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Methods and Tools for Measurement of Genu Recurvatum in Patients with Stroke: A Systematic Review

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ABSTRACT

Background: The effect of interventions in post stroke patients on proxies of motor changes especially Genu Recurvatum (GR) are well documented in literature. However, evidence based standard methods for its assessment haven't been established yet in patients with stroke.
Objectives: To explore literature to determine standard method for evaluation of Genu Recurvatum and to find out the best strategy or Instruments to assessed GR and the estimated range of knee hyperextension Stroke patients.
Data sources: A computerized Systematic Literature search was performed, from January 2000 to October 2022 to extract data. A best evidence synthesis was conducted to summarize the results.
Result: Twelve studies were included in the review. Eight out of ten studies have mentioned the degrees of GR. Various different methods have been found, commonest being the analysis of gait cycle by software and stance phase of gait cycle being commonest position.
Conclusion: The most widely preferred position for assessment of GR is stance phase of gait cycle by videotaping it and analysis with software method in patients with Stroke.

Keywords: Genu Recurvatum, Hyperextension, Hemiplegia, Stroke

INTRODUCTION

The World Health Organization (WHO) defined Cerebrovascular Accident (CVA) or stroke as 'Rapidly developed clinical signs of focal (or global) disturbance of cerebral function, lasting more than 24 hours or leading to death, with no apparent cause other than of vascular origin.[1] It is second largest cause of death and the third-largest cause of disability worldwide.[1,2] Stroke will occur in the lifespan of one in four people over the age of 25 worldwide. According to the Global Stroke Fact Sheet 2022; Stroke prevalence was 101 million and incidence was 12.2 million, most affected group being elderly population.[3] In India geriatric population stood at 1.36 billion (2019) and will grow by twenty percent until 2025, a demographic that is described vulnerable.[4] According to The Asian Stroke Advisory Panel, the overall incidence of stroke ranged from 116 to 483 /100,000 per year in Asia. [5] The average annual incident ratio of Stroke in India ranged from 108 -172 /100,000 population and estimated prevalence range from 26-757/100,000, in 2020. [6]

Stroke causes a variety of deficits, including motor, sensory, perceptual, and language impairments. The most noticeable impairment is motor weakness or hemiparesis on contralateral side of body, resulting in disability.[7,8] One of the variation that results with hemiplegia is Unilateral knee hyperextension i.e. in paretic limb, during weight bearing

(Stance).[9-10] Genu recurvatum (GR), another name for knee hyperextension, is defined by a ground response force vector that passes in front of the knee and causes complete extension (0°) or more. [11] Knee extension of more than 5 degrees is a potentially incapacitating condition. Approximately 70-75% of patients with Stroke have hemiparesis, of whom 40-60% have Genu Recurvatum. Some studies have considered, 5-10° as mild, 10-15° as moderate and >15° as severe genu recurvatum. Studies have shown that the peak amplitude of knee hyperextension (PKH) can range as high as 22^{o} in Stroke patients.[12]

The biomechanical trend of the lower extremity is altered by long-term hyperextension of the knee, and because of the inadequacy of the load-bearing reaction in knee joint, there is leaning of body in forward direction as the stability of the standing phase is reduced. [13] Walking like this for an extended period of time, leads to knee discomfort and cartilage injury, these alterations generate an unequal distribution of internal stress in the knee join and cause cumulative damage and degenerative changes in knee cartilage. [12] Genu recurvatum has also been found associated with proprioception deficits and a predisposition to knee ligament injury. It can alter weight bearing symmetry and gait in patients with stroke and can affect their functional recovery. [14]

The soft tissue structures restrain knee hyperextension. With the knee straight or slightly flexed the vector force is behind the knee in the relaxed standing posture, therefore there is a tendency for more knee flexion until the quadriceps contracts. [15] Studies have suggested that with knee hyperextension, the hip joint's axis runs obliquely, inferiorly and posteriorly, these favours putting the ground reaction force in front of the knee and allows patient to stand even with absence of quadriceps activity and concluded that GR could be the compensation for weakness of quadriceps muscle. [15-16]

Various Studies have utilized different techniques throughout the time in different population but there aren't sufficient evidences on validity and reliability of the techniques. It is still debateable which position is best and what instruments or tools provide accurate data regarding hyperextension of knee. Such as use of standard goniometer doesn't always provide proper alignment as it has limitation of size also position of patient. Measurement of knee hyperextension in supine position has also been done however some authors have suggested that knee hyperextension becomes more obvious and prominent in weight bearing position.[17] Certain studies have utilized visual estimation by therapist but that measurement is subjective, lacks accuracy and isn't reliable.

Studies have reported Genu Recurvatum to be the prominent impairment and its correction plays crucial role in rehabilitation of patients with Stroke. [18] The effect of interventions in post stroke patients on proxies of motor changes especially GR are well documented in literature. In scientific literature though various interventions have been suggested for treatment of GR but only few has provided details of its assessment. Up until, healthcare service providers haven't had clear preferences regarding evaluation of GR. Hence, the current study's aim was to thoroughly analyse the scientific literature & systematically review them in order to clarify the preferable approaches of evaluation of Genu Recurvatum and to determine the estimated range of hyperextension of knee joint in patients with Stroke.

