, dynamic balance drills, and agility training can effectively improve balance capabilities across varied BMI and Q - angle ranges.

This comprehensive understanding of the factors influencing balance is vital for developing targeted interventions that enhance balance and reduce the risk of injuries, providing a holistic approach to managing the biomechanical challenges posed by variations in body composition and structural alignment.

6. Conclusion

The study highlights a weak negative correlation between Q - angle, BMI, and static and dynamic balance, suggesting that these factors have a minor, albeit measurable, influence. Balance is a multifactorial phenomenon, and greater emphasis should be placed on improving neuromuscular control and strength rather than focusing solely on anatomical or compositional measures. These findings underscore the importance of holistic approaches to balance training and injury prevention strategies.

7. Limitations and Future Scope

7.1 Study Limitations

The weak correlation identified in the study between Q - angle, BMI, and balance performance may also be influenced by methodological or sample - specific factors. The study's sample size and demographic characteristics could be contributing to these results; a limited or homogenous population might reduce variability in Q - angle, BMI, and balance performance. Expanding the sample size and including a more diverse range of participants, such as different ages, activity levels, and genders, could potentially yield more robust findings. Additionally, the measurement techniques employed, such as the use of manual goniometers for Q - angle and simple calculations for BMI, might introduce variability or fail to accurately capture other relevant body composition elements like fat distribution or muscle mass, which could influence balance. Moreover, the study did not control for other confounding variables that can affect balance, such as lower limb strength, joint proprioception, and external conditions like the testing environment and footwear. These uncontrolled factors could dilute the observed correlations and impact the study's conclusions.

7.2 Recommendations for Future Research

Future studies should consider including additional variables such as muscle strength, joint range of motion, proprioception, and psychological factors like fear of falling to further explore their impact on balance. Longitudinal studies that track changes in balance over time with variations in Q - angle and BMI, such as during weight loss or postural correction programs, could also provide more detailed insights into the dynamics of these relationships. Moreover, the adoption of advanced measurement tools like 3D motion analysis systems, force plates, or dual - energy X - ray absorptiometry (DXA) would enhance the precision and reliability of data concerning balance, Q - angle, and body composition. These enhancements could lead to a better understanding of the complex interactions affecting balance and provide a more comprehensive evaluation of the factors involved.

References

[1] Pollock AS, Durward BR, Rowe PJ, Paul JP. What is balance? Clin Rehabil.2000 Aug; 14 (4): 402 - 6.
[2] Panta K, Arulsingh W, Raj JO, Sinha M, Rahman M. A study to associate the Flamingo Test and the Stork Test in measuring static balance on healthy adults. Foot Ankle Online J.2015; 8 (3): 1 - 4.
[3] Alexander KM, Kinney LaPier TL. Differences in static balance and weight distribution between normal subjects and subjects with chronic unilateral low back pain. J Orthop Sports Phys Ther.1998 Dec; 28 (6): 378 - 83.
[4] Russell AK, Zerr MC, Rinehart TG, Norris BM, Perkuhn NK. The relationship between lower extremity musculature strength, Q - angle, and single - leg balance.2014.
[5] Kuo AD, Zajac FE. A biomechanical analysis of muscle strength as a limiting factor in standing posture. J Biomech.
[6] 1993 Jan 1; 26: 137 - 50.
[7] Hungerford DS, Barry M. Biomechanics of the patellofemoral joint. Clin Orthop Relat Res.1979 Oct; 1 (144): 9 - 15.
[8] Hinman RS, May RL, Crossley KM. Is there an alternative to the full - leg radiograph for determining knee joint alignment in osteoarthritis? Arthritis Rheum.2006 Apr 15; 55 (2): 306 - 13.
[9] Parkkari J, Kannus P, Natri A, Lapinleimu I, Palvanen M, Heiskanen M, Vuori I, Järvinen M. Active living and injury risk. Int J Sports Med.2004 Apr; 25 (3): 209 - 16.
[10] Woodland LH, Francis RS. Parameters and comparisons of the quadriceps angle of college - aged men and women in the supine and standing positions. Am J Sports Med.1992 Mar; 20 (2): 208 - 11.
[11] Shaffer SW, Teyhen DS, Lorenson CL, Warren RL, Koreerat CM, Straseske CA, Childs JD. Y - balance test: a reliability study involving multiple raters. Mil Med.2013 Nov 1; 178 (11): 1264 - 70.

[12] Weiss L, DeForest B, Hammond K, Schilling B, Ferreira L. Reliability of goniometry - based Q - angle. PM R.2013 Sep 1; 5 (9): 763 - 8.
[13] Mizuno Y, Kumagai M, Mattessich SM, Elias JJ, Ramrattan N, Cosgarea AJ, Chao EY. Q - angle influences tibiofemoral and patellofemoral kinematics. J Orthop Res.2001 Sep; 19 (5): 834 - 40.
[14] Tsakoniti AE, Stoupis CA, Athanasopoulos SI. Quadriceps cross - sectional area changes in young healthy men with different magnitudes of Q - angle. J Appl Physiol.2008 Sep; 105 (3): 800 - 4.
[15] Daneshmandi H, Saki F, Shahheidari S, Khoori A. Lower extremity malalignment and its linear relation with Q - angle in female athletes. Procedia Soc Behav Sci.2011 Jan 1; 15: 3349 - 54.
[16] Denizoglu Kulli H, Yeldan I, Yildirim NU. Influence of quadriceps angle on static and dynamic balance in young adults. J Back Musculoskelet Rehabil.2019 Jan 1; 32 (6): 857 - 62.
[17] Earl JE, Hertel J. Lower - extremity muscle activation during the Star Excursion Balance Tests. J Sport Rehabil.2001 May 1; 10 (2): 93 - 104.

Author Profile

Dr. Konetigari Madhavi currently holds the designation of Principal and Professor at the College of Physiotherapy, Sri Venkateswara Institute of Medical Sciences. She holds a Ph. D in Cardio - Respiratory Sciences. Her current research interests span areas in Health Psychology, Educational Psychology and Psychoanalysis. She received various accolades and recognitions during her tenure.

Dr. V. Srikumari currently holds the designation of Associate Professor at the College of Physiotherapy, Sri Venkateswara Institute of Medical Sciences. She holds a Ph. D in Neurological sciences and her professional skills encompass Neurological Rehabilitation, Paediatric Rehabilitation, Pain management, Community based rehabilitation, Geriatric Rehabilitation, and Institutional Based Rehabilitation. She has authored many publications along with her students and holds keen interest in workshops and CME's to further her physiotherapy teaching and practice.

B. Veerendra Kumar is a student, pursuing his Bachelor of Physiotherapy (B. P. T) from College of Physiotherapy, Sri Venkateswara Institute of Medical Sciences. He is currently undergoing a 6 month internship, where he receives extensive exposure to various kinds of patients. As part of his internship, he took up the research question explored in this study.