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# INFLUENCE OF GENDER IN HEMIPLEGIC GAIT - A KINEMATIC ANALYSIS

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## ABSTRACT

**Background:** Gait is considered as a factor of high quality influencing rehabilitation and quality of life. Hemiplegics show asymmetric gait pattern and return of walking ability is an important indicator of successful rehabilitation. Gender based differences exist in hemiplegic gait. This can impact the outcome of rehabilitation. Though gait analyses have been carried out in different settings, there are very little studies regarding the influence of gender in gait in hemiplegia. Hence our study, comparing the kinematics of hip, knee and ankle of the hemiplegic limb is carried out. **Aims and Objectives:** The objective of the study is a comparison of gait analysis parameters of stroke survivors based on gender using Instrumental Gait Analysis (IGA) system. **Methods:** The present study is the outcome of an observational study conducted in the Gait Laboratory of Department of Physical Medicine and Rehabilitation, Medical College Kottayam. 100 subjects were selected for the study fulfilling the inclusion criteria. ISen3.08 system and STT-IWS sensors were used to carry out the Gait analysis and kinematic data was collected. Quantitative data was analyzed by descriptive statistical analysis. Qualitative data was expressed as frequency and percentage. **Results:** The mid stance knee and ankle and terminal stance knee were statistically significant. In mid stance, mean knee angle in males was -1.90 whereas in females it was 0.26. In terminal stance, males showed 9.08 and females 12.28. The ankle in midstance showed a value of -0.33 in males and 1.30 in females. **Conclusion:** This study confirms that there are gender based variations in the angular kinematic parameters in hemiplegic gait. Females are more severely affected in various phases of gait cycle with significant involvement in the mid stance and terminal stance phases.

**KEYWORDS :** Stroke, hemiplegia, gait, gender.

## BACKGROUND:

Stroke is the third leading cause of mortality and morbidity combined[1]. Many survivors suffer long term disability[2] and in spite of comprehensive rehabilitation care report a decline in their quality of life[3]. Stroke occurs in all ethnic groups and races in the world. It is the result of a non traumatic injury to the brain leading to varying grades of neurological deficits. 87% of stroke is of ischemic origin and the rest 13% haemorrhagic[4] with different mortality, morbidity and recovery patterns[4].

About 15 million people are affected by stroke, of which 5 million are permanently disabled[5].The prevalence rate in India is 84-264/ 100000 in rural areas and334-424/100000 in urban areas[6]. The mean age of stroke varied in different centers, with a value of 67 years in Trivandrum registry[7] and 60.03 years in Central Kerala[8]. In a study in Kerala, stroke occurred at a rate of 7.1-13.3 per 1000 per year in the age group above 55 years[7].

The incidence of stroke is found to be higher in women than men at all age groups till 80years[9].The lifetime risk of stroke in people above 25 years is 25.1% in women and 24.7% in men[10]. It is observed that women's' age at the onset of stroke is on an average 4 to 6 years older than that of men. The risk of stroke in females increases with age, probably because of the hormonal effects and increased life span[11]. Trivandrum registry showed a higher crude incidence rate in women, compared to men[7]. The functional outcomes and quality of life in women are reported to be poor compared to men[12].

Mobility and gait are important parameters which influence the functional outcome and quality of life. Locomotor ability is considered a factor of high priority in influencing quality of life. Though about 80% of stroke survivors regain walking ability[13], a majority of them have abnormal gait patterns[14].

Gait analysis evaluates the body movements, muscular activities and mechanics and can be carried out using Observational and Instrumental methods. Instrumental Gait Analysis which gives a three dimensional analysis of the gait quantifying the temporospatial, kinetic, kinematic and electro myographic parameters is the gold standard in gait analysis. Gait in hemiplegic patients is asymmetric and has reduced stride length, gait velocity and cadence in comparison with a normal person[15]. Hemiplegic gait is characterized by reduced hip flexion, reduced knee flexion, knee hyperextension in stance and increased plantar flexion of the ankle during both stance and swing phases of the gait cycle[16]

The effect of stroke is greater in women[17]. They also have more stroke events because of higher life expectancy, higher incidence at old age, hormonal and psychosocial factors. There also exists differences in post acute treatment, rehabilitation care and discharge disposition which has a bearing on the outcome. Interplay of demographic variables, co morbidities and psychosocial support with the disease severity plays a role in the functional outcome and quality of life. In hemiplegics, the functional outcome is worse in females[18, 19] due to various reasons which may be biological and social. Gait pattern is influenced by gender. Anthropometric features, weak musculature, older age of onset etc may account for this[20]. Women walked with short steps, slow speed, higher cadence, reduced range of motion of the hip and greater range in the ankle. These differences are observed in the spatiotemporal and angular kinematics assessed by gait analysis[20]. Rehabilitation using modalities like physiotherapy, robotics, neurolytic medications, functional electrical stimulation and virtual reality help to improve gait pattern. The severity of stroke, residual effects of stroke, early treatment and rehabilitation, response to therapy, co morbidities and cognition influences the outcome in gait rehabilitation.

