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Association of lower limb somatosensory impairments with walking, balance and falls in chronic stroke survivors: A cross-sectional study

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We the undersigned certify that we have carefully read and recommended to the Faculty of Medicine, University of Dhaka, for acceptance of this thesis entitled, **"Association of lower limb somatosensory impairments with walking, balance and falls in chronic stroke survivors: a cross-sectional study"**. Submitted by **Shanjida Hossain Sayema**, for the partial fulfillment of the requirements for the degree of Bachelor of Science in Physiotherapy (BSc. PT).

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Declaration

I declare that the work presented here is my own. All sources used have been cited appropriately. Any mistakes or inaccuracies are my own. I also declare that for any publication, presentation or dissemination of information of the study, I would be bound to take written consent from the Supervisor & Department of Physiotherapy of Bangladesh Health Professions Institute (BHPI).

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Contents

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Acronyms

ADLs	Activity of Daily Livings
BBS	Berg Balance Scale
BHPI	Bangladesh Health Professions Institute
CVA	Cerebrovascular Accident
EmNSA	Erasmus MC modifications to the Nottingham Sensory Assessment
FES-I	Fall Efficacy Scale-International
IRB	Institutional Review Board
10MWT	10 Meter Walk Test
SPSS	Statistical Package for the Social Sciences
WHO	World Health Organization

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Abstract

Background: Stroke is a major cause of disability worldwide, affecting physical, emotional and social aspects of life. Lower limb somatosensory impairments are common among chronic stroke survivors and are often linked to difficulties in walking, maintaining balance and preventing falls. Despite their clinical importance, sensory deficits remain under-addressed in stroke rehabilitation. Understanding the relationship between these sensory deficits and functional outcomes is essential for planning effective rehabilitation strategies. **Objectives:** To examine the association of lower limb somatosensory impairments with walking speed, balance and fall concern in individuals with chronic stroke. **Methodology:** A cross-sectional study was conducted among 123 chronic stroke survivors at the Centre for the Rehabilitation of the Paralyzed (CRP), Savar. Participants were divided into two groups based on presence or absence of somatosensory impairments. Among them 27 patients had sensory impairment with motor dysfunction. Participants were assessed using the Erasmus MC-modified Nottingham Sensory Assessment (EmNSA), 10-Meter Walk Test (10MWT), Berg Balance Scale (BBS) and Falls Efficacy Scale-International (FES-I). Statistical tests included, independent t-test, Mann–Whitney U test and Spearman's correlation. **Results:** Somatosensory impairments were found in 22% of participants, predominantly in the toes and foot. Those with sensory impairments had significantly slower walking speed, poorer balance and higher fall concern ($p < 0.05$) than participants without sensory impairments and a significant positive correlation was found between light touch impairment and balance ($r = 0.452$, $p = 0.018$). **Discussion:** The study highlights that lower limb somatosensory deficits, particularly in light touch, are associated with impaired functional performance in walking, balance and increased fear of falling. These findings suggest a need for integrating sensory assessments and sensory-specific rehabilitation strategies in stroke care. Future rehabilitation programs should focus on sensory retraining alongside motor recovery to reduce fall risk and improve mobility in stroke survivors.

Key words: *Chronic stroke, Somatosensory impairment, Walking speed, Balance, Fall, EmNSA*

Chapter-i	**Introduction**

1.1 Background

According to the World Health Organization (WHO), CVA or cerebrovascular accident is a term which is synonymous with 'stroke' and it is defined as rapidly developed clinical signs of focal (or global) disturbance of cerebral function, lasting more than 24 hours or leading to death with no other particular reason than vascular origin (Coupland AP et al., 2017). Stroke is the second leading cause of long-term disability worldwide, which significantly impacts individuals physically, emotionally and socially, often resulting in decreased mobility and daily functioning, also their quality of life (Feigin VL et al., 2022). Almost (85%) strokes are ischemic stroke, which is the most common type of stroke, primarily occurring from small blood vessel arteriosclerosis, cardiac embolism and large artery atherothrombosis & thromboembolism. Internationally around 15% of strokes occur as a result of intracerebral hemorrhage. Among two of them ischemic stroke is the most recurrent cause of disability and death globally (Tuo, Zhang and Lei, 2022). The Global Burden of Disease Study mentioned that approximately 80 million people have experienced stroke which is a life-threatening condition and nearly 13.7 million new cases of stroke occur each year. The burden of stroke is usually high in low to middle income countries, which account for nearly 70% of stroke cases and over 80% of stroke-related deaths globally (Feigin, Norrving & Mensah 2017). In the United States, the prevalence of stroke is about 3% in adults who are 20 years old or older, which is approximately 7 million strokes in the population (Saini, Guada and Yavagal, 2021). As stated by Murphy and Werring, (2020) hypertension is the most prevalent controllable risk factor for stroke, despite the fact that its contribution varies for several subtypes. According to Mondal et al. (2022), hypertension, dyslipidemia, tobacco use, diabetes and ischemic heart disease are the most common risk factors observed among stroke patients.

The impairments associated with stroke manifest a comprehensive diversity of clinical signs & symptoms including motor, cognitive and sensory deficits (Teasell & Hussein, 2016). Worldwide about 25% to 74% of 50 million stroke survivors are dependent on others for their activities of daily living (Veerbeek J et al., 2011). After stroke people experience various difficulties in their gait pattern, balance & co-ordination which are very essential to perform daily activities within the WHO's International Classification of Functioning, Disability and Health (ICF) activity and participation domains (Rooij et al., 2019).

Stroke population is often affected by somatosensory impairments which decrease the level of activity by restricting their participation and increase the rehabilitation period after initial recovery phase. According to health care professionals, by performing somatosensory assessment one can get useful prognostic information about functional outcome and recovery of stroke patients (Connell, Lincoln and Radford, 2008). Sensory impairments after stroke are very often reported (between 11% to 60%) and are nearly connected to recovery of function as per known that intact sensation is required to facilitate effective movement and functional outcome. Stroke survivors who have impaired sensation along with motor impairments tend to make less recovery (Tyson et al., 2013). Stroke survivors experience somatosensory impairment particularly tactile and proprioceptive discriminations, typically having difficulty in touch sensation, pressure, temperature, sense of limb position, textured surface discrimination and object recognition through the sense of touch, which are crucial for balance and gait (Carey, 1995). The characteristics and intensity of somatosensory impairment differs mainly based on the site and extent of the lesion, which can be cortical, subcortical (including thalamus and brainstem) or due to associated origin. In addition, most of the ruptured major cerebral arteries also may result in somatosensory impairment (Carey, 2017).

According to the study of Gorst et al. (2019) somatosensory impairments of lower limb are very common & present in more than half of the chronic stroke patients, reported that about 56% of the study sample had somatosensory deficits in the lower limbs, mostly tactile discrimination is impaired. Somatosensory impairments of the leg adversely influence gait and balance as sensory input from the lower limbs contributes to gait pattern and walking ability, allowing individuals to adjust their movements depending on ground condition, position of the body and also other environmental factors. Post-stroke planter tactile sensation deficits are related to balance impairment and instability during standing or moving (Parsons et al, 2016). Consequently, tactile and proprioceptive impairments can hamper paretic limb load perception, leading to difficulty in weight bearing leg and resulting impaired balance and risk of falls after stroke as the body relies on proprioceptive and tactile feedback to make postural adjustments and preventing falls (Duysens and Massaad, 2015). In the Tyson et al. (2013) study, stroke survivors with somatosensory impairments have greater falling tendencies than those without somatosensory impairments, leading to recurrent falls which can result in various injuries, fear of falling and also decreased quality of life. Thorough clinical examination of the type and characteristics of somatosensory impairment is required to ascertain appropriate assessment and retraining of somatosensory functions post-stroke (Carey, 2017). Therefore, this study aims to identify the association of lower limb somatosensory impairments with walking, balance and falls in chronic stroke survivors.

1.2 Justification

Among stroke survivors, a significant proportion experience long- term impairments, including motor, sensory and cognitive deficits. Chronic stroke survivors, in particular, often suffer from persistent issues that can severely impact their quality of life. Somatosensory impairments, particularly in the lower limbs, can significantly impact on key functional outcomes like walking ability, balance and the risk of falls in chronic stroke survivors. Sensory input is essential for adapting gait mechanics, maintaining postural stability and reducing falls. These functional outcomes are critical for the independence and quality of life of stroke survivors. The study's focus on the association between sensory impairments and these outcomes helps to clarify how sensory deficits contribute to difficulties in walking and balance and the increased risk of falls. While there is extensive research on motor impairments post-stroke, there is comparatively less research focusing on the somatosensory aspects and their direct association with functional outcomes such as walking, balance and fall incidence. Identifying the extent and impact of these deficits is critical for improving long term recovery. There is still limited understanding of how specific sensory deficits, such as impaired proprioception or loss of tactile sensation contribute to walking difficulties, postural instability and fall risk. Addressing this gap can provide a more comprehensive understanding of the multifaceted impacts of stroke on the neuromuscular system. It can guide clinicians in assessing sensory deficits more comprehensively and integrating sensory rehabilitation techniques into therapy such as sensory re-education, tactile stimulation and proprioceptive training could be incorporated along with traditional motor focused therapies. Moreover, understanding the link between sensory impairments and falls can lead to the development of more effective fall prevention programs. There is no evidence of this type of research in our country so far. Therefore, this study is justified by its potential to fill critical gaps in our understanding of somatosensory impairments in chronic stroke survivors and their effects on walking, balance and falls. Findings from this study could significantly enhance the understanding of stroke rehabilitation and lead to more effective and comprehensive treatment strategies, improving patient independence, reducing fall risk and ultimately enhancing the quality of life for chronic stroke survivors. The outcome of this study could provide a more comprehensive approach to post-stroke care, addressing both motor and sensory recovery in a balanced and effective manner.

1.3 Research question

What is the association of lower limb somatosensory impairments with walking, balance and falls in chronic stroke survivors?

1.4 Study objectives

1.4.1 General objective

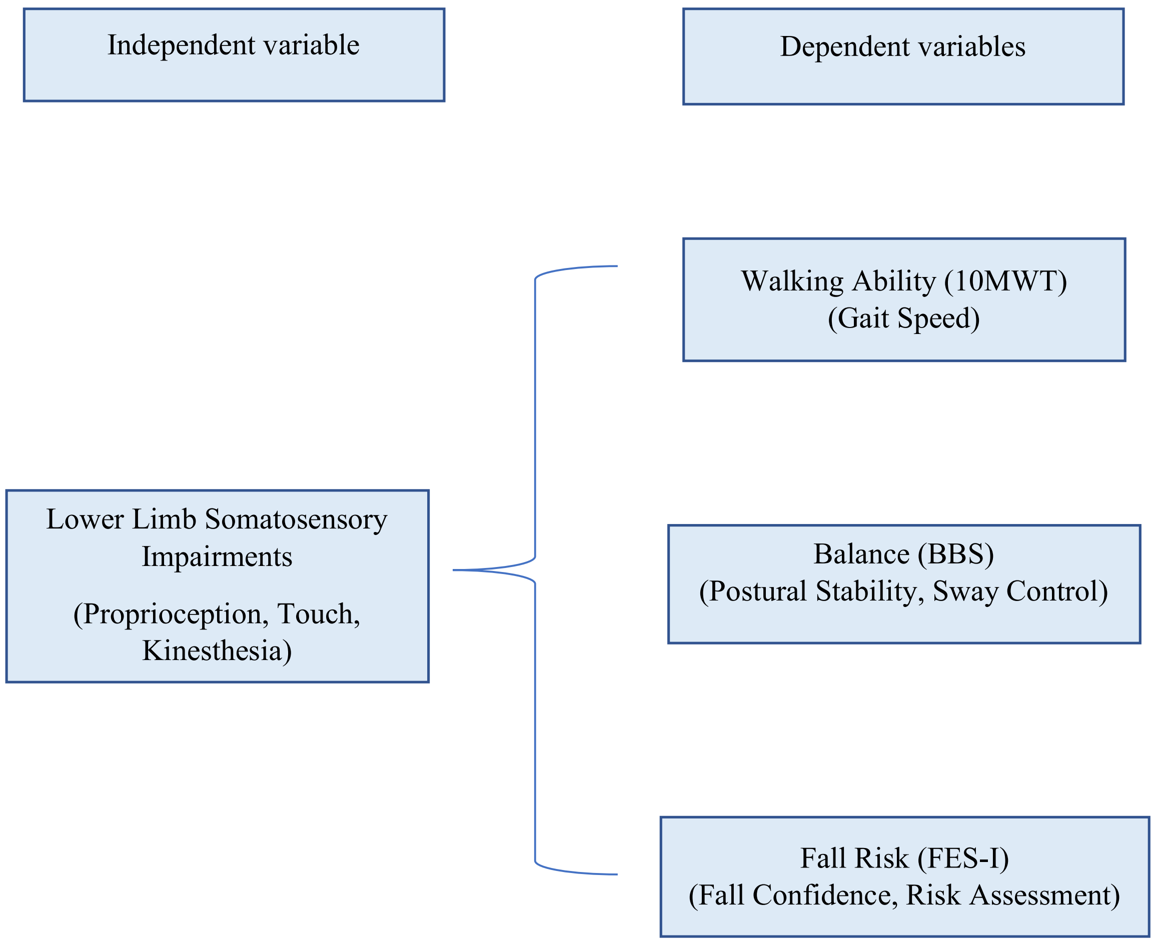
To identify the association of lower limb somatosensory impairments with functional outcomes such as walking speed, balance and the risk of falling among chronic stroke patients.

1.4.2 Specific objectives

To-

- Describe the socio-demographic characteristics of the patients with chronic stroke.
- Determine the prevalence of lower limb somatosensory impairments in chronic stroke survivors.
- Compare walking speed, balance and fall concern between chronic stroke survivors with and without lower limb somatosensory impairments.
- Identify the association between lower limb somatosensory impairments and walking speed, balance & fall concern.

1.5 Conceptual framework



1.6 Operational definition

1.6.1 Stroke

Stroke is a neurological dysfunction of cerebrovascular cause leading to disruption of blood flow to the brain, resulting in motor, sensory or cognitive impairments that persists longer than 24 hours.

1.6.2 Chronic stroke survivors

Chronic stroke survivors include individuals who have experienced stroke greater than 3 months, ensuring that they are beyond the acute phase of recovery.

1.6.3 Lower limb somatosensory impairments

Lower limb somatosensory impairments are defined as deficits of sensory inputs in the lower extremities, including tactile sensation, proprioception and kinesthesia.

1.6.4 Walking

Walking refers to the functional capability to ambulate effectively over a specified distance, evaluated using 10-Meter Walk Test (10MWT), which measures walking speed in meters per second (m/s).

1.6.5 Balance

Balance refers to the ability to maintain postural stability during both static and dynamic activities, assessed using the Berg Balance Scale (BBS).

1.6.6 Falls

Unintentional events where chronic stroke survivors lose balance and come to rest on the ground or a lower surface during daily activities, often influenced by impairments in lower limb somatosensory functions, balance or walking ability.

Chapter-ii Literature review

Stroke is a clinically defined syndrome of acute, focal neurological deficit attributed to vascular injury (infarction, hemorrhage) of the central nervous system (Murphy & Werring., 2020). Kuriakose & Xiao, (2020) stated that Clots form in the brain and interrupt blood flow, clogging arteries and causing blood vessels to break, leading to bleeding. Rupture of the arteries leading to the brain during stroke results in the sudden death of brain cells owing to a lack of oxygen. They also mentioned that the incidence of stroke increases with age, doubling after the age of 55 years. However, in an alarming trend, strokes in people aged 20-54 years increased from 12.9% to 18.6% of all cases globally between 1990 and 2016. Nevertheless, age-standardized attributable death rates decreased by 36.2% over the same period. The highest reported stroke incidence is in China, where it affects an estimated 331-378 individuals per 100,000 life years. The second-highest rate is in eastern Europe (181-218 per 100,000 life years) and the lowest in Latin America (85-100 per 100,000 life years). According to Rexrode et al. (2022) women have a higher prevalence and incidence of intracranial aneurysms and substantially higher incidence of subarachnoid hemorrhage compared with men, whereas men have higher rates of hemorrhagic stroke. Across the life span, recent data from Canada show that the risk of ischemic stroke and transient ischemic attack (TIA) is higher for women than men <30 years of age, higher in men for midlife and then equal above 80 years of age. In the oldest category (>85 years), there is some suggestion that women have higher incidence of stroke than men. Stroke remains the second leading cause of long-term disability worldwide, with over 50% of survivors experiencing persistent sensory and motor impairments. These impairments disrupt the integration of sensory feedback essential for walking, balance and postural control, leading to increased fall risk and reduced functional independence (Serrada et al., 2019).

Somatosensory impairments of the lower limbs are common features among survivors of chronic stroke. Following a stroke, damage to the brain disrupts the neural pathways that process and integrate sensory information, leading to a diminished ability to perceive and respond to environmental and internal cues (Connell et al., 2008). The consequences of such impairments are devastating in terms of mobility and balance, increasing the risk of falls. Lower limb somatosensory impairment impairs accurate perception of touch, pressure, vibration and proprioception. These sensory deficits disrupt functional abilities such as maintaining balance, effective walking and recovery from minor postural deviations. Also, these impairments disrupt sensorimotor integration and lead to mobility challenges that are often overlooked in stroke rehabilitation practices. The implications for quality of life and autonomy are significant, as falls often lead to additional injuries, fear of falling and social isolation (Gorst et al., 2018).

Kessner, Bingel & Thomalla, (2016) mentioned that somatosensory impairments are present approximately 50-80% of stroke survivors. (Tyson and Hanley, 2015) explained that such impairments tend to present in two types namely exteroceptive deficits including a reduction in sensitivity to touch, pressure and temperature and proprioceptive deficits, interfering with awareness of the position and movement of the limbs. Exteroceptive impairments predominantly affect the ability to detect any changes in lower limb contact and pressure, thereby influencing postural adjustments and the initiation of gait. The loss of proprioceptive input from the lower limbs is particularly debilitating, as it impairs the body's ability to accurately gauge limb position during static and dynamic tasks. Sidarta et al. (2022) further reveals that proprioception deficits, particularly in the distal regions of the limb (toes and ankles), are more frequent and have more significant implications than proximal impairments (hip and knee). Somatosensory impairments are often overlooked despite their critical role in recovery, necessitating a deeper exploration of their impact on functional outcomes (Serrada et al., 2019).

Proprioception is essential for adjusting muscle activity in response to changes in body position, and its absence leads to uncoordinated movements, instability, and increased reliance on visual feedback for balance control (Chia et al., 2019). This reliance on vision can create difficulties, especially in low-visibility conditions or when rapid adjustments are required during walking, further exacerbating the risk of falls in chronic stroke survivors (Arif et al., 2022). Impairments of proprioception further contribute to disturbances in joint position sense and movement detection abilities that are fundamental to the coordination of leg movements during locomotion. Lower limb somatosensory impairments, especially deficits in proprioception and tactile sensation, have been consistently linked to compromised walking performance in stroke survivors. According to Gorst et al. (2019), such impairments are prevalent in chronic stroke survivors and contribute significantly to functional limitations in walking ability. Gorst's 2017 doctoral dissertation further emphasizes that the foot, ankle and overall lower limb somatosensory dysfunctions play a crucial role in the reduced ability to walk, owing to the essential contribution of sensory feedback in coordinating movement and maintaining postural stability. The loss of proprioceptive input from the lower limbs impairs a survivor's capacity to make appropriate adjustments during gait, leading to decreased walking speed, increased asymmetry and reduced endurance (Arif et al., 2022). An example of this can be found from a cross-sectional study conducted by Gorst et al. (2019), which investigated proprioception and touch sensitivity associated with the lower limbs of chronic stroke survivors. The study identified deficits in these modalities, especially at the foot and ankle level were associated with increased postural sway and a higher incidence of falls. These findings determined that sensory deficits are the root of understanding post-stroke complications that affect gait and stability.

Walking requires complex sensory and motor integration, relying heavily on proprioceptive feedback to adjust gait patterns and maintain balance. Proprioceptive impairments hinder the ability of chronic stroke survivors to sense joint position and movement, resulting in reduced walking speed and gait asymmetry. A study by Gorst et al. (2019) found that proprioceptive deficits were significantly correlated with slower walking speeds and an increased risk of stumbles during gait. Carey and Matyas. (2013) provided that proprioceptive deficit primarily affects gait symmetry, developing asymmetrical walking tendencies. While doing so, it not only reduces the efficiency of their gait but also enhances the chances of falling. Gait pattern of stroke survivors with somatosensory impairments usually presents modified step length, stride width and gait velocity. Zeilig et al. (2012) studied that contribution of proprioceptive impairments to these gait deviations lead to a slower and more cautious pattern of walking.

Stroke survivors with proprioceptive impairments exhibit slower walking speeds than those with intact sensory function. Additionally, proprioceptive impairments contribute to increased variability in step length and increased reliance on compensatory strategies, such as visual feedback, which can lead to fatigue and a greater risk of falls. Sensory integration during walking also becomes compromised, making it difficult for survivors to adapt to changing terrain, inclines, or obstacles (Sidarta et al., 2022). This cautious gait is a compensatory strategy that occurs because of the reduced capability of properly detecting ground contact and joint position. In many cases, this is not sufficient to prevent falls when the individual is exposed to uneven surfaces or sudden perturbations in the environment. Goble et al. (2010) studied the function of proprioception on gait mechanics in stroke survivors. They administered a series of sensory examinations to test the effect of proprioceptive impairments would have on step-to-step variability and coordination. The results of the study indicated that the participants with greater degrees of proprioceptive deficits had increased step variability, resulting in more missteps, which are two underlying factors leading to falls in an individual. The study therefore underlines the role of sensory rehabilitation as a means to regain more constant stable gait patterns. In addition to proprioception, tactile sensation plays a key role in the ability to detect surface changes and maintain stability during walking. Tactile receptors in the skin provide information about ground surface characteristics, which is vital for adjusting gait patterns and distributing weight appropriately (Wutzke et al., 2013). When tactile sensation is compromised, as is often the case in stroke survivors, individuals are less able to detect and respond to uneven surfaces, increasing the likelihood of tripping or slipping (Yates et al., 2002).

In functional mobility, balance is an important component because it requires the integration of visual, vestibular and somatosensory inputs. For instance, in individuals with stroke, impaired somatosensory input from the lower limbs means that the body depends much on sensory input from the lower limbs to make fine adjustments necessary for upright posture. Tyson and Hanley, (2015) established the fact that impairments in proprioception and touch significantly affect postural stability because the body depends so much on sensory input from the lower limbs for making fine adjustments essential for upright posture. Their results indicated that those with significant tactile deficits were more likely to exhibit poor balance and postural control, particularly during tasks requiring single-leg stance or transitions between different surfaces. The study also noted that tactile impairments tend to exacerbate other motor deficits, creating a compounded effect on functional mobility.

Postural control relies on accurate sensory feedback from the lower limbs to maintain balance, especially during dynamic tasks. Stroke survivors with somatosensory impairments experience increased postural sway, poor balance, and difficulties in maintaining stability. Center of Force (COF) analyses show that stroke survivors with proprioceptive deficits have increased sway in both anterior-posterior and medio-lateral directions during static standing, reflecting poor balance control (Sidarta et al., 2022). Balance impairments become particularly evident during dynamic tasks, such as standing with eyes closed or walking on uneven surfaces, where visual input is minimized, and reliance on somatosensory input increases. Research indicates that balance impairments in stroke survivors are strongly correlated with sensory deficits, especially proprioception. For example, individuals with both tactile and proprioceptive impairments often face greater challenges in regaining independent walking ability compared to those with isolated motor impairments. Proprioceptive training has been shown to improve balance and reduce sway, but the spontaneous recovery of sensory function post-stroke is limited and targeted interventions are often required (Gorst et al., 2019). Chia et al. (2019) conducted a systematic review and meta-analysis on sensory retraining interventions, finding that targeted exercises aimed at improving tactile sensation in the lower limbs could lead to modest improvements in balance and gait. However, the authors cautioned that the effectiveness of such interventions may vary depending on the severity of the sensory deficits and the timing of the intervention relative to stroke onset. Schabrun and Hillier., (2015) further explored the association of sensory impairments with postural control. They concluded that individuals with severe sensory deficits had larger postural sway and are more likely to adopt compensatory strategies-much as over-relying on visual cues-to maintain their balance. While these may prevent falls within a controlled environment, they are highly ineffective in natural environments where sensory stimuli are not easily predictable. Therefore, it underscores the need for rehabilitation methods that focus on the sensory deficits during balance training.

Falls are one of the most common causes of injury and reduced quality of life among stroke survivors. Falls are a major concern in the stroke population, with up to 73% of stroke survivors experiencing at least one fall within the first-year post-stroke (Yates et al., 2002). The risk of fall increases significantly in those with impairments of the somatosensory abilities of the lower limbs. Awosika et al. (2023) emphasized that sensory systems reweighting is a critical mechanism by which the CNS adjusts its reliance on different sensory inputs for balance control. In individuals with chronic stroke, insufficiencies in sensory reweighting, particularly in integrating visual, vestibular and somatosensory information, were strongly associated with increased fall risk. Their observational cohort study revealed that survivors with greater impairments in sensory reweighting exhibited more severe walking difficulties and a higher propensity for falls, especially during tasks requiring rapid postural adjustments. Ribeiro et al. (2015) conducted a study that established proprioceptive training can reduce fall risk by improving balance and stability in chronic stroke survivors. By improving sensory information, individuals could better perceive the change in position of a limb and make necessary adjustments to minimize falls. One of the most significant challenges faced by stroke survivors is the fear of falling, which can severely limit their participation in physical activities and exacerbate functional decline.

Gorst et al. (2019) found that fear of falling was more prevalent among individuals with pronounced sensory impairments, as they often lack confidence in their ability to maintain balance during walking. This fear leads to reduced mobility, which in turn contributes to muscle deconditioning and further deterioration of balance control (Jamali et al., 2017). The implications of somatosensory impairments extend beyond motor function to psychological factors such as fear of falling. Gorst et al. (2019) reported that chronic stroke survivors with greater sensory deficits in the lower limbs were more likely to report fear of falling, which in turn restricted their participation in physical activities. Falls are often related to impaired proprioception, reduced balance control and difficulty adjusting to environmental hazards such as uneven surfaces or inclines. Stroke survivors with somatosensory impairments have an increased fear of falling, which contributes to a reduction in physical activity, social isolation and decreased quality of life. Impaired proprioception, particularly at the ankle, was one of the strongest predictors of fall risk. Survivors with poor proprioception at the ankle were more likely to experience multiple falls compared to those with intact sensory function. Additionally, impairments in sharp-blunt discrimination and tactile perception further increase fall risk, as survivors may have difficulty detecting obstacles or hazards in their path. This fear exacerbates the physical consequences of stroke by limiting the opportunities for functional recovery through movement and exercise. Furthermore, Yang et al. (2022) explored the complex pathways between somatosensory impairments, physical ability, and affective symptoms, such as anxiety and depression, in stroke survivors. They concluded that sensory impairments not only hinder physical function but also contribute to emotional distress, further complicating the rehabilitation process.

Stroke survivors often develop compensatory strategies to cope with their sensory impairments, such as relying more heavily on vision or using assistive devices for walking. While these strategies can help mitigate fall risk in the short term, they may limit long-term recovery by reinforcing maladaptive movement patterns and reducing the brain's capacity for sensory reweighting (Wutzke et al., 2013). For example, survivors who become overly reliant on visual feedback for balance may struggle in environments where visual input is compromised, such as in dimly lit spaces or on uneven terrain (Awosika et al., 2023). To address these challenges, rehabilitation programs should incorporate interventions that promote sensory integration and encourage the use of multiple sensory modalities for balance control. Sensory retraining exercises, such as weight-bearing tasks on different surfaces, vibration training, and proprioceptive exercises, have shown promise in improving sensory function and reducing fall risk in stroke survivors (Chia et al., 2019). Moreover, technologies such as virtual reality and robotic-assisted therapy offer new avenues for enhancing sensory feedback and facilitating motor learning in a controlled, task-specific environment (Gorst et al., 2017). Ekmekçioğlu et al. (2023) also highlighted the importance of trunk control in maintaining balance and preventing falls. Their study found that trunk stability, which is influenced by lower limb sensory input, plays a critical role in the ability to recover from postural deviations. Therefore, rehabilitation efforts should focus not only on improving lower limb sensory function but also on enhancing core stability to promote better overall postural control.

Gorst et al. (2019) utilized a range of measurement scales in their study to explore the association between lower limb somatosensory impairments and functional outcomes in chronic stroke survivors including Erasmus MC modifications to the Nottingham Sensory Assessment (EmNSA) for assessing somatosensory impairments like light touch, pressure and proprioception in the lower limbs, 10-Meter Walk Test (10MWT) to measure walking ability, Timed Up and Go (TUG) for assessing mobility, Functional Reach Test (FRT) to evaluate balance, Centre of Force (CoF) velocity for analyzing static and dynamic balance, Falls Efficacy Scale-International (FES-I) to assess fall-related self-efficacy and reported incidence of falls.

In the study of Arif et al. (2022), to find out the impact of lower extremity somatosensory deficits on balance and gait in sub-acute stroke patients, they employed the distal proprioception test for joint position sense, a bolay gauge for two-point discrimination, a soft brush for light touch pressure and a tuning fork for vibration sense. Balance was evaluated using the Berg Balance Scale (BBS) and the Timed Up and Go (TUG) test, while gait was analyzed using the Wisconsin Gait Index.

Parsons et al. (2016) investigated the relationship between plantar cutaneous sensation and standing balance in post-stroke individuals. They used monofilament testing to measure sensation thresholds on the affected foot and force plate analysis to assess standing balance by tracking the variability of the center of pressure (COP). Additionally, the Berg Balance Scale (BBS) was applied to evaluate functional balance performance.

Awosika et al. (2023) explored a study named insufficiencies in sensory systems reweighting is associated with walking impairment severity in chronic stroke. The researchers used the Modified Clinical Test of Sensory Interaction in Balance (mCTSIB) and Spatiotemporal Gait Parameters to assess postural stability and walking function in chronic stroke survivors.

Cho & Kim. (2021) carried out a study to explore the impact of ankle proprioception deficits on balance impairment in patients with chronic stroke. They used several scales to assess balance and proprioception. They evaluated ankle proprioception to assess joint position sense deficits. Balance was measured using the Berg Balance Scale (BBS), Mini-BESTest and the Functional Reach Test (FRT), while the Timed Up and Go (TUG) test was used to assess functional mobility.

According to these related studies commonly used measurement tools, in this study researcher performed the assessment of somatosensory impairment using Erasmus MC modifications to the Nottingham Sensory Assessment (EmNSA), 10-Meter Walk Test (10MWT) to measure walking speed and ability, the Berg Balance Scale (BBS) was used to assess functional balance performance and Falls Efficacy Scale-International (FES-I) to assess fall-related self-efficacy and fear of falling during daily activities. These outcome measurement tools provided a comprehensive approach to understanding the impact of somatosensory impairments on walking, balance and falls in stroke survivors.

Stroke survivors with combined sensory and balance impairments had significantly higher fall risks than those with isolated motor deficits. The inclusion of sensory retraining in balance-focused programs, such as joint position awareness exercises, has been shown to significantly enhance postural control and reduce fall risks in stroke survivors. Effective walking rehabilitation must integrate both motor and sensory interventions to improve gait biomechanics and walking outcomes. These findings align with growing evidence suggesting that addressing sensory deficits alongside motor impairments enhances overall functional mobility. A multidisciplinary approach remains essential to address the multifaceted challenges posed by these impairments, enabling better functional independence and quality of life for stroke survivors (Raipure, Kovela & Harjpal., 2023).

Chapter-iii	Methodology

3.1 Study design

A cross-sectional study design was selected to conduct this study to investigate the association of lower limb somatosensory impairments with walking, balance and falls in chronic stroke survivors.

3.2 Study site

Researcher selected the Neurology unit of the Physiotherapy department of Centre for the Rehabilitation of the Paralyzed (CRP), Savar, Dhaka for conducting the study.

3.3 Study duration

The study was conducted from 1st June 2024 to 31st May 2025, approximately 1 year, from initial recruitment through to the final dissemination of results.

3.4 Study population

In this study the chronic stroke patients who are admitted at CRP were chosen as study population to carry out the study.

3.5 Sampling technique

A purposive sampling technique was used by the researcher to draw out the sample from the study population. The researcher was interested in individuals with stroke and specific somatosensory impairments. So, selecting participants with these specific impairments ensures the relevance of the study.

3.6 Sample size calculation

The equation to calculate the sample size is given below-

$$n = \frac{z^2pq}{d^2}$$

$$= \frac{(1.96)^2 \times 0.3 \times (1-0.3)}{(0.05)^2}$$

$$= \frac{0.806}{(0.05)^2}$$

$$= 322.6944$$

$$= 323$$

Where,

n = Sample size

z = linked to 95% confidence interval (use 1.96)

p = expected prevalence, 0.3% (Islam et al., 2013)

q = 1- p (expected non-prevalence)

d = margin of error at 5% (standard value of 0.05)

So, the required sample size (n) is approximately 323

3.7 Selection criteria

3.7.1 Inclusion criteria

- Aged 18 and above.
- Both male and female.
- Diagnosed with both ischemic and hemorrhagic stroke at least three months prior.
- Able to independently stand and walk at least 10m indoors (with or without assistive device). (Gorst er al.,2019)

3.7.2 Exclusion criteria

- Severe understanding difficulty.
- Other neurological or orthopedic conditions affecting the lower limbs.
- Lack of interest to participate in research activities.
- Use of medications that significantly increase fall risk (Gorst et al., 2019).

3.8 Method of data collection

A written consent was taken from the participants before collecting data. A relevant questionnaire was used for the assessment of the patients and to accumulate data through face-to-face interview. Structured format was used for obtaining data from the participants.

3.9 Data collection tools

Researcher used information and consent form & a standard questionnaire form as data collection tools. The researcher constructed the questionnaire with the supervisor's advice and consent, following specific guidelines. It was designed to gather information related to somatosensory function, motor skills and personal details of stroke survivors. The questionnaire included "socio-demographic information of stroke patients, stroke related information and primary outcome measurements focused on examining functional outcomes such as walking ability and balance using 10-Meter walk test (10MWT) and Berg Balance Scale (BBS). These measurements are crucial for understanding the impact of lower limb somatosensory impairments on gait and balance. Secondary outcome measurements included- Fear of falling, assessed with the Falls Efficacy Scale-International (FES-I) and lower limb somatosensory function assessed using the Erasmus MC modifications to the (revised) Nottingham Sensory Assessment (EmNSA) to find out sensory deficits. From these measurements researcher gained a comprehensive view of the participant's overall functional status.

3.10 Measurement tools

10-Meter Walk Test (10MWT)

The 10-Meter Walk Test (10MWT) is a simple and effective assessment tool used to measure walking speed and gait performance. In this test, the participant walks a distance of 10 meters at a comfortable pace, and their time to complete the distance is recorded. The test is typically conducted in a straight, flat and unobstructed area. Walking speed is calculated by dividing the distance walked by the time taken, often expressed in meters per second. The 10MWT is valuable for evaluating mobility, assessing changes in gait over time, and determining the effectiveness of rehabilitation interventions (Graham et al., 2008).

Instructions:

- Patients will be asked to walk 10 meters (about 33 feet) at their usual walking speed.
- Start the stopwatch as they begin walking and stop it when they reach the end.

- Time will be recorded and walking speed will be calculated.

Berg Balance Scale (BBS)

This scale was used to examine static and dynamic balance in stroke patients. The Berg Balance Scale (BBS) is a comprehensive assessment tool designed to evaluate balance of person and those with balance impairments. It includes 14 tasks that range from simple to complex, such as sitting, standing, reaching, and turning. Each task is scored on a 5-point scale from 0 (unable to perform) to 4 (able to perform independently), with a maximum total score of 56. The BBS is widely used to assess fall risk and track balance changes over time, helping to guide rehabilitation and intervention strategies (Berg et al., 1989).