Muscle weakness and spasticity are the major determinants of gait[21] in hemiplegics of both genders .The various factors like the structure and tilt of pelvis, length of the limbs, flexibility,

muscle power and abdominal musculature influence the gender based variations in gait parameters. Very few studies have analyzed these deviations and the factors causing them. There is paucity of studies with regard to gender variations in hemiplegic gait. Hence we attempted to perform a comparative analysis of the angular kinematics involving the hip, knee and ankle among stroke survivors based on gender. This study is expected to throw light on the subtle variations which could be made use of in rehabilitation of gait in stroke survivors.

## MATERIAL AND METHODS:

The present descriptive study was held in the gait laboratory, Department of Physical Medicine and Rehabilitation, Government Medical College, Kottayam. The study was from March 2019 to March 2020 among the stroke patients who attended the outpatient clinic and the subjects were selected based on the inclusion criteria. The objective of the study was to compare the angular kinematics of hip, knee and ankle in the sagital plane in hemiplegic subjects based on gender variations. Based on a previous study on the kinematic parameters of gait in hemiplegic patients, sample size of 100 was calculated[14].

The standard deviation of stride length was taken from the study for sample size calculation.

$$n = \frac{4 \times SD^2}{d^2}$$

n= sample size, SD= standard deviation, d= precision = 20% x SD

SD=0.20

$SD^2 = 0.20 \times 0.20 = 0.04$

$4SD^2 = 4 \times 0.04 = 0.16$

$d = 20\% \times SD = 20\% \times 0.2 = 0.04$

$d^2 = 0.0016$

$n = 4SD^2/d^2 = 0.16 \div 0.0016 = 100$

We included subjects with (1) 'first stroke' having unilateral hemiplegia, unilateral hemispheric lesions confirmed by computed tomography (CT) or magnetic resonance imaging (MRI), (2) age between 45-65 years, (3) duration of hemiplegia between 1-12 months, (4)ability to walk at least 10 meters without any help or assistive devices, (5) ability to understand verbal commands (6) willingness to cooperate with the study and (7) no other diagnosed diseases affecting walking performances.

We excluded subjects with (1) previous history of severe diseases of heart, lung, liver, kidney etc and concomitant neurological diseases, (2) stroke due to traumatic brain injury and tumor, (3) impaired comprehension, aphasia and cognitive disorders and (4) non-cooperative patient/ caregiver.

The study was conducted after obtaining ethical clearance from Institutional Review Board and informed consent from patients. The personal data of the subjects were kept confidential during and after the study.

A motion capture system and multiple sensors were used to obtain the kinematic data. STT-IWS inertial sensors are employed in the iSen system and real time data were transferred to the software.

The sensors were attached to thighs, legs, feet and mid pelvis. The subjects were made to walk a distance of 5 meters at their natural velocity bare foot .The sensors capture the excursions of the joints and the virtual image of the joint was recorded in the computer. One gait cycle, extending from the initial contact of hemiplegic limb to the next initial contact of the same limb, was taken for assessment. The excursions of hip, knee and ankle in the sagital plane were analyzed.

## Statistical Analysis:

The data was summarized in an excel sheet. Descriptive statistics was performed to find out mean, standard deviation for the demographic variable and outcome variables. Quantitative data was expressed in mean and standard deviation. Qualitative data was expressed as frequency and percentage. Microsoft excel, word was used to generate graph and tables.

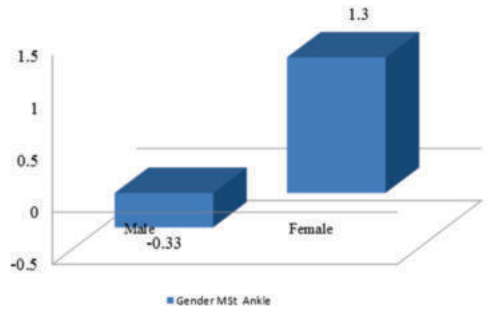
## RESULTS:

In our study we analyzed the angular excursions of hip, knee and ankle joints of all the subjects. A comparison of the angular kinematics was made between male and female subjects included in the study.

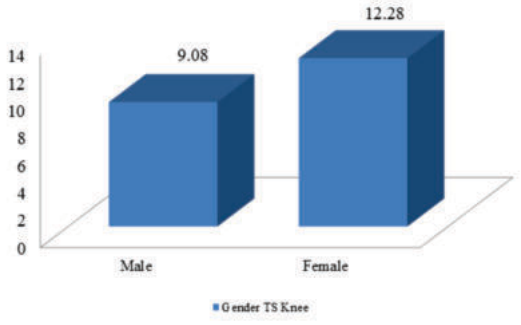
Out of 100 subjects, 64 were males and36 females. The mean age of males were 55.89 (SD 6.13) and females were58.36 (SD5.45).