Erasmus MC modifications to the (revised) Nottingham Sensory Assessment (EmNSA)

The Erasmus MC modifications to the (revised) Nottingham Sensory Assessment (EmNSA) assesses sensory function in the lower limbs by evaluating light touch, pressure, vibration, and proprioception. It involves applying stimuli to various areas and recording the participant's responses to gauge sensory impairments. This assessment helps diagnose sensory deficits and guide rehabilitation strategies (Stolk-Hornsveld et al., 2006).

The scoring for each sensory modality is:

0: No sensation- participant does not feel the stimulus.
1: Reduced sensation- participant feels the stimulus but with less intensity or accuracy.
2: Normal sensation- participant feels the stimulus as expected with normal intensity and accuracy.
These scores are used to assess sensory function in different areas of the lower limbs.

Falls Efficacy Scale-International (FES-I)

The Falls Efficacy Scale-International (FES-I) is a tool designed to assess an individual's fear of falling during various daily activities. It consists of 16 items that cover a range of activities, such as walking, climbing stairs and shopping. Participants rate their level of concern about falling in these situations on a scale from 1 (not at all concerned) to 4 (very concerned). The total score ranges from 16 to 64, with higher scores indicating a greater fear of falling (Yardley et al., 2005). The FES-I is widely used to evaluate fall-related anxiety and to predict fall risk which can impact their overall mobility and quality of life. It is valuable in research for helping to guide fall prevention and intervention strategies.

3.11 Data analysis procedure

Data analysis was carried out using the Statistical Package of Social Science (SPSS) version 25 and Microsoft Excel 2021. The analysis process involved several key steps including descriptive and inferential statistics along with interpretation of results. The statistical decision was taken according to the nature of the data, objective and expert opinion.

3.11.1 Determination of the nature of data

The variables were determined as nominal, ordinal, interval, and ratio data and considered their parametric or non-parametric properties based on data type, normality test and standard procedure (Hicks, 1999).

Table-1.3.11.1: Data category and normality test of data

Variable	Description	Data type	Normality test	Data distribution
Age overall	18-80 (years)	Ratio	P= (.001)	Non-parametric
Gender	Male, Female	Nominal	-	Non-parametric
Marital status	Married, Unmarried	Nominal	-	Non-parametric
Living area	Urban, Rural, Semiurban	Nominal	-	Non-parametric
Educational level	No formal schooling, Primary, Secondary, Graduate	Ordinal	-	Non-parametric
Occupation	Jobless, Service holder, Businessman, Housewife, Others	Ordinal	-	Non-parametric

Variable	Description	Data type	Normality test	Data distribution
Duration of stroke	(months)	Ratio	P= (.001)	Non-parametric
Type of stroke	Ischemic, Hemorrhagic	Nominal	-	Non-parametric
Affected side	Left, right	Nominal	-	Non-parametric
Avg walking speed (10MWT)	(m/s)	Ratio	P= (.001)	Non-parametric
BBS total score	(0–56)	Interval	P= (.062)	Parametric
FES-I total score	(16–64)	Interval	P= (.001)	Non-parametric
Light touch total	(0–8)	Ratio	P= (.001)	Non-parametric
Pressure total	(0–8)	Ratio	P= (.001)	Non-parametric
Pin prick total	(0–8)	Ratio	P= (.001)	Non-parametric
Sharp/blunt total	(0–8)	Ratio	P= (.001)	Non-parametric
Proprioception total	(0–8)	Ratio	P= (.001)	Non-parametric

3.11.2 Determination of statistical test

The statistical analysis was performed as descriptive and inferential statistics based on the parametric or non-parametric nature of the data. Descriptive statistics were applied to summarize the characteristics of the study population. Frequency and percentage were calculated for categorical (nominal and ordinal) variables such as gender, marital status, living area, type of stroke, and affected side. For continuous variables (interval and ratio data) including age, duration of stroke (in months), average walking speed (10MWT), Berg Balance Scale (BBS) scores, and Falls Efficacy Scale-International (FES-I) scores, mean and standard deviation were calculated.

In the inferential section, a normality test was performed for continuous variables to determine the appropriate statistical tests. Based on the results, the independent t-test was used to compare the mean BBS scores between groups as the data were normally distributed, while the Mann-Whitney U test was applied for non-normally distributed variables such as 10MWT and FES-I. Spearman's correlation was conducted to explore the relationship between sensory modality scores and functional outcomes. Statistical significance was determined at a p-value < 0.05.

3.12 Ethical consideration

Ethical consideration for this study was thoroughly addressed to ensure the protection and well-being of the participants. The research proposal was submitted to the Institutional Review Board (IRB) and the study received approval from the board. Researcher followed the guidelines provided by Bangladesh Medical Research Council (BMRC) and World Health Organization (WHO). Informed consent was obtained from each participant before enrollment, ensuring that they were fully aware of the study's purpose, objectives, procedures, potential risks, benefits and the time commitment involved. Participants were assured of their right to withdraw from the study at any time if they don't want to participate. Their safety and confidentiality were also ensured. Regular monitoring and oversight were maintained throughout the study by the researcher to address any ethical concerns that might arise.

3.13 Informed consent

The informed consent process ensured that all the participants were fully aware of their involvement based on their voluntary decision. Each participant was provided with a comprehensive information sheet outlining the study's purpose, procedure, duration, potential risks, benefits and their right to withdraw at any time if they feel discomfort and discuss about their problem with senior authorities. Participants were assured that their information would be anonymized to prevent identification in any reports or publications and would be handled with the highest level of confidentiality. Before written consent, a detailed verbal explanation of the study was given. After receiving and understanding the information, participants were asked to sign a consent form. This form confirmed their willingness to participate in the study.

Chapter-iv Results

The findings derived from the analysis of data collected from the participants are presented here in a summarized and visualized manner. Data were collected from 123 individuals with chronic stroke, categorized into two groups based on the presence or absence of lower limb somatosensory impairments. The group with somatosensory impairments consisted of 27 participants, while the group without impairments included 96 participants. The findings were analyzed based on socio-demographic characteristics, sensory assessment and functional outcomes related to walking speed, balance and fear of falling.

Table-1: Baseline socio-demographic characteristics of the participants

Characteristics	Percentage (%)	Frequency (n)
Gender		
Male	74	91
Female	26	32
Age overall (Mean ± SD)		53.93 ± 12.292
Marital status		
Married	98	121
Unmarried	1	1
Widow	1	1
Education		
No formal schooling	14.6	18
Primary	20.3	25
Secondary	25.2	31
Higher secondary	14.6	18
Graduate	19.5	24
Post-graduate	5.7	7
Living area		
Rural	39	48
Urban	41.5	51
Semi-urban	19.5	24

Characteristics	Percentage (%)	Frequency (n)
Occupation		
Jobless	2.4	3
Service holder	30.1	37
Businessmen	23.6	29
Housewife	22.8	28
Others	21.1	26

As shown in Table-1, among the total participants (n=123), the majority were male 74% (n = 91), while females comprised 26% (n = 32). The mean age of the participants was 53.93 years (SD = 12.29), indicating a middle-aged to older adult population. Most participants were married 98% (n = 121), with only 1% unmarried and 1% widow participant. Regarding educational background, a varied distribution was observed. Approximately 14.6% (n = 18) had no formal education, while 20.3% (n = 25) had primary education. Secondary education was the most common level attained by 25.2% (n = 31) of participants. Both higher secondary and no formal education categories had the same proportion 14.6% (n = 18). Graduate-level education was reported by 19.5% (n = 24) and only 5.7% (n = 7) had completed postgraduate studies. Most of the participants lived in urban areas, with 41.5% (n = 51) individuals, while 39% (n = 48) were from rural areas and 19.5% (n = 24) from semi-urban locations. When looking at occupations, 37 participants (30.1%) were service holders, 29 (23.6%) were businessmen, 28 (22.8%) were housewives, and 26 (21.1%) belonged to other professions. Only 3 participants (2.4%) were jobless. This shows that the majority were employed, with service holders forming the largest group.

4.2 Age of the participants

The data shows that most participants fall within the 45 to 65-year age range, with a peak frequency around 55 years. The mean age is 53.93 years and the standard deviation is 12.29, indicating a moderately diverse age spread. Overall, the distribution suggests that the majority of stroke survivors in this sample are middle-aged to older adults.

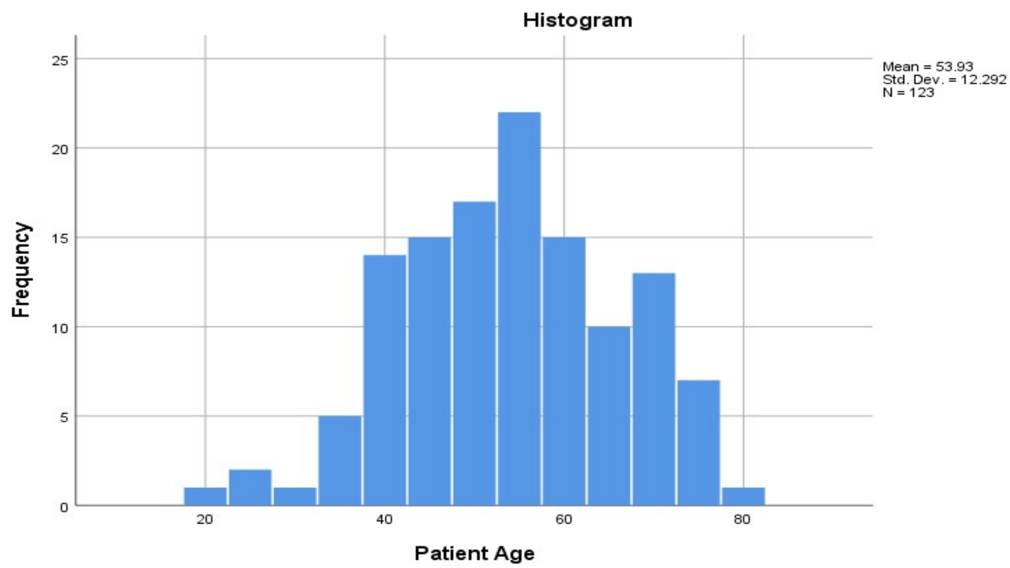


Figure-1: Age of the participants

4.3 Gender of the participants

Male participants made up (n=91) of the study population, while females accounted for (n=32), indicating a predominance of male stroke survivors in the sample.

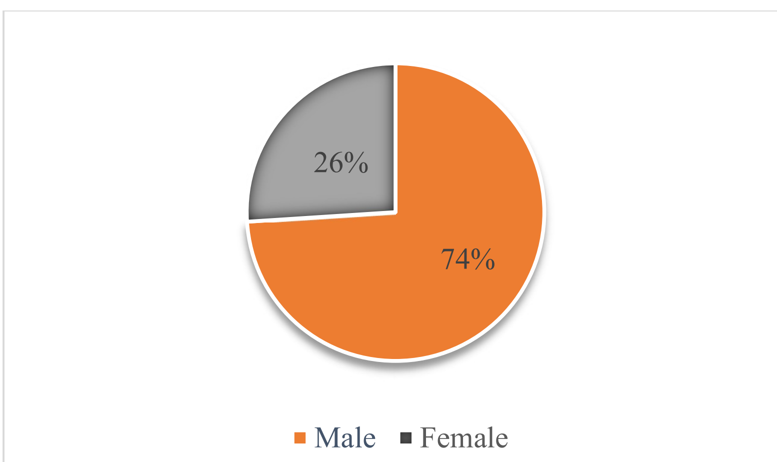


Figure-2: Gender of the participants

4.4 Living area of the participants

Participants predominantly resided in urban areas (n=51) and rural areas (n=48), while a smaller proportion (n=24) lived in semi-urban locations, indicating a diverse representation across different living environments.

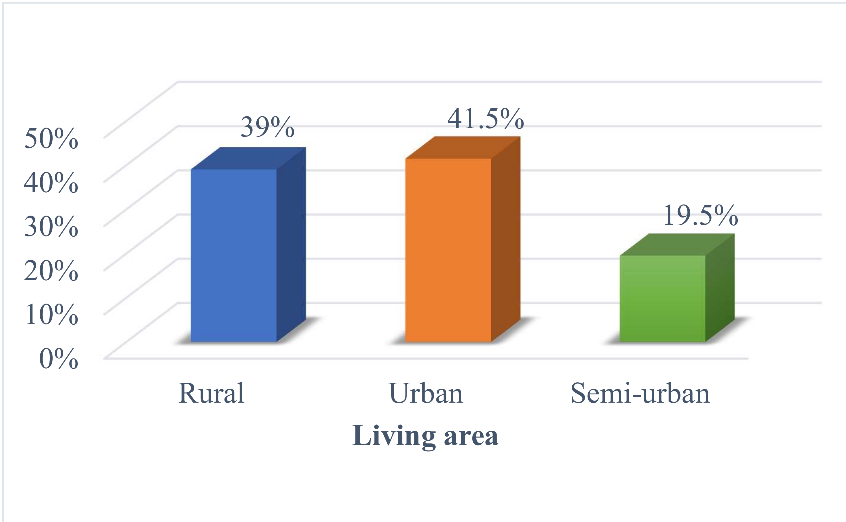


Figure-3: Living area of the participants

4.5 Occupation of the participants

The largest occupational group among participants was service holders (n=37), followed by businessmen (n=29), housewives (n=28) and a small proportion were jobless (n=3). Additionally, (n=26) of participants were categorized as "others" based on their occupational background.

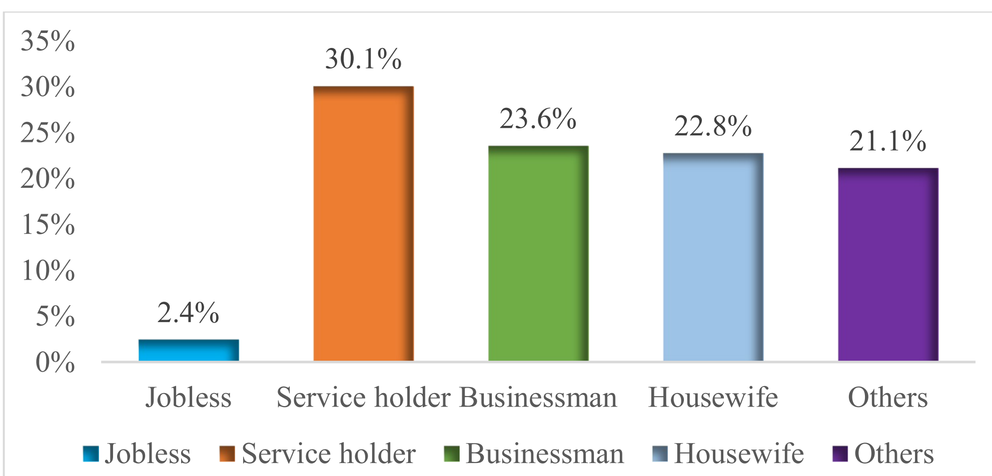


Figure-4: Occupation of the participants

Table-2: Stroke-related clinical characteristics of the participants (n=123)

Characteristics	Percentage (%)	Frequency (n)
Duration of stroke		
(3-6) months	59.3	73
(7-10) months	23.6	29
(11-14) months	8.9	11
(15-23) months	2.4	3
>23 months	5.7	7
Type of stroke		
Ischemic	81.3	100
Hemorrhagic	18.7	23
Affected side		
Right	45.5	56
Left	54.5	67

Table-2 presents the stroke-related clinical characteristics of the participants included in the study. The majority of participants (59.3%) had experienced a stroke within the past 3 to 6 months, indicating that most were in the earlier phase of chronic stroke. A smaller proportion had longer durations since stroke onset, with only (5.7%) having stroke durations greater than 23 months. Regarding stroke type, ischemic stroke was more prevalent (81.3%) compared to hemorrhagic stroke (18.7%). In terms of the affected side, slightly more participants had left-sided strokes (54.5%) compared to right-sided strokes (45.5%). These findings highlight a predominance of ischemic and relatively recent stroke cases in the study population.

4.5 Duration of stroke among participants

More than half of the participants (n=73) had a stroke duration of 3–6 months. Others had durations of 7–10 months (n=29), 11–14 months (n=11) and a small proportion had stroke durations exceeding 23 months (n=7) or between 15–23 months (n=3).

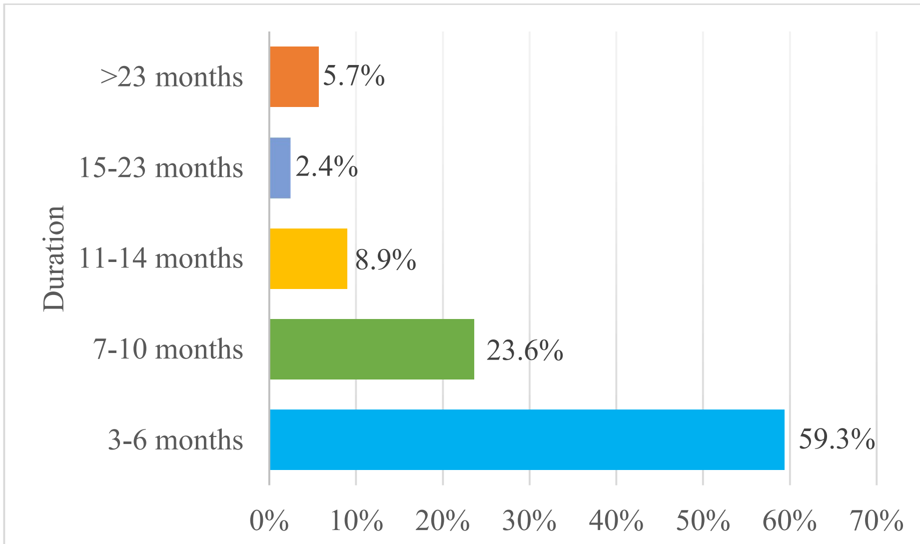


Figure-5: Duration of stroke among participants

4.6 Type of stroke among the participants

The majority of participants (n=100) had sustained an ischemic stroke, while (n=23) had experienced a hemorrhagic stroke, aligning with typical stroke prevalence patterns.