**Table I: Gender Wise Comparison**

| Sl.No: | Variable | | Male | Female | p-value |
|---|---|---|---|---|---|
| 1 | Number | | 64 | 36 | |
| 2 | Age | | 55.89±6.13 | 58.36±5.45 | <0.047 |
| 3 | IC | Hip | 11.00±7.81 | 11.68±5.73 | >0.646 |
| | | Knee | 2.25±4.76 | 2.97±4.11 | >0.447 |
| | | Ankle | -4.36±5.44 | -4.20±5.50 | >0.888 |
| 4 | LR | Hip | 4.21±5.36 | 5.79±5.27 | >0.156 |
| | | Knee | 1.46±5.86 | 2.77±7.05 | >0.320 |
| | | Ankle | -4.80±4.49 | -4.76±3.92 | >0.968 |
| 5 | Mst | Hip | -0.72±4.67 | 0.33±4.53 | >0.278 |
| | | Knee | -1.90±4.16 | 0.26±4.89 | <0.021 |
| | | Ankle | -0.33±3.53 | 1.30±3.28 | <0.025 |
| 6 | TS | Hip | -12.44±6.36 | -10.94±7.05 | >0.277 |
| | | Knee | 9.08±6.23 | 12.28±7.85 | <0.028 |
| | | Ankle | -6.01±3.57 | -5.18±5.24 | >0.353 |
| 7 | PS | Hip | -6.13±9.37 | -4.03±4.45 | >0.210 |
| | | Knee | 21.55±8.10 | 20.84±6.13 | >0.646 |
| | | Ankle | -14.53±7.10 | -13.89±8.39 | >0.684 |
| 8 | Msw | Hip | 9.69±8.38 | 11.39±9.14 | >0.349 |
| | | Knee | 20.72±15.06 | 20.01±11.60 | >0.806 |
| | | Ankle | -5.77±6.71 | -3.78±6.30 | >0.149 |




**Graph I:** Mid Stance Ankle




**Graph II:** Terminal Stance Knee

There was reduced range of motion of hip joint during the entire gait cycle. During initial contact, the hip in the affected limb of the hemiplegic patient moved into flexion with a mean angle of 11.0 (SD 7.81) in males and 11.68 (SD 5.75) in females. In the loading response phase, the hip gradually extends and reaches a value of 4.21 (SD 5.36) in males and 5.79 (SD 5.12) in females. The hip receded further into extension, being -0.72 (SD4.62) in males and 0.33 (SD4.53) in females in mid stance. In the terminal stance there is extension of the hip,-12.44 (SD 6.32) and -10.94 (SD 7.05) in males and females respectively. In preswing the mean hip angle in males was-6.13 (SD9.37) and -4.03(SD4.4) in females. Mid swing phase showed a mean value of 9.69±8.38 in males and11.39±9.14 in females with the hip moving into flexion. There was difference in the range of motion of hip between the two genders, but these were not of statistical significance.

In the beginning of gait cycle, the knee is in a mean angle of flexion of 2.25 (SD4.76) in males and 2.97(SD4.11) in females. In the loading response, the knee remains in reduced flexion in both genders with a value of 1.46 (SD5.86) and 2.77 (SD7.05) in males and females respectively. In the mid stance and terminal stance, the knee in males gives a mean value of-1.90 (SD4.16) and 9.08 (SD6.23) respectively indicating reduced flexion. Female knee gives a mean value of 0.26 (SD4.89) in mid stance and12.28 (SD7.85) in terminal stance. These values are significant statistically. In the preswing and mid swing phases, the knee moves in a narrow range in both sexes.

The ankle joint remained in plantar flexion throughout the gait cycle in males. The mean joint angle values were -4.36 (SD.44) in initial contact, -4.80 (SD4.49) in loading response, -0.33 (SD3.5) in mid stance and -6.01 (SD3.52) in terminal stance in males. In females, it was -4.20 (SD5.50) in initial contact and-4.76 (SD3.92) in loading response. In the mid stance phase, the value was 1.30 (SD3.28) and in terminal stance -5.18 (SD5.24). The mid stance ankle was statistically significant in the comparison. It shows dorsiflexion though to a limited extent in males. The ankle in the swing phase remained in plantarflexion. In preswing it was -14.5 (SD7.10) in males and-13.85 (SD8.33) in females. In midswing, again it was 5.77 (SD6.71) in males and -3.78 (SD6.30) in females.