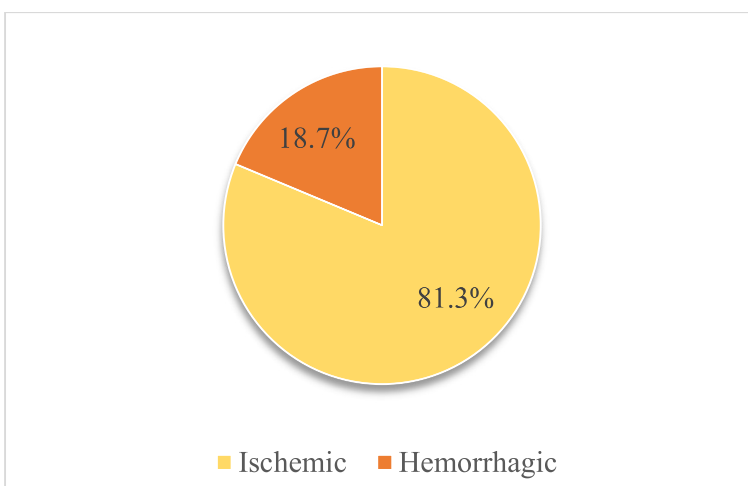


Figure-6: Type of stroke among the participants

4.7 Affected side of the participants

Among the participants, left-sided involvement was slightly more frequent (n=67) than right-sided (n=56), indicating a relatively even distribution of stroke-affected body sides in the sample.

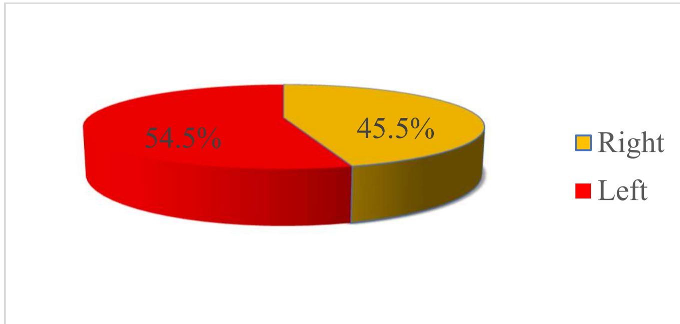


Figure-7: Affected side of the participants

Table-3: Comorbidity profile among the participants

Comorbidities	Frequency (n)	Percentage %
Hypertension	36	29.3
Diabetes	19	15.4
Hypertension & Diabetes	31	25.2
Hypertension; Diabetes & Heart disease	17	13.8
Hypertension & Heart disease	8	6.5
Diabetes & Heart disease	1	0.8
Diabetes & kidney disease	3	2.4
Hypertension; Heart disease & kidney disease	1	0.8
Others	1	0.8
None	6	4.9
Total	**123**	**100.0**

As shown in Table-3, comorbidity analysis revealed that hypertension was the most prevalent condition, either alone 29.3% (n=36) or in combination with diabetes 25.2%

(n=31). Additionally, 15.4% (n=19) of participants reported having diabetes, while 13.8% (n=17) had a combination of hypertension, diabetes, and heart disease. Other less frequent combinations included diabetes with kidney disease (2.4%) (n=3) and multiple conditions involving heart and kidney issues. A small proportion 4.9% (n=6) reported no comorbid conditions.

4.8 Prevalence of lower limb somatosensory impairments

Out of 123 participants, (n=27) were found to have lower limb somatosensory impairments, while the remaining (n=96) did not show any impairment. This reflects a considerable prevalence of sensory dysfunction in chronic stroke survivors, particularly in the distal lower limb.

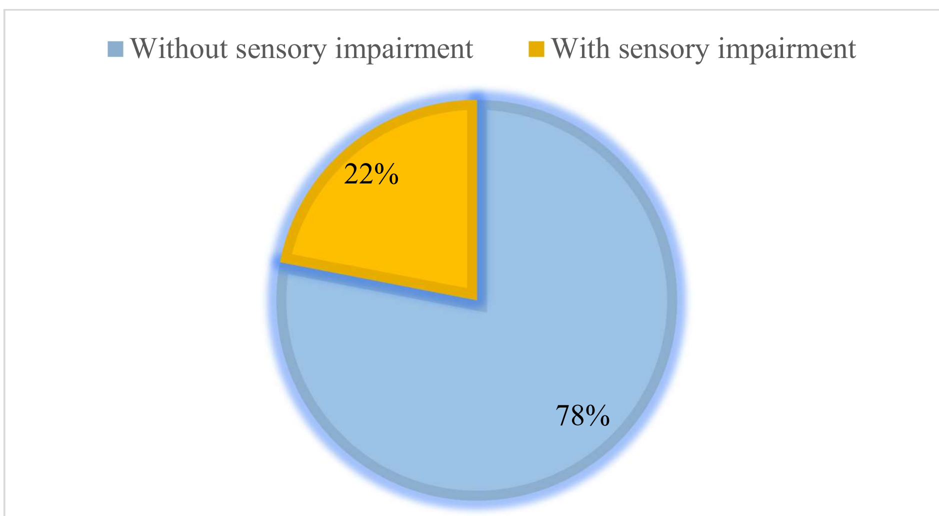


Figure-8: Distribution of chronic stroke survivors with and without lower limb somatosensory impairment

Table-4: Prevalence of somatosensory performance by modality and body region in chronic stroke patients assessed with EmNSA (n=123)

Modalities	Limb Area	Classification	Frequency (n)	Percentage %
Light Touch	Thigh	Normal	123	100
	Knee	Impaired	15	12.2
		Normal	108	87.8
	Foot	Impaired	22	17.9
		Normal	101	82.1
	toes	Impaired	27	22
		Normal	96	78
Pressure	Thigh	Normal	123	100
	Knee	Impaired	1	0.8
		Normal	122	99.2
	Foot	Impaired	14	11.4
		Normal	109	88.6
	Toes	Impaired	27	22
		Normal	96	78
Pin Prick	Thigh	Normal	123	100
	Knee	Impaired	6	4.9
		Normal	117	95.1
	Foot	Impaired	13	10.6
		Normal	110	89.4
	Toes	Impaired	27	22
		Normal	96	78
Sharp/Blunt	Thigh	Normal	123	100
	Knee	Impaired	3	2.4
		Normal	120	97.6
	Foot	Impaired	13	10.6
		Normal	110	89.4
	Toes	Impaired	26	21.1
		Normal	97	78.9
Proprioception	Thigh	Normal	123	100
	Knee	Normal	123	100
	Foot	Impaired	8	6.5
		Normal	115	93.5
	Toes	Impaired	21	17.1
		Normal	102	82.9

The anatomical distribution of somatosensory impairments by modality is presented in Table-4. **The Erasmus MC modifications to the (revised) Nottingham Sensory**

Assessment (EmNSA) was used to assess somatosensory impairments among the patients. Overall, sensation was more frequently impaired in distal regions of the affected lower limb (toes and foot) across all modalities. Specifically, light touch impairment was observed in 22% at the toes and 17.9% at the foot. For pressure sensation, 22% of participants had impaired sensation at the toes and 11.4% at the foot. Pin prick testing also showed similar impairment levels at the toes (22%) and foot (10.6%). Sharp/blunt discrimination showed (21.1%) impairment at the toes and (10.6%) at the foot. Proprioceptive deficits were also observed, with (17.1%) impairment at the toes and (6.5%) at the foot. The ability to perceive light touch, pressure sensation and pin prick was the most frequently impaired, with each showing 22% impairment at the toes. Notably, no participants showed sensory deficits at the thigh across any modality and proprioception at the knee remained intact in all individuals.

4.9 Distribution of light touch sensation impairment in the lower limb region:

The distribution of light touch sensation impairment in the lower limb reveals that the toes were the most frequently affected region, with 27 individuals (22%) exhibiting impairment. This was followed by the foot, with 22 individuals (17.9%) and the knee, with 15 individuals (12.2%). These findings indicate a distal-to-proximal gradient in sensory impairment, with greater impairment observed in more distal areas such as the toes and feet.

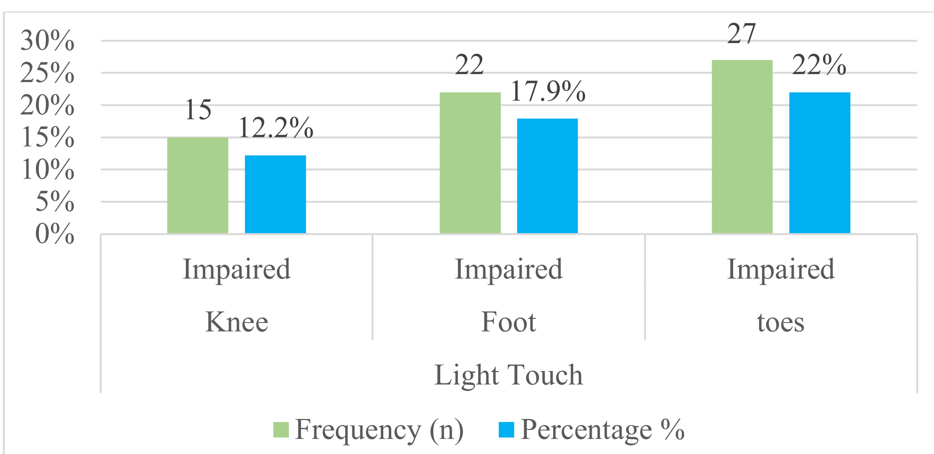


Figure-9: Light touch sensation impairment

4.10 Distribution of pressure sensation impairment in the lower limb region:

Toes are the most commonly affected region, with 27 individuals (22%) experiencing impairment. This is followed by the foot with 14 individuals (11.4%), while the knee is the least affected, with only 1 individual (0.8%).

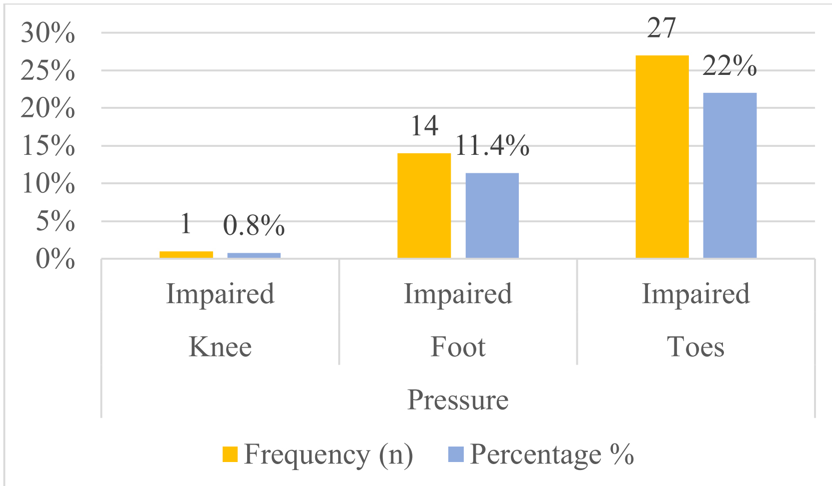


Figure-10: Pressure sensation impairment

4.11 Distribution of pin prick sensation impairment in the lower limb region:

The highest frequency of impairment was recorded at the toes, affecting 27 individuals (22%). The foot was impaired in 13 individuals (10.6%), while the knee showed the lowest occurrence with 6 individuals (4.9%).

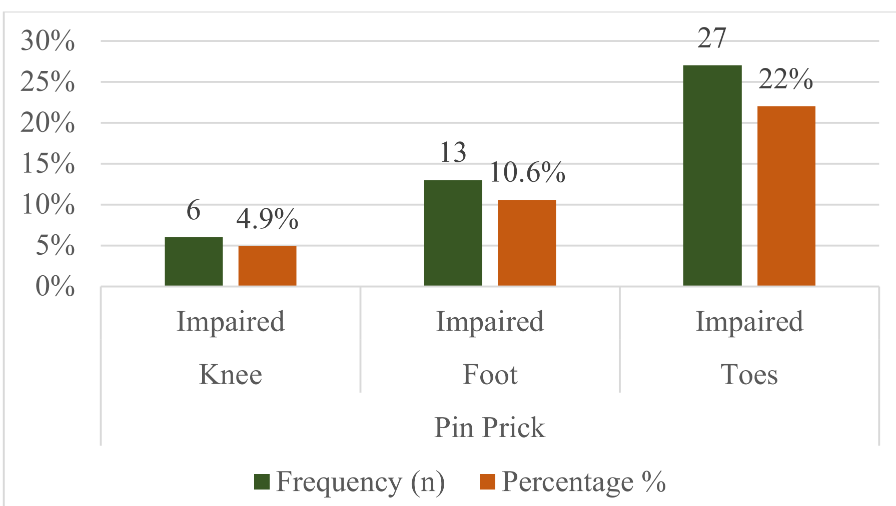


Figure-11: Pin prick sensation impairment

4.12 Distribution of sharp/blunt sensation impairment in the lower limb region:

Sharp/blunt sensation impairment was most prevalent in the toes, with 26 individuals (21.1%) affected. The foot showed impairment in 13 individuals (10.6%), while the knee was the least affected with only 3 individuals (2.4%).

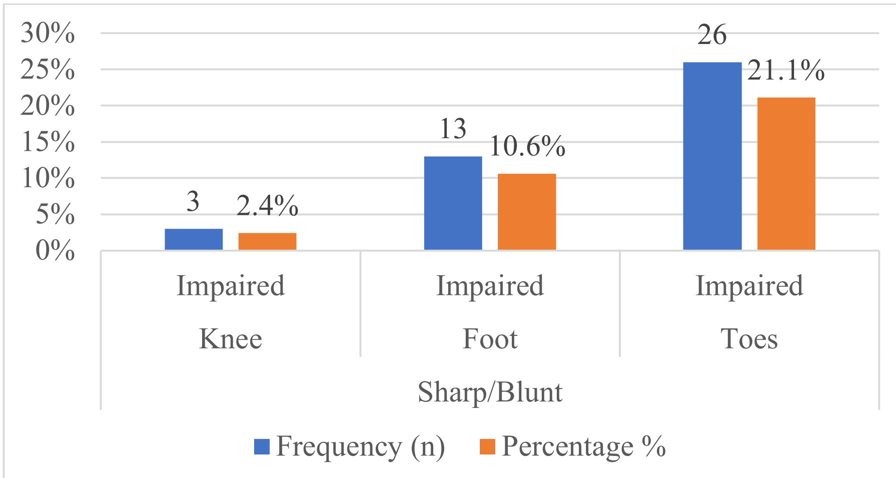


Figure-12: Sharp/blunt sensation impairment

4.13 Distribution of proprioception sensation impairment in the lower limb region:

Proprioception impairment was predominantly observed at the toes, with 21 individuals (17.1%) affected, compared to 8 individuals (6.5%) at the foot. No impairment was reported at the knee.

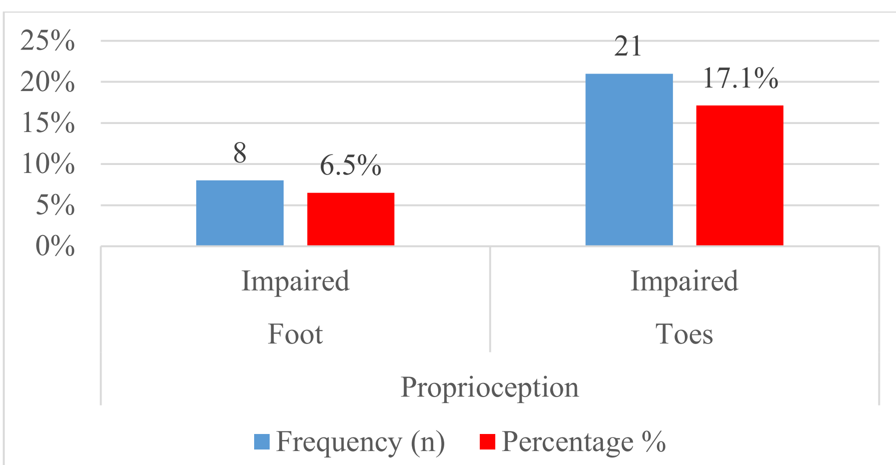


Figure-13: Proprioception sensation impairment

Table-5: Average scores of walking, balance and fall concern in participants

	Mean± SD	
Functional outcome	**Without sensory impairment (n=96)**	**With sensory impairment (n=27)**
10 Meter Walk Test (10MWT) (m/s)	0.47 ± 0.22	0.24 ± 0.08
Berg Balance Scale (BBS)	44.35 ± 4.97	39.78 ± 4.56
Falls Efficacy Scale-International (FES-I)	27.85 ± 7.22	32.04 ± 6.50

The results presented in Table-5 demonstrate that chronic stroke survivors with lower limb somatosensory impairments performed worse across all functional outcomes compared to those without such impairments. Specifically, participants with sensory impairments exhibited significantly slower walking speed on the 10 Meter Walk Test (mean = 0.24 m/s) than those without impairments (mean = 0.47 m/s). Additionally, their balance performance, as measured by the Berg Balance Scale (BBS), was lower (mean = 39.78) compared to participants without sensory impairments (mean = 44.35). Furthermore, individuals with sensory deficits reported greater concern about falling, indicated by higher scores on the Falls Efficacy Scale-International (FES-I), (mean = 32.04) versus those without deficits (mean = 27.85). These findings suggest that somatosensory impairments are associated with reduced walking ability, poorer balance, and increased fear of falling in chronic stroke survivors.

4.14 Categorical distribution of balance performance (BBS) in stroke participants

Among 96 patients without sensory impairment, (n=19) participants scored between 21–40 (indicating walking with assistance), while (n=77) participants scored between 41–56 (indicating independent balance). In contrast, among 27 participants with sensory impairment, (n=16) scored in the 21–40 range and (n=11) scored in the 41–56 range. This indicates that a larger number of participants with sensory impairments had reduced balance requiring assistance, whereas most participants without impairments demonstrated independent balance.

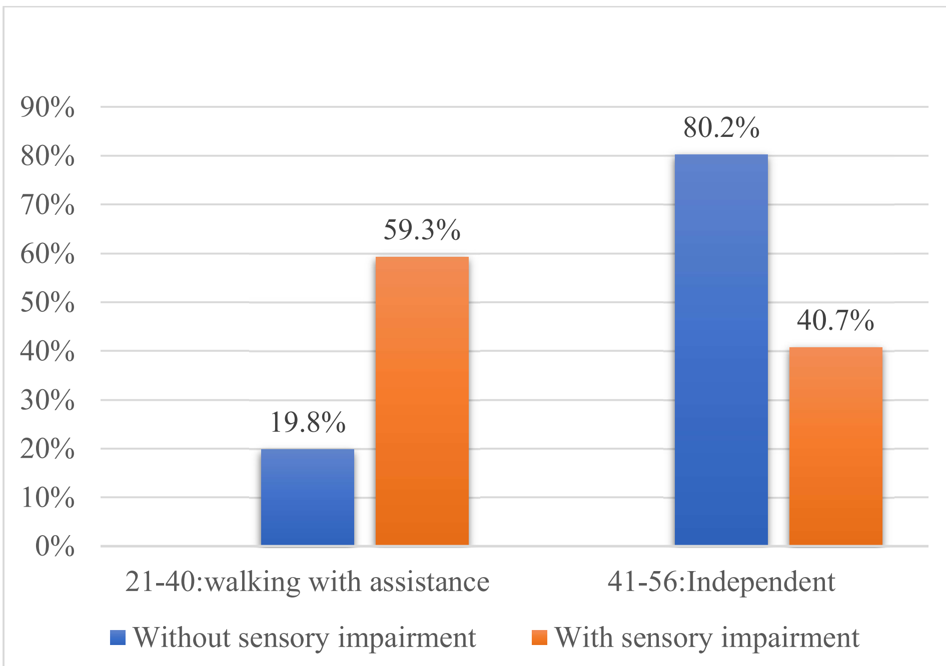


Figure-14: BBS score categories in participants

4.15 Categorical distribution of participants by concern of falling (FES-I)

Among 96 participants without sensory impairment, (n=5) individuals had low concern (16–19), (n=42) had moderate concern (20–27), and (n=49) had high concern (28–64). In contrast, among 27 participants with sensory impairment, none had low concern, (n=8) had moderate concern, and (n=19) had high concern about falling. This shows that a greater number of participants with sensory impairments fall into the high concern category compared to the other categories.

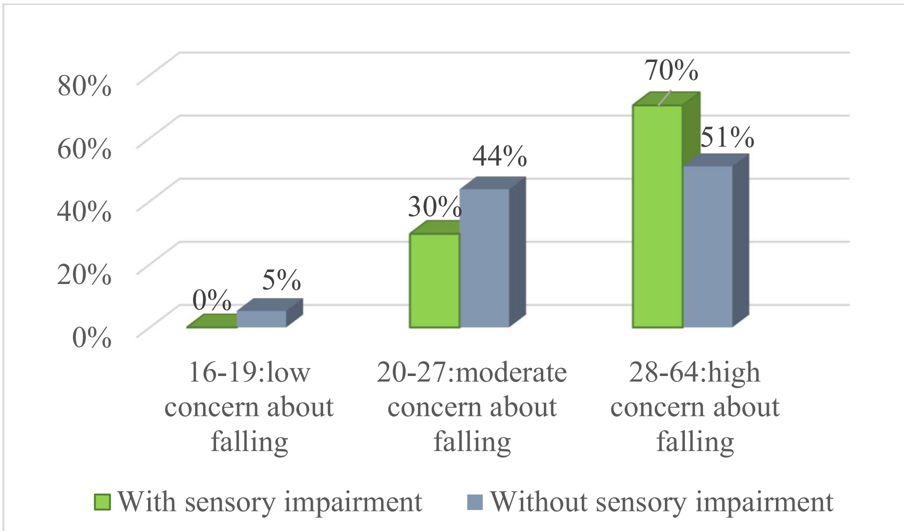


Figure-15: FES-I score categories in participants

Inferential statistical analysis:

Table-6: Comparison of balance ability between stroke survivors

Outcome variable	Group	Mean	Test value	p-value
BBS (Balance performance)	Without sensory impairment (n=96)	44.35	4.508	< 0.001
	With sensory impairment (n=27)	39.78		

In Table-6, independent samples t-test was done because data was normally distributed & this parametric test was appropriate for this group comparison. The test demonstrated a statistically significant difference in balance performance between stroke survivors with and without lower limb somatosensory impairments. Participants without sensory impairment exhibited significantly better balance ability (M=44.35) compared to those with sensory impairment (M=39.78) & ($t = 4.508$, $p < 0.001$). This suggests that lower limb sensory impairments are strongly associated with reduced balance function in chronic stroke survivors.

Table-7: Comparison of walking speed and fall concern between stroke survivors

Outcome Variables	Group	Mean	Test value	p-value
10MWT (Walking speed)	Without sensory impairment (n = 96)	71.22	411	< .001
	With sensory impairment (n = 27)	29.22		
FES-I (Falls Concern)	Without sensory impairment (n = 96)	56.85	801.5	0.002
	With sensory impairment (n = 27)	80.31		

The Mann-Whitney U test was employed in this analysis because the data for the outcome variables-10-Meter Walk Test (10MWT) for walking speed and Falls Efficacy Scale-International (FES-I) for fall concern-were not normally distributed, as identified through prior normality testing. This non-parametric test was therefore appropriate for comparing the two independent groups: stroke survivors with and without lower limb somatosensory impairments. The results revealed statistically significant differences in both walking speed and fall concern between the two groups. Stroke survivors without sensory impairment demonstrated significantly faster walking speeds (Mean = 71.22) compared to those with sensory impairment (Mean = 29.22), with a Mann-Whitney U value of 411 and a p-value of < 0.001. Similarly, fall concern was significantly higher in individuals with sensory impairment (Mean = 80.31) compared to those without impairment (Mean = 56.85), with a U value of 801.5 and a p-value of 0.002. These findings indicate that lower limb somatosensory impairments are strongly associated with reduced walking speed and increased fear of falling in chronic stroke survivors.

Table-8: Association between lower limb somatosensory modalities and functional outcomes in chronic stroke survivors (n = 27)

Somatosensory Modalities	Walking Speed (10MWT)	Balance (BBS)	Falls (FES-I)
Light touch	r = 0.253 p = 0.203	r = 0.452 **p = 0.018***	r = –0.296 p = 0.134
Pressure	r = 0.035 p = 0.861	r = 0.025 p = 0.901	r = –0.146 p = 0.466
Pin prick	r = 0.233 p = 0.242	r = 0.339 p = 0.084	r = –0.193 p = 0.334
Sharp-blunt discrimination	r = 0.379 p = 0.051	r = 0.040 p = 0.843	r = –0.070 p = 0.728
Proprioception	r = 0.105 p = 0.604	r = –0.007 p = 0.974	r = 0.000 p = 0.998

r: Spearman's rho.

Significance: $p < 0.05$

Table-8 presents the Spearman's correlation coefficients (r), showing the association between various lower limb somatosensory modalities and functional outcomes-walking speed (10MWT), balance performance (BBS) and fall concern (FES-I)-in chronic stroke survivors (n = 27). The test was chosen because two of the outcome variables-10MWT and FES-I were not normally distributed. Although BBS scores were normally distributed and are typically analyzed using parametric tests such as Pearson's correlation, Spearman's correlation was used for consistency across all outcome variables and due to the ordinal or continuous nature of the somatosensory modality scores and this test is appropriate for assessing monotonic relationships without assuming linearity or normal distribution.

Light touch sensitivity showed a moderate positive correlation with balance performance ($r = 0.452$, $p = 0.018$*), which is statistically significant. This implies that better light touch sensation in the lower limb is associated with better balance. However, its correlation with walking speed ($r = 0.253$, $p = 0.203$) and fall concern ($r = –0.296$, $p = 0.134$) was not statistically significant, although the negative r value for falls suggests a potential trend where improved light touch might be linked to reduced fear of falling. Pressure sensation had negligible correlations across all outcomes: walking speed ($r = 0.035$), balance ($r = 0.025$), and falls ($r = –0.146$), with all p-values > 0.4. Pin prick sensation showed a low to moderate positive correlation with balance ($r = 0.339$, $p = 0.084$), though not statistically significant. It also had weak associations with walking speed ($r = 0.233$) and falls ($r = –0.193$), again not significant. The negative correlation with falls suggests that improved pin prick sensation might be associated with less fear of falling, but the evidence is inconclusive. Sharp-blunt discrimination had a moderate positive correlation with walking speed ($r = 0.379$, $p = 0.051$), approaching statistical significance, indicating that those who performed better in this sensory test tended to walk faster. However, no meaningful relationships were observed with balance or falls ($p > 0.7$). Proprioception was not significantly correlated with any of the functional outcomes, showing very weak correlations with walking speed ($r = 0.105$), balance ($r = –0.007$) and falls ($r = 0.000$), with all p-values well above 0.6. Only light touch vs. BBS reached statistical significance ($p < 0.05$), highlighting the importance of superficial tactile sensation in maintaining balance post-stroke.

Result summary: This study found that 22% chronic stroke survivors had lower limb sensory problems, especially in the toes and feet. Those with these impairments walked more slowly, had poorer balance and were more afraid of falling than those without sensory impairment. Among all sensations, light touch was most associated to better balance, showing how important it is for staying steady after a stroke.

Chapter-v	Discussion

This chapter represents the discussion of the results of the study in relation to the research questions and objectives. This cross-sectional study aimed to investigate the association of lower limb somatosensory impairments with walking speed, balance and fear of falling among chronic stroke survivors. The findings revealed that stroke survivors with somatosensory impairments demonstrated significantly poorer functional performance in terms of slower walking speed, reduced balance capacity and higher concern about falling, compared to those without such impairments. This aligns with neurological understanding that somatosensory input is critical for gait, postural orientation and dynamic stability and its disruption contributes to increased mobility risk and falls (Marigold & Eng, 2006).

A total of 123 participants with chronic stroke were included in this study, among whom 27 had lower limb somatosensory impairments while 96 did not. Descriptive analysis revealed that the majority of participants were male (approximately 74%) than female which was (26%) and aged above 50 years, consistent with the demographic trend of higher stroke prevalence among older males. Similar gender distributions were observed in previous studies such as by Gorst et al. (2018), where male stroke survivors were predominant, indicating a consistent pattern of higher stroke burden among males. The affected side was slightly more frequent on the left (54%) and ischemic stroke was more common (81%) than hemorrhagic stroke (19%), aligning with findings from Benjamin et al. (2019), who reported that ischemic stroke accounts for approximately 87% of all stroke cases worldwide. Most participants in this study had been living with stroke for (3-6) months mostly, classifying them as chronic stroke survivors. This is consistent with the inclusion criteria of similar studies (e.g., Tyson et al., 2014; Gorst et al., 2018), which focus on chronic stroke patients to better understand long-term sensory and functional impairments. The presence of comorbidities such as hypertension (29%) and diabetes (15%) were common among participants, which is in line with global findings on stroke risk factors reported by Feigin et al. (2014), reinforcing the need for comprehensive medical management in stroke rehabilitation.

In this study, approximately 22% of stroke survivors presented with lower limb somatosensory impairments, based on the Erasmus modified Nottingham Sensory

Assessment (EmNSA). This finding is well-aligned with the results of Gorst et al. (2018), who conducted a large cross-sectional analysis of chronic stroke survivors to examine the prevalence and functional implications of lower limb somatosensory impairments. They reported that approximately 52% of participants had impairments in at least one lower limb sensory modality and these individuals demonstrated significantly slower walking speed, worse balance and increased self-reported disability.

In this study, somatosensory impairments were most frequently observed at the distal regions-particularly the toes and foot, across all sensory modalities. Light touch, pressure and pin prick sensation were each impaired in 22% of participants at the toes, while sharp/blunt discrimination was impaired in 21.1% and proprioception in 17.1% at the same location. In contrast, impairments at the foot ranged from 10.6% to 17.9% and no sensory deficits were detected at the thigh in any modality. These findings strongly align with those of Gorst et al. (2018), who similarly reported that distal somatosensory loss, particularly in the toes and foot were significantly more common than proximal impairments and that light touch and proprioception were the most frequently affected modalities. Additionally, Tyson and Hanley (2014) found that distal light touch and pin prick deficits were more predictive of functional limitations than proximal deficits in stroke survivors.

Functional outcomes such as walking speed was assessed using the 10-Meter Walk Test (10MWT), balance was evaluated with the Berg Balance Scale (BBS) & concern about falling was assessed using the Falls Efficacy Scale-International (FES-I) (Gorst et al., 2018; Blum and Korner-Bitensky, 2008). The average walking speed among participants with sensory deficits was 0.24 m/s, indicative of severely limited community ambulation, while those without impairments walked at a mean speed of 0.47 m/s. Similarly, balance ability was reduced in the sensory-impaired group, with a mean score of 39.78, which falls below the threshold associated with independent balance. Fear of falling was also elevated in this group, with a mean score of 32.04, suggesting a high concern about falls and reduced confidence during daily activities.

For group comparison of walking speed between participants, non-parametric analysis (Mann-Whitney U test) was conducted due to non-normal distribution of the data. The results showed a statistically significant difference in walking speed between the two groups, participants without somatosensory impairments walk significantly faster than those with impairments. This finding is consistent with results from Gorst et al. (2018), who also employed the 10MWT and reported that lower limb sensory impairments were associated with significantly reduced walking speed in chronic stroke survivors. The role of sensory input in locomotor function is further supported by Tyson and Hanley (2014), who demonstrated that deficits in tactile and proprioceptive sensation negatively affected gait velocity and independence. Impaired sensation may hinder the ability to perceive ground reaction forces, leading to compensatory gait patterns, reduced confidence and slower walking speed.

To compare concern about falling between two groups, the Mann-Whitney U test was applied, similar to walking speed, as the data were not normally distributed. The results showed that stroke survivors with lower limb somatosensory impairments had significantly higher FES-I scores, indicating greater fear of falling compared to those without impairments. This finding is consistent with Gorst et al. (2018), who also used the FES-I in their study and reported that individuals with sensory deficits had higher levels of fall concern and reduced balance confidence. Batchelor et al. (2012) found that stroke survivors with impaired sensation and balance had significantly higher FES-I scores and Schmid et al. (2013) linked decreased plantar cutaneous feedback to increased fear of falling. This elevated fear of falling may stem from poor sensory feedback, reduced balance confidence and past experiences of instability.

In case of BBS to compare balance ability, an independent samples t-test revealed a statistically significant difference in balance performance between stroke survivors with and without lower limb somatosensory impairments. Participants without sensory impairments demonstrated superior balance ability ($M = 44.35$) compared to those with impairments ($M = 39.78$), $t = 4.508$, $p < 0.001$. This finding aligns with previous research indicating that lower limb sensory deficits, particularly in proprioception, are associated with compromised balance and increased fall risk in chronic stroke survivors (Gorst et al., 2018).

To explore the association between lower limb somatosensory modalities and functional outcomes-walking speed, balance performance and fall concern in chronic stroke survivors ($n = 27$) with sensory impairments, Spearman's rank-order correlation was applied. Light touch sensation in the lower limb showed a statistically significant moderate positive correlation with balance performance, indicating that better superficial tactile sensation is associated with improved postural control. Approximately 45% of the variability in balance scores can be explained by differences in light touch function. This finding aligns with Gorst et al. (2018), they used non-parametric test (Spearman's correlation) and reported that light touch and proprioceptive deficits were significantly associated with functional impairments. Similarly, Tyson and Hanley (2014) emphasized the strong predictive value of light touch, particularly at distal lower limb sites, in determining balance and gait outcomes post-stroke. Other sensory modalities in this study-such as pressure, pin prick, sharp/blunt discrimination and proprioception did not show statistically significant associations with functional outcomes, though some trends were noted. For example, sharp/blunt discrimination approached significance for walking speed, suggesting a potential clinical link. These trends are consistent with previous research by Schabrun and Hillier (2009), which noted that deep and discriminatory sensory pathways might influence function, but the evidence remains variable. The weak and non-significant correlations observed for proprioception and pressure sensation in this study differ from some earlier findings, such as those by Inglis et al. (2020), who reported stronger links between proprioceptive loss and motor coordination.

One of the key strengths of this study is the use of detailed, modality-specific scoring for lower limb somatosensory assessment, rather than simple binary (present/absent) classifications. Using the Erasmus MC-modified Nottingham Sensory Assessment (EmNSA), five modalities-light touch, pressure, pin-prick, sharp/blunt discrimination, and proprioception were each assessed at multiple anatomical sites, offering a nuanced and functionally relevant sensory profile. This structured approach closely followed the methodology used by Gorst et al. (2018), who emphasized the importance of assessing both the prevalence and distribution of somatosensory impairments to understand their functional impact. A further methodological strength is the selection of appropriate statistical tests based on data characteristics, including the independent t-test, Mann-Whitney U test & Spearman's rho. These choices were guided by the results of normality testing, consistent with statistical best practices (Field, 2024) and directly aligned with the analytical framework employed in Gorst et al. (2018), who also applied non-parametric and parametric methods depending on data distribution when analyzing the relationship between somatosensory impairments and walking speed, balance and falls. By adhering to such a validated methodology, the present study ensures both statistical rigor and comparability with established research in this domain.

The findings from this study have strong clinical relevance. Rehabilitation programs for stroke survivors often focus primarily on motor recovery, while sensory deficits are under-assessed and under-treated. The results suggest that sensory evaluations should be standard practice, particularly assessments of light touch, pin prick and proprioception, as they are significantly related to walking speed, balance and fall concern. Moreover, sensory-based interventions-including proprioceptive training, sensory stimulation protocols and somatosensory retraining-could play a key role in improving functional recovery. Studies have shown that interventions targeting sensory pathways (e.g., sensory discrimination tasks, vibration therapy, mirror therapy) can enhance motor outcomes and confidence in mobility (Sathian et al., 2011; Carey et al., 2016). This reinforces the need for integrated sensorimotor rehabilitation strategies, particularly in patients showing sensory impairment, to reduce fall risk and increase independence.