## DISCUSSION:

Males constituted 64% and females 36% of the subjects in our study. This proportion of males to females is comparable with similar studies done in Kerala[7,8]. In males group, the mean age is 55.89 and SD is 6.13 and in females, the mean age is 58.36 and SD is 5.45 which was statistically significant (p value >0.047). The mean age for men to have their first stroke was reported to be 60.08-75.3 years, while for females it was 65.3-80.4 years[22].In our study women were older than men at the onset of stroke which was comparable to global literature.

Gender based variations were observed in regularity and symmetry of gait [23]. The gait of females was slower with short steps, increased cadence and reduced joint excursions [20]. In our study variations were observed between the two sexes while analyzing the kinematics of gait in hemiplegic subjects. The biological and psychosocial factors, anthropometric and kinematic factors and the quality of rehabilitation influence the gait pattern in the hemiplegic patient and can account for these variations. Spatiotemoral and kinematic analysis helps in the assimilation of the data which can become the basis for interventions in a structured gait rehabilitation program. However, only very few studies have been conducted among the hemiplegic patients. Our study focused on the kinematics of hip, knee and ankle of the affected hemiplegic limb in the sagital plane.

In our study, there was reduced hip extension in the stance phase and delay in initiation of hip flexion in preswing, observed in both male and female subjects. There was also reduced hip flexion during midswing. These observations correlate well with the existing studies[24, 25, 26]. The knee at initial contact was in increased flexion (males 2.25 and females 2.97) and goes into extension as more loads are borne in the loading response.The slow receding of the knee from the maximal flexion is important for shock absorption. At mid stance, knee in male subjects went into hyperextension, unlike the females. This may be due to decreased activity of knee extensors and knee flexors which prevents the controlled movements of the knee[25]. At late stance phase there is flexion of the knee, but the mean angle is reduced. Swing phase also showed reduced knee flexion, which is primarily responsible for compensatory strategies. The ankle at initial contact and loading response remained in plantar flexion, leading to forefoot or toe strike instead of heel strike. The relative ankle dorsi flexion at mid stance is also reduced. In the swing phase also, there is excessive plantar flexion which will hinder toe clearance[25,26].

Women rely more on ankle excursions while men rely on hip mobility for ambulation [27.] This effect is more apparent in the elderly women. The mean hip angle is found to be more in females throughout the gait cycle. This observation was similar to the normal hip and is due to greater anterior pelvic tilt in the female pelvis. Hip extension is reduced in the terminal stance in both genders, with reduction more in females. Reduced extension can predispose to more pelvic tilt, development of contractures, decreased balance and further shortening of stride length[28]. Female hip usually shows increased adduction in the coronal lane and increased internal rotation in the transverse plane. Our study did not analyze the movements in the coronal plane and transverse plane.

Females had lesser knee joint flexor tone and at loading response, lesser extensor power. In hemiplegic gait, knee in initial contact and loading response showed greater flexion in females. But these differences were not significant statistically. Mid stance knee and terminal stance knee were statistically significant. The hyperextension of the knee in males may be attributed to quadriceps weakness, spasticity, reduced flexor tone and increased ankle plantar flexion. There may be weakness of the plantar flexors of the ankle which can also contribute to the knee flexion. This is responsible for more stiff legged gait in males. Knee extensor mechanism is the key for independent mobility and stability[29]Women are reported to have less extensor strength and lower stability[30]. This will explain the increased flexion of the knee in the stance phase[25].

The ankle remains in plantar flexion during the initial contact and loading response. The ankle joint movements in the females are generally lower than the males in our study. The mid stance ankle mean angle is statistically significant. The ankle is in minimal dorsiflexion in males, compared to females. As per studies, female ankle joint flexion in swing is smaller than males and generated less torque for forward movement. A combination of reduced ankle dorsiflexion, weak plantarflexion and reduced hip extension is likely to effect the propulsive movement of the body. The swing phase differences in the ankle is likely to hinder the foot clearance and balance prior to initial contact. The increased power in the muscles, length of the limb and severity of lesions may be responsible for these variations.

These kinematic variables require further detailed studies. The tone, power and the neurological coordination are important in good rehabilitation process. With the advent of artificial intelligence and modern technologies, even the subtle variations can be analyzed for developing a personalized program in gait rehabilitation.

## CONCLUSION:

Our study confirms that gender based variations exist in hemiplegic gait. Females show more severe involvement than males in the angular. Kinematics of various phases of gait cycle. The knee and ankle in mid stance and the knee in terminal stance are significantly affected.

## LIMITATIONS:

This was a direct observational study. There was no control group and there was no follow up assessment of the subjects. The temporospatial parameters were not assessed.

## FUTURE SCOPE:

The analysis of gait provides insight into the need of various interventional strategies and can enhance ambulation potential and provides better quality of life.

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