Limitations

Regarding this study there were some situational limitation or barriers to consider the result of the study. The study had small sample size. Only 123 samples were taken in this study which do not represent the condition of entire country's chronic stroke patients. Time was one of the major limitations. Due to the limited time available for the research, a large number of samples could not be managed for the study. The sample was collected only from CRP, Savar, Dhaka. If it was collected from other many institutes and rehabilitation center across the country, the result would be more reliable and appropriate. There was little evidence to support the result of this project in the context to Bangladesh. Because this study was cross-sectional, it could identify associations but could not establish causal relationships between somatosensory impairments and functional outcomes. Although fear of falling was assessed via the FES-I, the actual fall history or incidence of falls in the participants was not recorded. This limits the ability to directly link sensory impairments to live fall events, which would strengthen the clinical relevance of your findings. As this was the researcher's first research project, there were certain limitations due to limited experience in applying research techniques and strategies, particularly concerning the practical aspects of conducting research. Consequently, there may be some unintentional mistakes or shortcomings in the process.

Chapter-vi	Conclusion & recommendations

Conclusion

Despite the limited sample size and the cross-sectional nature of this study, it provided significant insight into the functional implications of lower limb somatosensory impairments in chronic stroke survivors. The study revealed that individuals with sensory deficits, particularly in distal regions like the toes and foot, experienced reduced walking speed, impaired balance and a greater concern about falling compared to those without such impairments. These findings were evaluated using standardized and validated tools, including the Erasmus MC modifications to the Nottingham Sensory Assessment (EmNSA), 10-Meter Walk Test (10MWT), Berg Balance Scale (BBS), and Falls Efficacy Scale-International (FES-I). These outcome measures captured the sensory and functional status of participants with reliability and clinical relevance. The findings support the need for sensory-focused assessment and rehabilitation strategies in stroke management. Somatosensory input, especially light touch and proprioception, plays a crucial role in maintaining posture, coordinating movement and preventing falls. Deficits in these modalities compromise not only physical function but also psychological stability due to increased fear of falling. While motor impairments have been the primary focus of stroke rehabilitation, this study contributes to the growing body of evidence that sensory impairments should not be overlooked, particularly as they impact day-to-day functionality and recovery pathways. Understanding how sensory dysfunction influences movement and stability enriches the broader view of stroke rehabilitation. It also opens new discussions about how stroke survivors adapt to altered sensory experiences and modify their expectations and perceptions of mobility and independence. This underscores the complexity of post-stroke recovery and the need for more inclusive, multidimensional approaches to patient assessment and care. Nevertheless, this study provides an important foundation for future investigations into the sensory dimensions of stroke recovery and underscores the importance of holistic rehabilitation strategies.

Recommendations

Though the study had several limitations, the researcher has identified some areas where future research and practical application can be improved for better outcomes. The main recommendations are as follows:

1. A larger sample size should be considered in future studies to increase the statistical power and enhance the generalizability of the results.
2. In future research, a random sampling technique rather than purposive sampling is recommended. This would reduce sampling bias and allow for more representative and generalizable findings across various demographic and clinical profiles.
3. The study was conducted within a limited timeframe. Extending the study period in future research would allow for more extensive data collection and potentially include longitudinal follow-up to assess changes over time.
4. This research was conducted in a single center (CRP, Savar). Future studies should involve participants from multiple rehabilitation centers across different regions of Bangladesh to ensure broader applicability of the findings.
5. Additional outcome measures could be included in future studies to establish stronger connections between sensory impairments and real-life functional limitations.
6. In future research, sensory-based intervention programs such as proprioceptive training, sensory re-education or task-specific balance activities could be tested to determine their effectiveness in improving walking, balance and fall prevention.
7. Lastly, incorporating both quantitative and qualitative approaches in future research could provide deeper insight into the lived experiences of stroke survivors with sensory impairments, including how these deficits impact their confidence, independence and quality of life.

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Appendix-1

বাংলাদেশ হেলথ্ প্রফেশন্স ইনস্টিটিউট (বিএইচপিআই)
Bangladesh Health Professions Institute (BHPI)
(The Academic Institute of CRP)

Ref: CRP-BHPI/IRB/12/2024/1025 Date: 15/12/2024

To
Shanjida Hossain Sayema
4th Year B.Sc. in Physiotherapy
Session: 2019-20, Student ID: 112190510
BHPI, CRP, Savar, Dhaka-1343, Bangladesh

Subject: Approval of the thesis proposal "Association of lower limb somatosensory impairments with walking, balance and falls in chronic stroke survivors: a cross sectional study" by ethics committee.

Dear Sayema,
Congratulations.
The Institutional Review Board (IRB) of BHPI has reviewed and discussed your application to conduct the above mentioned dissertation, with yourself, as the principal investigator and Nadia Afrin Urme as thesis supervisor. The Following documents have been reviewed and approved:

Sl. No.	Name of the Documents
1	Research Proposal
2	Questionnaire (English version)
3	Information sheet & consent form

The purpose of the study is to investigate the relationship of lower limb somatosensory impairments with functional outcomes such as walking ability, maintaining balance and the risk of falling among chronic stroke patients. The study involves use of a questionnaire including EmNSA, 10-Meter Walk Test (10MWT), Berg Balance Scale (BBS) and Falls Efficacy Scale-International (FES-I) that may take 30 to 40 minutes to fill in the questionnaire or participate in the test and there is no likelihood of any harm to the participants and participation in the study may benefit the participants or other stakeholders by improving targeted rehabilitation strategies to enhance walking ability, balance and reducing fall risk in chronic stroke survivors . The members of the Ethics committee have approved the study to be conducted in the presented form at the meeting held at **9 AM on 15th July, 2024 at BHPI (44th IRB Meeting).**

The institutional Ethics committee expects to be informed about the progress of the study, any changes occurring in the course of the study, any revision in the protocol and patient information or informed consent and ask to be provided a copy of the final report. This Ethics committee is working accordance to Nuremberg Code 1947, World Medical Association Declaration of Helsinki, 1964 - 2013 and other applicable regulation.

Best regards,

Muhammad Millat Hossain,
Associate Professor & Course Coordinator, MRS
Member Secretary, Institutional Review Board (IRB)
BHPI, CRP, Savar, Dhaka-1343, Bangladesh

সিআরপি-চাপাইন, সাভার, ঢাকা-১৩৪৩, বাংলাদেশ। ফোনঃ +৮৮ ০২ ২২৪৪৪৫৪৬৪-৫, +৮৮ ০২ ২২৪৪৪১৪০৪, মোবাইলঃ +৮৮ ০১৭৩০ ০৫৯৬৪৭
CRP-Chapain, Savar, Dhaka-1343, Bangladesh. Tel: +88 02 224445464-5, +88 02 224441404, Mobile: +88 01730059647
E-mail : principal-bhpi@crp-bangladesh.org, Web: bhpi.edu.bd

Appendix-2

Permission Letter

Date: 26/12/2024

Head

Department of Physiotherapy

Centre for the Rehabilitation of the Paralyzed (CRP)

Chapain, Savar, Dhaka-1343

Through: Head, Department of Physiotherapy, BHPI.

Subject: Prayer for seeking permission to collect data for conducting research project.

Sir,

With due respect and humble submission to state that I am Shanjida Hossain Sayema, a student of 4th year B.Sc. in Physiotherapy at Bangladesh Health Professions Institute (BHPI). The Ethical committee has approved my research project entitled: **"Association of lower limb somatosensory impairments with walking, balance and falls in chronic stroke survivors"** under the supervision of Nadia Afrin Urme, Lecturer, Department of Physiotherapy, BHPI. I want to collect data for my research project from the Department of Physiotherapy at CRP. So, I need permission for data collection from the Neurology Unit of Physiotherapy Department at CRP-Savar, Dhaka-1343. I would like to assure that anything of the study will not be harmful for the participants and the Department itself.

I, therefore pray and hope that you would be kind enough to grant my application and give me permission for data collection and oblige thereby.

Forwarded,
26/12/2024

Yours faithfully,

Forwarded and Recommened for kind approval.
28.12.2024.

Dr. Shazal Kumar Das, PhD
Assistant Professor and Head
Department of Physiotherapy
BHPI, CRP, Savar, Dhaka-1343.

Shanjida Hossain Sayema

4th Year B.Sc. in Physiotherapy

Class Roll: 18; Session: 2019-20

Bangladesh Health Professions Institute (BHPI)

(An academic Institution of CRP)

CRP-Chapain, Savar, Dhaka-1343.

Approved
31/12/24

Prof. Dr. Mohammad Anwar Hossain, PhD
Professor Physiotherapy Department BHPI
Senior Consultant & Head
Physiotherapy Department
CRP, Savar, Dhaka-1343

Appendix-3

Information sheet (English)

Research study tittle: Association of lower limb somatosensory impairments with walking, balance and falls in chronic stroke survivors: a cross-sectional study.

Objective of the study:

1. This study is being conducted to investigate the association of lower limb somatosensory impairments with functional outcomes such as walking ability, maintaining balance and the risk of falling among chronic stroke patients.
2. To collect the socio-demographic information of the person with stroke.

Participants of the study: Chronic stroke patients with lower limb somatosensory impairments, aged 18 and above, able to independently stand and walk at least 10m indoors are invited to participate in this research study.

Data collection procedure: If you participate in this study, you will be asked to some personal and other related information for the study by using a questionnaire. This will take approximately 20-30 minutes of your time.

Benefits of participations: Participants will have the opportunity to reflect on, share and more aware of their thoughts and feelings about their somatosensory impairments. Additionally, your participation and better statements are likely to help us find the answer to the research questions and in future study it may benefitted to the researcher.

Risks of participations: We do not foresee any risk or discomfort from your participation in the study.

Economic benefits: You will not be given any money or gifts to take part in this research.

Confidentiality: All information provided by you will be treated as confidential it will ensure that the source of information remains secret. Also, your name will not appear anywhere and no one except me will know about your specific answers.

Voluntary participation: Yours participation in this study is voluntary, so you may choose to participate or not. Your decision will not to volunteer will not influence the treatment you may be receiving either now or in the future. If you do not wish to continue, you have the right to withdraw from the study, without penalty, at any time.

Who to contact: If you have any query, you may ask me now or later, even after the study has started. If you wish to ask questions later, you may contact any of the following:

Researcher:

Shanjida Hossain Sayema

4th Professional B.Sc. in Physiotherapy

Bangladesh Health Professions Institute (BHPI)

Contact no: 01998129812

E-mail: shanjida.sayema@gmail.com

Or,

My research supervisor:

Nadia Afrin Urme

Lecturer, Department of Physiotherapy

Bangladesh Health Professions Institute (BHPI), CRP, Savar, Dhaka- 1343.

E-mail: afrinnadia4127@yahoo.com

<u>Consent certificate</u>

A) Participant or witness:

1. Did you understand the information sheet?

☐ Yes

☐ No

2. Do you have anything else to know?

☐ Yes

☐ No

(If yes, ...)

3. Do you understand that you will not benefit financially from this research?

☐ Yes

☐ No

4. Are you allowed to ask questions?

☐ Yes

☐ No

5. Do you consent to your information being recorded?

☐ Yes

☐ No

6. Have you got enough time to decide?

☐ Yes

☐ No

7. Are you consenting to participate in this study?

☐ Yes

☐ No

Name of Participant _________________________________

Signature of Participant ____________________________ Date _______________

If participant is Illiterate

Name of literate witness _____________________________

Thumb print of participant

Signature of literate witness _________________________ Date ______________

B) Researcher:

I explained the above study precisely to the participant and the participant indicated willingness to participate in the study.

Name of Researcher ________________________________

Signature of Researcher ____________________________ Date _______________

Questionnaire (English version)

Thank you for participating in this questionnaire. The purpose of this study is to explore the association between lower limb somatosensory impairments and their effects on walking ability, balance and the incidence of falls in individuals who have experienced a chronic stroke. Below is the questionnaire designed to gather relevant data from chronic stroke survivors.

Please answer every section and mark one option from each which is most appropriate.

Patient's Identification

Date:

Patient's name: Patient's ID:

Address: Mobile No:

Part- I: Socio-Demographic Information:

No.	Question	Response
1.	Age	_______ years
2.	Gender	□ Male □ Female
3.	Marital status	□ Married □ Unmarried □ Widow □ Widower □ Separated
4.	Living area	□ Rural □ Urban □ Semi-urban

5.	Educational level	□ No formal schooling □ Primary □ Secondary □ Higher Secondary □ Graduate □ Post-graduate □ Others
6.	Occupation	□ Jobless □ Service holder □ Businessman □ Housewife □ Student □ Others

Part- II: Stroke Related Information:

No.	Question	Response
7.	Duration of stroke	________ months/years
8.	Type of stroke	□ Ischemic □ Hemorrhagic
9.	Affected side	□ Right □ Left □ Both
10.	Co-morbidities	□ Hypertension □ Diabetes □ Heart Disease □ Kidney Disease □ Others: ____________

Part- III: Assessment of somatosensory impairments of lower limb in chronic stroke patients:

The Erasmus MC modifications to the (revised) Nottingham Sensory Assessment (EmNSA) will be used to evaluate sensory function in individuals who have experienced neurological conditions such as stroke. This assessment will help in identifying specific sensory impairments in areas like touch, pressure, pain and proprioception.

Instructions:

2 =Normal: Sensation is normal without any difficulties.

1 =Impaired: Sensation is present but altered compared to the contralateral side.

0 =Absent: No sensation detected.

Please (✓) to indicate your answer below.

The Erasmus MC modifications to the (revised) Nottingham Sensory Assessment (EmNSA):

Sensory Modality	Test Area	Right Limb	Left Limb
Light touch	Thigh/Hip	0 =Absent 1 =Impaired 2 =Normal	0 =Absent 1 =Impaired 2 =Normal
	Shin/Knee	0 =Absent 1 =Impaired 2 =Normal	0 =Absent 1 =Impaired 2 =Normal
	Foot/Ankle	0 =Absent 1 =Impaired 2 =Normal	0 =Absent 1 =Impaired 2 =Normal
	Toes	0=Absent 1=Impaired 2 =Normal	0 =Absent 1 =Impaired 2 =Normal

Pressure	Thigh/Hip	0=Absent 1=Impaired 2 =Normal	0 =Absent 1 =Impaired 2 =Normal
	Shin/Knee	0=Absent 1=Impaired 2 =Normal	0=Absent 1 =Impaired 2 =Normal
	Foot/Ankle	0=Absent 1=Impaired 2 =Normal	0 =Absent 1 =Impaired 2 =Normal
	Toes	0 =Absent 1 =Impaired 2 =Normal	0 =Absent 1 =Impaired 2 =Normal
Pin prick	Thigh/Hip	0 =Absent 1 =Impaired 2 =Normal	0 =Absent 1 =Impaired 2 =Normal
	Shin/Knee	0 =Absent 1 =Impaired 2 =Normal	0 =Absent 1 =Impaired 2 =Normal
	Foot/Ankle	0 =Absent 1 =Impaired 2 =Normal	0 =Absent 1 =Impaired 2 =Normal
	Toes	0 =Absent 1 =Impaired 2 =Normal	0 =Absent 1 =Impaired 2 =Normal
Sharp/blunt	Thigh/Hip	0 =Absent 1 =Impaired 2 =Normal	0 =Absent 1 =Impaired 2 =Normal

	Shin/Knee	0 =Absent 1 =Impaired 2 =Normal	0 =Absent 1 =Impaired 2 =Normal
	Foot/Ankle	0 =Absent 1 =Impaired 2 =Normal	0 =Absent 1 =Impaired 2 =Normal
	Toes	0 =Absent 1 =Impaired 2 =Normal	0 =Absent 1 =Impaired 2 =Normal
Proprioception	Thigh/Hip	0 =Absent 1 =Impaired 2 =Normal	0 =Absent 1 =Impaired 2 =Normal
	Shin/Knee	0 =Absent 1 =Impaired 2 =Normal	0 =Absent 1 =Impaired 2 =Normal
	Foot/Ankle	0 =Absent 1 =Impaired 2 =Normal	0 =Absent 1 =Impaired 2 =Normal
	Toes	0 =Absent 1 =Impaired 2 =Normal	0 =Absent 1 =Impaired 2 =Normal

Part- IV: Measurement of walking speed:

The 10-Meter Walk Test (10MWT) will be used to measure how fast someone can walk on a short distance, which will help us to understand their walking ability after a stroke.

Instructions:

- Patients will be asked to walk 10 meters (about 33 feet) at their usual walking speed.
- Time will be recorded and walking speed will be calculated.

Test attempt	Time taken(seconds)	Walking speed(m/s)	Average speed
1st trial			
2nd trial			

Part-V: Assessment of balance function through various tasks:

The Berg Balance Scale (BBS) is a widely used clinical test of a person's static and dynamic balance abilities. It consists of 14 items that assess balance through a series of tasks involving sitting, standing and changing positions consisting of a five-point ordinal scale ranging from 0 to 4, with 0 indicating the lowest level of function and 4 the highest level of function.

Item	Task Measures	Score
11.	**Sitting to standing: (***Please stand up. Try not to use your hand for support)* 4: Able to stand without using hands and stabilize independently 3: Able to stand independently using hands 2: Able to stand using hands after several tries 1: Needs minimal assist to stand or stabilize 0: Needs moderate to maximal assist to stand	

12.	**Standing unsupported:** *(Please stand for two minutes without holding on)* 4: Able to stand 2 minutes unsupported 3: Able to stand 2 minutes unsupported with supervision 2: Able to stand 30 seconds unsupported 1: Needs several tries to stand 30 seconds unsupported 0: Unable to stand 30 seconds unsupported	
13.	**Sitting with back unsupported but feet supported on floor or stool:** *(Please sit with arms folded for 2 minutes)* 4: Able to sit safely and securely for 2 minutes 3: Able to sit for 2 minutes under supervision 2: Able to sit for 30 seconds 1: Able to sit for 10 seconds 0: Unable to sit without support for 10 seconds	
14.	**Standing to sitting:** *(Please sit down)* 4: Sits safely without use of hands 3: Sits safely with minimal use of hands 2: Uses hand or back of legs against chair to control descent 1: Sits independently but has uncontrolled descent 0: Needs assistance to sit	
15.	**Transfers (from on chair to another):** *(Arrange chair for pivot transfer. Ask subject to transfer one way toward a seat with armrests and one way toward a seat without armrests. You may use a bed and a chair)* 4: Able to transfer safely with minor use of hands 3: Able to transfer safely definite need of hands 2: Able to transfer with verbal cuing and/or supervision 1: Needs one person to assist to transfer 0: Needs two people to assist or supervise to transfer	

16.	**Standing unsupported with eyes closed:** *(Please close your eyes and stand still for 10 seconds)* 4: Able to stand 10 seconds safely 3: Able to stand 10 seconds with supervision 2: Able to stand 3 seconds 1: Unable to keep eyes closed 3 seconds but stays safely 0: Needs help to keep from falling	
17.	**Standing unsupported with feet together:** *(Place your feet together and stand without holding on)* 4: Able to place feet together independently and stand 1 minute safely 3: Able to place feet together independently and stand 1 minute with supervision 2: Able to place feet together independently but unable to hold for 30 seconds 1: Needs help to attain position but able to stand 15 seconds feet together 0: Needs help to attain position and unable to hold for 15 seconds	
18.	**Reaching forward with outstretched arm while standing:** *(Lift arm to 90 degrees. Stretch out your fingers and reach forward as far as you can. Ask subject to use both arms when reaching to avoid rotation of the trunk)* 4: Can reach forward confidently 25 cm (10 inches) 3: Can reach forward 12 cm (5 inches) 2: Can reach forward 5 cm (2 inches) 1: Reaches forward but needs supervision 0: Loses balance while trying/requires external support	

19.	**Pick up object from the floor from a standing position:** *(Pick up the object, which is placed in front of your feet)* 4: Able to pick up object independently and stand up safely 3: Able to pick up object independently but cannot stand up independently 2: Unable to pick up but reaches 2-5 cm from object and keeps balance independently 1: Unable to pick up and needs supervision while trying 0: Unable to try/needs assist to keep from losing balance or falling	
20.	**Turning to look behind over left and right shoulders while standing:** *(Turn to look directly behind you over toward the left shoulder. Repeat to the right. Examiner may pick an object to look at directly behind the subject to encourage a better twist turn)* 4: Looks behind from both sides and weight shifts well 3: Looks behind one side only other side shows less weight shift 2: Turns sideways only but maintains balance 1: Needs supervision when turning 0: Needs assist to keep from losing balance or falling	
21.	**Turn 360 degrees:** *(Turn completely around in a full circle. Pause. Then turn a full circle in the other direction)* 4: Able to turn 360 degrees safely in 4 seconds or less 3: Able to turn 360 degrees safely one side only 4 seconds or less 2: Able to turn 360 degrees safely but slowly 1: Needs close supervision or verbal cuing 0: Needs assistance while turning	

22.	**Placing alternate foot on step or stool while standing unsupported:** *(Place each foot alternately on the step/stool. Continue until each foot has touch the step/stool four times)* 4: Able to stand independently and complete 8 steps safely in 20 seconds 3: Able to stand independently and complete 8 steps in > 20 seconds 2: Able to complete 4 steps with supervision 1: Able to complete > 2 steps but needs minimal assist 0: Needs assistance to keep from falling / unable to try	
23.	**Standing unsupported one foot in front:** *(Place one foot directly in front of the other. If you feel that you cannot place your foot directly in front, try to step far enough ahead that the heel of your forward foot is ahead of the toes of the other foot. To score 3 points, the length of the step should exceed the length of the other foot and the width of the stance should approximate the subject's normal stride width)* 4: Able to place foot tandem independently and hold 30 seconds 3: Able to place foot ahead independently and hold 30 seconds 2: Able to take small step independently and hold 30 seconds 1: Needs help to step but can hold 15 seconds 0: Loses balance while stepping or standing	
24.	**Standing on one foot:** *(Stand on one foot as long as you can without holding on)* 4: Able to stand independently for 10 seconds 3: Able to stand independently for 7-10 seconds 2: Able to stand independently and hold 3-7 seconds 1: Tries to lift foot but unable to hold for 3 seconds 0: Unable to try or needs assistance to prevent fall	
	Total Berg Balance Score	/56

The maximum score on the Berg Balance Scale is 56

Interpretation of total scores:

41-56: Independent

21-40: Walking with assistance

0-20: Wheelchair bound

Part-VI: Assessment of fear of falling during various activities of daily living:

The Falls Efficacy Scale-International (FES-I) consists of 16 items, each representing a common activity. Respondents rate their concern about falling during each activity on a 4-point scale. Here is the detailed table for the FES-I questionnaire:

Item	Activity	Score (concern about falling)			
		Very concerned (4)	Fairly concerned (3)	Somewhat concerned (2)	Not at all concerned (1)
25.	Cleaning the house (e.g., sweep, vacuum, dust)				
26.	Getting dressed or undressed				
27.	Preparing simple meals				
28.	Taking a bath or shower				
29.	Going to the shop				
30.	Getting in or out of a chair				
31.	Going up or down stairs				
32.	Walking around in the neighborhood				
33.	Reaching for something above your head or on the ground				
34.	Going to answer the telephone before it stops ringing				
35.	Walking on a slippery surface (e.g., wet or icy)				

36.	Visiting a friend or relative				
37.	Walking in a place with crowds				
38.	Walking on an uneven surface (e.g., rocky ground, poorly maintained pavement)				
39.	Walking up or down a slope				
40.	Going out to a social event (e.g., religious service, family gathering or club meeting)				
	Sub Total				
				TOTAL	/64

The total score ranges from 16 (no concern about falling) to 64 (extreme concern about falling). Higher scores indicate a greater fear of falling.

Interpretation of the total scores:

16-19: low concern about falling

20-27: moderate concern about falling

28-64: high concern about falling

তথ্য তালিকা(বাংলা)

গবেষণার শিরোনাম: দীর্ঘমেয়াদি স্ট্রোক রোগীদের হাঁটা, ভারসাম্য এবং পড়ে যাওয়ার সঙ্গে নিম্ন অঙ্গের সংবেদনশীল দুর্বলতার সম্পর্ক: একটি ক্রস-সেকশনাল গবেষণা।

গবেষণার উদ্দেশ্য:

১। দীর্ঘমেয়াদি স্ট্রোক রোগীদের মধ্যে নিম্ন অঙ্গের সংবেদনশীল সমস্যার সঙ্গে হাঁটা, ভারসাম্য এবং পড়ে যাওয়ার ঝুঁকির সম্পর্ক নির্ধারণ করা।

২। স্ট্রোক রোগীদের সামাজিক ও ব্যক্তিগত তথ্য সংগ্রহ করা।

গবেষণায় অংশগ্রহণকারীরা: ১৮ বছর বা তদূর্ধ্ব বয়সের, স্ট্রোকে আক্রান্ত রোগী যারা নিজেরা অন্তত ১০ মিটার হাঁটতে ও দাঁড়াতে সক্ষম, তাদের গবেষণায় অংশগ্রহণের জন্য আমন্ত্রণ জানানো হচ্ছে।

তথ্য সংগ্রহ পদ্ধতি: প্রশ্নপত্রের মাধ্যমে কিছু ব্যক্তিগত ও প্রয়োজনীয় তথ্য জিজ্ঞাসা করা হবে। সময় লাগবে আনুমানিক ২০-৩০ মিনিট।

অংশগ্রহণের উপকারিতা: অংশগ্রহণকারীরা তাদের শারীরিক সংবেদী দুর্বলতা সম্পর্কে তাদের চিন্তাভাবনা এবং অনুভূতি সম্পর্কে প্রতিফলিত করার, শেয়ার করার এবং আরও সচেতন হওয়ার সুযোগ পাবে। উপরন্তু, আপনার অংশগ্রহণ এবং আরও ভাল বিবৃতিগুলি আমাদের গবেষণা প্রশ্নের উত্তর খুঁজে পেতে সাহায্য করবে এবং ভবিষ্যতে গবেষণায় এটি গবেষকের জন্য উপকৃত হতে পারে।

অংশগ্রহণের ঝুঁকি:আমরা আশা করি না যে এই গবেষণায় অংশগ্রহণের কারণে আপনার কোনো ঝুঁকি বা অস্বস্তি হবে।

আর্থিক সুবিধা: এই গবেষণায় অংশগ্রহণের জন্য কোনো টাকা বা উপহার দেওয়া হবে না।

গোপনীয়তা: আপনার দেওয়া সকল তথ্য গোপনীয় রাখা হবে। আপনার নাম কোথাও প্রকাশ করা হবে না এবং আপনার নির্দিষ্ট উত্তর শুধুমাত্র গবেষকের জানা থাকবে।

স্বেচ্ছাসেবী অংশগ্রহণ: আপনার অংশগ্রহণ সম্পূর্ণ স্বেচ্ছাসেবী। আপনি অংশগ্রহণ করবেন কিনা তা সম্পূর্ণ আপনার ইচ্ছার ওপর নির্ভর করে।যদি অংশগ্রহণ করতে না চান, এটি আপনার বর্তমান বা ভবিষ্যতের চিকিৎসার ওপর কোনো প্রভাব ফেলবে না। আপনি যে কোনো সময় গবেষণা থেকে সরে যাওয়ার অধিকার রাখেন।

যোগাযোগ: আপনার কোনো প্রশ্ন থাকলে, গবেষণার সময় বা পরে নিচের যেকোনো একজনের সাথে যোগাযোগ করতে পারেন:

গবেষক:
সানজিদা হোসেন সায়মা
৪র্থ বর্ষ, বিএসসি ইন ফিজিওথেরাপি
বাংলাদেশ হেলথ প্রফেশনস ইনস্টিটিউট (বি এইচ পি আই)
ফোন: ০১৯৯৮১২৯৮১২
ইমেইল: Shanjida.sayema@gmail.com

অথবা,

গবেষণা তত্ত্বাবধায়ক:
নাদিয়া আফরিন উর্মি
লেকচারার, ফিজিওথেরাপি বিভাগ
বি এইচ পি আই, সিআরপি, সাভার, ঢাকা-১৩৪৩
ইমেইল: afrinnadia4127@yahoo.com

অনুমতি সনদ

ক)অংশগ্রহণকারী বা সাক্ষী:

১. আপনি কি তথ্য শীটটি বুঝেছেন?

□ হ্যাঁ

□ না

২. আপনার কি কিছু জানতে বাকি আছে?

□ হ্যাঁ

□ না

(যদি হ্যাঁ হয়,…………………………………………………………………….)

৩. আপনি কি বুঝেছেন যে এই গবেষণায় আপনি আর্থিক সুবিধা পাবেন না?

□ হ্যাঁ

□ না

৪. আপনি কি প্রশ্ন করার অনুমতি পাচ্ছেন?

□ হ্যাঁ

□ না

৫. আপনি কি আপনার তথ্য রেকর্ড করার সম্মতি দিচ্ছেন?

□ হ্যাঁ

□ না

৬. সিদ্ধান্ত নেওয়ার জন্য আপনার কি যথেষ্ট সময় পেয়েছেন?

□ হ্যাঁ

□ না

৭. আপনি কি এই গবেষণায় অংশগ্রহণ করতে সম্মত?

□ হ্যাঁ

□ না

অংশগ্রহণকারীর নাম: ______________________

অংশগ্রহণকারীর স্বাক্ষর: ____________________ তারিখ: ______________

যদি অংশগ্রহণকারী নিরক্ষর হন:

সাক্ষীর নাম: ______________________

অংশগ্রহণকারীর টিপসই: _______________

সাক্ষীর স্বাক্ষর: ______________________ তারিখ: _______________

খ)গবেষক:

আমি উপরের গবেষণা সম্পর্কে সঠিকভাবে অংশগ্রহণকারীকে ব্যাখ্যা করেছি এবং তিনি অংশগ্রহণ করতে ইচ্ছুক বলে সম্মতি দিয়েছেন।

গবেষকের নাম: _________________

গবেষকের স্বাক্ষর: ________________ তারিখ-------------------------

প্রশ্নপত্র (বাংলা ভার্সন)

এই প্রশ্নাবলীতে অংশগ্রহণ করার জন্য আপনাকে ধন্যবাদ। এই অধ্যয়নের উদ্দেশ্য হল দীর্ঘমেয়াদি স্ট্রোক রোগীদের মধ্যে নিম্ন অঙ্গের সংবেদনশীল সমস্যার সঙ্গে হাঁটা, ভারসাম্য এবং পড়ে যাওয়ার ঝুঁকির সম্পর্ক নির্ধারণ করা। দীর্ঘমেয়াদি স্ট্রোক রোগীদের কাছ থেকে প্রাসঙ্গিক তথ্য সংগ্রহ করার জন্য ডিজাইন করা প্রশ্নাবলী নীচে দেওয়া হল।

অনুগ্রহ করে প্রতিটি বিভাগের উত্তর দিন এবং প্রতিটি থেকে একটি বিকল্প চিহ্নিত করুন যা সবচেয়ে উপযুক্ত।

রোগীর পরিচয়

তারিখ:

রোগীর নাম: রোগীর আইডি:

ঠিকানা: মোবাইল নম্বর:

পর্ব- ১: সামাজিক-জনসংখ্যাতাত্ত্বিক তথ্য:

নং.	প্রশ্ন	উত্তর
১.	বয়স	______ বছর
২.	লিঙ্গ	□ পুরুষ □ মহিলা
৩.	বৈবাহিক অবস্থা	□ বিবাহিত □ অবিবাহিত □ বিধবা □ বিধুর □ পৃথক
৪.	বসবাসের এলাকা	□ গ্রামীণ □ শহর □ আধা-শহর

৫.	শিক্ষাগত স্তর	□ কোনো আনুষ্ঠানিক শিক্ষা নেই □ প্রাথমিক □ মাধ্যমিক □ উচ্চ মাধ্যমিক □ স্নাতক □ স্নাতকোত্তর □ অন্যান্য
৬.	পেশা	□ বেকার □ চাকরিজীবী □ ব্যবসায়ী □ গৃহিণী □ শিক্ষার্থী □ অন্যান্য

পর্ব- ২: স্ট্রোক সম্পর্কিত তথ্য:

নং.	প্রশ্ন	উত্তর
৭.	স্ট্রোক হওয়ার সময়কাল	________ মাস / বছর
৮.	স্ট্রোকের ধরণ	□ ইস্কেমিক □ হেমোরেজিক
৯.	আক্রান্ত দিক	□ ডান □ বাম □ উভয়
১০.	অন্যান্য রোগ	□ উচ্চ রক্তচাপ □ ডায়াবেটিস □ হৃদরোগ □ কিডনি রোগ □ অন্যান্য: ___________

পর্ব- ৩: দীর্ঘস্থায়ী স্ট্রোক রোগীদের নিম্নাঙ্গের সংবেদনশক্তি মূল্যায়ন:

এরাসমাস এমসি সংশোধিত (পুনর্গঠিত) নটিংহাম সংবেদনশীলতা মূল্যায়ন (ইএমএনএসএ) স্ট্রোকের মতো স্নায়বিক অবস্থার অভিজ্ঞতা আছে এমন ব্যক্তিদের সংবেদনশীল ক্রিয়া মূল্যায়ন করতে ব্যবহার করা হবে।এই মূল্যায়ন স্পর্শ, চাপ, ব্যথা, এবং প্রোপ্রিওসেপশন-এর মতো নির্দিষ্ট সেন্সরি প্রতিবন্ধকতা সনাক্ত করতে সাহায্য করে।

নির্দেশাবলী:

২ = স্বাভাবিক: আপনি প্রত্যাশিত মতো অনুভব করতে পারেন, কোনো অসুবিধা ছাড়াই।

১ = প্রতিবন্ধক: আপনি অনুভব করতে পারেন, কিন্তু এটি স্বাভাবিকের তুলনায় ভিন্ন বা কম।

০ = অনুপস্থিত: আপনি কোনোভাবেই অনুভব করতে পারছেন না।

অনুগ্রহ করে (✓) নিচে আপনার উত্তর নির্দেশ করুন।

এরাসমাস এমসি সংশোধিত (পুনর্গঠিত) নটিংহাম সংবেদনশীলতা মূল্যায়ন (ইএমএনএসএ):

সংবেদী মাধ্যম	পরীক্ষার এলাকা	ডান পা	বাম পা
হালকা স্পর্শ	উরু/নিতম্ব	০ = অনুপস্থিত ১ = প্রতিবন্ধক ২ = স্বাভাবিক	০ = অনুপস্থিত ১ = প্রতিবন্ধক ২ = স্বাভাবিক
	হাঁটু	০ = অনুপস্থিত ১ = প্রতিবন্ধক ২ = স্বাভাবিক	০ = অনুপস্থিত ১ = প্রতিবন্ধক ২ = স্বাভাবিক
	গোড়ালি	০ = অনুপস্থিত ১ = প্রতিবন্ধক ২ = স্বাভাবিক	০ = অনুপস্থিত ১ = প্রতিবন্ধক ২ = স্বাভাবিক
	আঙুল	০ = অনুপস্থিত ১ = প্রতিবন্ধক ২ = স্বাভাবিক	০ = অনুপস্থিত ১ = প্রতিবন্ধক ২ = স্বাভাবিক
চাপ	উরু/নিতম্ব	০= অনুপস্থিত ১= প্রতিবন্ধক ২ = স্বাভাবিক	০ = অনুপস্থিত ১ = প্রতিবন্ধক ২ = স্বাভাবিক

	হাঁটু	০ = অনুপস্থিত ১ = প্রতিবন্ধক ২ = স্বাভাবিক	০ = অনুপস্থিত ১ = প্রতিবন্ধক ২ = স্বাভাবিক
	গোড়ালি	০ = অনুপস্থিত ১ = প্রতিবন্ধক ২ = স্বাভাবিক	০ = অনুপস্থিত ১ = প্রতিবন্ধক ২ = স্বাভাবিক
	আঙুল	০ = অনুপস্থিত ১ = প্রতিবন্ধক ২ = স্বাভাবিক	০ = অনুপস্থিত ১ = প্রতিবন্ধক ২ = স্বাভাবিক
পিন প্রিক	উরু/নিতম্ব	০ = অনুপস্থিত ১ = প্রতিবন্ধক ২ = স্বাভাবিক	০ = অনুপস্থিত ১ = প্রতিবন্ধক ২ = স্বাভাবিক
	হাঁটু	০ = অনুপস্থিত ১ = প্রতিবন্ধক ২ = স্বাভাবিক	০ = অনুপস্থিত ১ = প্রতিবন্ধক ২ = স্বাভাবিক
	গোড়ালি	০ = অনুপস্থিত ১ = প্রতিবন্ধক ২ = স্বাভাবিক	০ = অনুপস্থিত ১ = প্রতিবন্ধক ২ = স্বাভাবিক
	আঙুল	০ = অনুপস্থিত ১ = প্রতিবন্ধক ২ = স্বাভাবিক	০ = অনুপস্থিত ১ = প্রতিবন্ধক ২ = স্বাভাবিক
ধারালো/ভোঁতা	উরু/নিতম্ব	০ =অনুপস্থিত ১ = প্রতিবন্ধক ২ = স্বাভাবিক	০ =অনুপস্থিত ১ = প্রতিবন্ধক ২ = স্বাভাবিক
	হাঁটু	০ =অনুপস্থিত ১ = প্রতিবন্ধক ২ = স্বাভাবিক	০ =অনুপস্থিত ১ = প্রতিবন্ধক ২ = স্বাভাবিক
	গোড়ালি	০ =অনুপস্থিত ১ = প্রতিবন্ধক ২ = স্বাভাবিক	০ =অনুপস্থিত ১ = প্রতিবন্ধক ২ = স্বাভাবিক

	আঙুল	০ =অনুপস্থিত ১ = প্রতিবন্ধক ২ = স্বাভাবিক	০ =অনুপস্থিত ১ = প্রতিবন্ধক ২ = স্বাভাবিক
প্রোপ্রিওসেপশন	উরু/নিতম্ব	০ =অনুপস্থিত ১ = প্রতিবন্ধক ২ = স্বাভাবিক	০ =অনুপস্থিত ১ = প্রতিবন্ধক ২ = স্বাভাবিক
	হাঁটু	০ =অনুপস্থিত ১ = প্রতিবন্ধক ২ = স্বাভাবিক	০ =অনুপস্থিত ১ = প্রতিবন্ধক ২ = স্বাভাবিক
	গোড়ালি	০ =অনুপস্থিত ১ = প্রতিবন্ধক ২ = স্বাভাবিক	০ =অনুপস্থিত ১ = প্রতিবন্ধক ২ = স্বাভাবিক
	আঙুল	০ =অনুপস্থিত ১ = প্রতিবন্ধক ২ = স্বাভাবিক	০ =অনুপস্থিত ১ = প্রতিবন্ধক ২ = স্বাভাবিক

পর্ব- ৪: হাঁটার গতি পরিমাপ:

১০ -মিটার ওয়াক টেস্ট (10MWT) একটি স্বল্প দূরত্বে কেউ কত দ্রুত হাঁটতে পারে তা পরিমাপ করতে ব্যবহার করা হবে, যা আমাদের স্ট্রোকের পরে তাদের হাঁটার ক্ষমতা বুঝতে সাহায্য করবে।

নির্দেশাবলী:

- রোগীদের তাদের স্বাভাবিক হাঁটার গতিতে ১০ মিটার (প্রায় ৩৩ ফুট) হাঁটতে বলা হবে।
- সময় রেকর্ড করা হবে এবং হাঁটার গতি গণনা করা হবে।

পরীক্ষা প্রচেষ্টা	সময় (সেকেন্ডে)	হাঁটার গতি (মি/সে)	গড় গতি
প্রথম পরীক্ষা			
দ্বিতীয় পরীক্ষা			

পর্ব- ৫ : বিভিন্ন কাজের মাধ্যমে ভারসাম্য ক্রিয়া মূল্যায়ন:

বার্গ ব্যালান্স স্কেল (বিবিএস) হলো একটি বহুল ব্যবহৃত ক্লিনিক্যাল পরীক্ষা যা একজন ব্যক্তির স্থির এবং গতিশীল ভারসাম্য সক্ষমতা মূল্যায়ন করে। এটি ১৪টি ধাপে বিভক্ত, যা বসা, দাঁড়ানো এবং অবস্থান পরিবর্তনের মাধ্যমে ভারসাম্য যাচাই করে। প্রতিটি ধাপ ০ থেকে ৪ পর্যন্ত পাঁচ ধরণের মানদণ্ডে মূল্যায়ন করা হয়, যেখানে ০ সর্বনিম্ন সক্ষমতা এবং ৪ সর্বোচ্চ সক্ষমতা নির্দেশ করে।

পদ	কাজের পরিমাপ	স্কোর
১১.	**বসা থেকে দাঁড়ানো:** ৪: হাত ব্যবহার না করে সম্পূর্ণ স্বাধীনভাবে দাঁড়াতে পারে ৩: হাত ব্যবহার করে সম্পূর্ণ স্বাধীনভাবে দাঁড়াতে পারে ২: একাধিক চেষ্টার পর হাত ব্যবহার করে দাঁড়াতে পারে ১: দাঁড়াতে সামান্য সহায়তা প্রয়োজন ০: দাঁড়াতে মাঝারি থেকে সর্বোচ্চ সহায়তা প্রয়োজন	
১২.	**দাঁড়িয়ে থাকা (সহায়তা ছাড়া):** ৪: ২ মিনিট ধরে স্বাধীনভাবে দাঁড়াতে পারে ৩: ২ মিনিট ধরে স্বাধীনভাবে দাঁড়াতে পারে, তবে তত্ত্বাবধান প্রয়োজন ২: ৩০ সেকেন্ড ধরে স্বাধীনভাবে দাঁড়াতে পারে ১: ৩০ সেকেন্ড ধরে দাঁড়ানোর জন্য বেশ কয়েকবার চেষ্টা করতে হয় ০: ৩০ সেকেন্ড ধরে দাঁড়াতে পারে না	
১৩.	**পায়ের সমর্থন নিয়ে পিছনে সাপোর্ট ছাড়াই বসা:** ৪: ২ মিনিট নিরাপদে এবং নিশ্চিতভাবে বসতে পারে ৩: ২ মিনিট তত্ত্বাবধানে বসতে পারে ২: ৩০ সেকেন্ড বসতে পারে ১: ১০ সেকেন্ড বসতে পারে ০: ১০ সেকেন্ড সমর্থন ছাড়া বসতে পারে না	
১৪.	**দাঁড়ানো থেকে বসা:** ৪: হাত ব্যবহার না করেই নিরাপদে বসে ৩: হাতের সামান্য ব্যবহার করে নিরাপদে বসে ২: হাত বা পায়ের পেছন ব্যবহার করে ধীরে বসে ১: স্বাধীনভাবে বসে, কিন্তু অনিয়ন্ত্রিতভাবে নামে ০: বসতে সহায়তা প্রয়োজন	

১৫.	**স্থানান্তর (এক চেয়ার থেকে অন্য চেয়ারে):** ৪: হাতের সামান্য ব্যবহার করে নিরাপদে স্থানান্তর করতে পারে ৩: হাতের নির্দিষ্ট ব্যবহার করে নিরাপদে স্থানান্তর করতে পারে ২: মৌখিক নির্দেশনা এবং/অথবা তত্ত্বাবধান সহ স্থানান্তর করতে পারে ১: স্থানান্তরের জন্য এক ব্যক্তির সহায়তা প্রয়োজন ০: স্থানান্তরের জন্য দুই ব্যক্তির সহায়তা বা তত্ত্বাবধান প্রয়োজন	
১৬.	**চোখ বন্ধ অবস্থায় সহায়তা ছাড়া দাঁড়ানো:** ৪: ১০ সেকেন্ড নিরাপদে দাঁড়াতে পারে ৩: তত্ত্বাবধান সহ ১০ সেকেন্ড দাঁড়াতে পারে ২: ৩ সেকেন্ড দাঁড়াতে পারে ১: চোখ বন্ধ রেখে ৩ সেকেন্ড ধরে রাখতে পারে না তবে নিরাপদে থাকে ০: পড়ে যাওয়া থেকে রক্ষা পেতে সহায়তা প্রয়োজন	
১৭.	**পা একসাথে রেখে সহায়তা ছাড়া দাঁড়ানো:** ৪: স্বাধীনভাবে পা একসাথে রেখে ১ মিনিট নিরাপদে দাঁড়াতে পারে ৩: স্বাধীনভাবে পা একসাথে রেখে ১ মিনিট তত্ত্বাবধানে দাঁড়াতে পারে ২: স্বাধীনভাবে পা একসাথে রাখতে পারে কিন্তু ৩০ সেকেন্ড ধরে রাখতে পারে না ১: অবস্থান অর্জনে সহায়তা প্রয়োজন কিন্তু ১৫ সেকেন্ড দাঁড়াতে পারে ০: অবস্থান অর্জনে সহায়তা প্রয়োজন এবং ১৫ সেকেন্ড ধরে রাখতে পারে না	
১৮.	**সামনে প্রসারিত হাত দিয়ে সামনে পৌঁছানো দাঁড়িয়ে থাকা অবস্থায়:** ৪: আত্মবিশ্বাসের সাথে ২৫ সেমি (১০ ইঞ্চি) পৌঁছাতে পারে ৩: ১২ সেমি (৫ ইঞ্চি) পৌঁছাতে পারে ২: ৫ সেমি (২ ইঞ্চি) পৌঁছাতে পারে ১: সামনে পৌঁছায় কিন্তু তত্ত্বাবধান প্রয়োজন ০: চেষ্টা করার সময় ভারসাম্য হারায়/বাহ্যিক সমর্থন প্রয়োজন	
১৯.	**দাঁড়ানো অবস্থায় মেঝে থেকে বস্তু উঠানো:** ৪: স্বাধীনভাবে বস্তু উঠাতে এবং নিরাপদে দাঁড়াতে পারে ৩: স্বাধীনভাবে বস্তু উঠাতে পারে কিন্তু স্বাধীনভাবে দাঁড়াতে পারে না ২: বস্তু উঠাতে পারে না কিন্তু বস্তু থেকে ২-৫ সেমি পৌঁছাতে পারে এবং ভারসাম্য বজায় রাখে ১: বস্তু উঠাতে পারে না এবং চেষ্টা করার সময় তত্ত্বাবধান প্রয়োজন ০: চেষ্টা করতে পারে না/ভারসাম্য হারানো থেকে রক্ষা পেতে সহায়তা প্রয়োজন	

২০.	**দাঁড়িয়ে থাকা অবস্থায় বাঁ ও ডান কাঁধের ওপরে পিছনে তাকানো:** ৪: উভয় দিক থেকে পিছনে তাকায় এবং ভারসাম্য বজায় রাখে ৩: শুধুমাত্র একদিকে পিছনে তাকায়, অন্যদিকে কম ভারসাম্য প্রদর্শন করে ২: কেবল পাশের দিকে ঘুরে, তবে ভারসাম্য বজায় রাখে ১: ঘুরতে গেলে তত্ত্বাবধান প্রয়োজন ০: ভারসাম্য হারানো থেকে রক্ষা পেতে সহায়তা প্রয়োজন	
২১.	**৩৬০ ডিগ্রি ঘোরা:** ৪: নিরাপদে ৪ সেকেন্ড বা তার কম সময়ে ৩৬০ ডিগ্রি ঘুরতে পারে ৩: এক দিক থেকে নিরাপদে ৪ সেকেন্ড বা তার কম সময়ে ৩৬০ ডিগ্রি ঘুরতে পারে ২: নিরাপদে ৩৬০ ডিগ্রি ঘুরতে পারে কিন্তু ধীর গতিতে ১: ঘুরার সময় নিকট তত্ত্বাবধান বা মৌখিক নির্দেশনার প্রয়োজন ০: ঘুরার সময় সহায়তা প্রয়োজন	
২২.	**সহায়তা ছাড়া দাঁড়িয়ে বিকল্প পা মাচা বা স্টুলে রাখা:** ৪: স্বাধীনভাবে দাঁড়াতে এবং ২০ সেকেন্ডে ৮টি ধাপ সম্পূর্ণ করতে পারে ৩: স্বাধীনভাবে দাঁড়াতে এবং ২০ সেকেন্ডের বেশি সময়ে ৮টি ধাপ সম্পূর্ণ করতে পারে ২: তত্ত্বাবধান সহ ৪টি ধাপ সম্পূর্ণ করতে পারে ১: ২টির বেশি ধাপ সম্পূর্ণ করতে পারে কিন্তু সামান্য সহায়তা প্রয়োজন ০: পড়ে যাওয়া থেকে রক্ষা পেতে সহায়তা প্রয়োজন / চেষ্টা করতে পারে না	
২৩.	**এক পা সামনে রেখে সহায়তা ছাড়া দাঁড়ানো:** ৪: স্বাধীনভাবে পা ট্যান্ডেমে রাখতে এবং ৩০ সেকেন্ড ধরে রাখতে পারে ৩: স্বাধীনভাবে পা সামনে রাখতে এবং ৩০ সেকেন্ড ধরে রাখতে পারে ২: ছোট ধাপ স্বাধীনভাবে নিতে এবং ৩০ সেকেন্ড ধরে রাখতে পারে ১: পদক্ষেপ নিতে সহায়তা প্রয়োজন কিন্তু ১৫ সেকেন্ড ধরে রাখতে পারে ০: পদক্ষেপ নেওয়ার বা দাঁড়ানোর সময় ভারসাম্য হারায়	
২৪.	**এক পায়ে দাঁড়ানো:** ৪: ১০ সেকেন্ড স্বাধীনভাবে দাঁড়াতে পারে ৩: ৭-১০ সেকেন্ড স্বাধীনভাবে দাঁড়াতে পারে ২: ৩-৭ সেকেন্ড স্বাধীনভাবে দাঁড়াতে পারে ১: পা তুলতে চেষ্টা করে কিন্তু ৩ সেকেন্ড ধরে রাখতে পারে না ০: চেষ্টা করতে পারে না বা পড়ে যাওয়া রোধে সহায়তা প্রয়োজন	
	মোট বার্গ ব্যালান্স স্কোর	/৫৬

বার্গ ব্যালেন্স স্কেলে সর্বোচ্চ স্কোর হল- ৫৬

মোট স্কোর ব্যাখ্যা:

৪১-৫৬: স্বাধীনভাবে চলাফেরা

২১-৪০: সহায়তা নিয়ে হাঁটা

০-২০: হুইলচেয়ার নির্ভর

পর্ব- ৬: দৈনন্দিন জীবনের বিভিন্ন কার্যকলাপের সময় পড়ে যাওয়ার ভয় মূল্যায়ন করা:

ফলস এফিকেসি স্কেল-ইন্টারন্যাশনাল (FES-I) ১৬টি আইটেম নিয়ে গঠিত, যেখানে প্রতিটি আইটেম একটি সাধারণ দৈনন্দিন কার্যকলাপকে উপস্থাপন করে। অংশগ্রহণকারীরা প্রতিটি কার্যকলাপের সময় পড়ে যাওয়ার বিষয়ে তাদের উদ্বেগের মাত্রা ৪-পয়েন্টের একটি স্কেলে মূল্যায়ন করেন।এখানে FES-I প্রশ্নমালার বিস্তারিত তালিকা:

পদ	কার্যকলাপ	স্কোর (পড়ে যাওয়ার উদ্বেগ)			
		খুব উদ্বিগ্ন (৪)	মাঝারি উদ্বিগ্ন (৩)	কিছুটা উদ্বিগ্ন (২)	মোটেও উদ্বিগ্ন না (১)
২৫.	বাড়ি পরিষ্কার করা (যেমন: ঝাড়ু, ভ্যাকুয়াম, ধুলো)				
২৬.	পোশাক পরা বা খোলা				
২৭.	সাধারণ খাবার তৈরি করা				
২৮.	স্নান বা গোসল করা				
২৯.	বাজারে যাওয়া				
৩০.	চেয়ার থেকে ওঠা/বসা				
৩১.	সিঁড়ি ওঠা/নামা				
৩২.	আশেপাশে হাঁটা				
৩৩.	উপর থেকে কিছু নেওয়া বা নিচ থেকে তোলা				
৩৪.	বাজানো বন্ধ হওয়ার আগেই ফোন ধরতে যাওয়া				
৩৫.	পিচ্ছিল জায়গায় হাঁটা (যেমন, ভেজা বা বরফ)				

৩৬.	একটি বন্ধু বা আত্মীয় পরিদর্শন				
৩৭.	ভিড়ের মধ্যে হাঁটা				
৩৮.	অমসৃণ জায়গায় হাঁটা (যেমন, পাথুরে মাটি, খারাপভাবে রক্ষণাবেক্ষণ করা ফুটপাথ)				
৩৯.	উঁচু-নিচু ঢালে হাঁটা				
৪০.	সামাজিক অনুষ্ঠানে যাওয়া (যেমন, ধর্মীয় সেবা, পরিবার সমাবেশ বা ক্লাব মিটিং)				
আংশিক যোগফল					
মোট স্কোর:					/৬৪

মোট স্কোর পরিসীমা ১৬ (পতন নিয়ে কোন উদ্বেগ নেই) থেকে ৬৪ (চরম উদ্বেগজনক) পতন সম্পর্কে)। উচ্চ স্কোর পতনের একটি বড় ভয় নির্দেশ করে।

মোট স্কোর ব্যাখ্যা:

১৬-১৯: পতন সম্পর্কে কম উদ্বেগ

২০-২৭: পতন সম্পর্কে মাঝারি উদ্বেগ

২৮-৬৪: পতন সম্পর্কে উচ্চ উদ্বেগ