METHODOLOGY

2.1 Selection Criteria

Studies, on patients with stroke, focusing on knee hyperextension i.e., Genu Recurvatum, irrespective of design, were enrolled in this study. The chief area of interest was Genu Recurvatum secondary to hemiparesis. Studies published in languages other than English were excluded.

2.2. Search and Study Selection Process

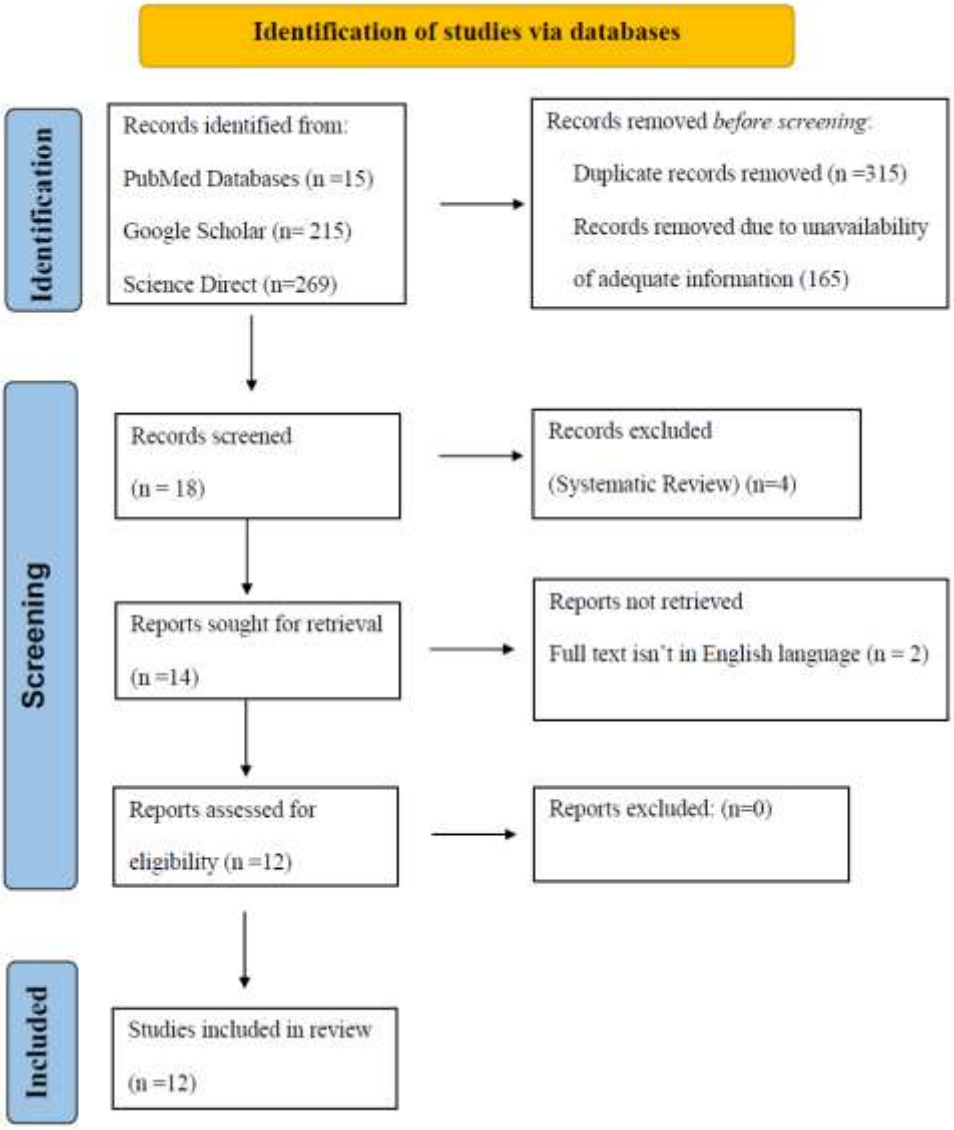
Studies available in the English language between January 2000 to October 2022 were searched using databases such as PubMed, Science Direct, Scopus, and Google Scholar. The following key words were used to identify research articles, Stroke, hemiparesis, Genu Recurvatum and Knee Hyperextension.

2.3 Data Extraction

Data was extracted through various Electronic Data base searched by SM. The Title and Abstract of all the retrieved results were then screened for eligibility by SM & SG. Screening process was aimed at narrowing down the volume of articles by rejecting the studies that are not relevant or appropriate for review. The full texts of the relevant articles were then reviewed by two authors (SM and SG) for their suitability for inclusion in the review.

2.4 Data Analysis

The selected studies were analysed in terms of Screening Criteria, Procedure and outcome measures used in study. Screening Criteria and Outcome measure suggested about the Device / Instrument or criteria used to measure Genu Recurvatum. Procedure of the study provides information about Degree of Genu Recurvatum and the positions in which Genu Recurvatum is measured in patients with stroke.



RESULT

12 studies were included after reviewing 18 non duplicated. Across the studies 320 participants were included in study.

Table 1. Characteristics of Studies

Sr. No	Author	Degree of GR		Device with which GR is measured	Position in which GR is measured
1.	Malathy Appasamy [19]			Clinical Observation of a patient.	Stance Phase
2.	Figen Gokolu [20]	$>15^0$		Ant-Post and Lateral radiographs of the knee joint.	By loading in the Standing position
3.	Yasuhiro Tani [21]	-	-	Visual Estimation.	Walking
4.	Meg E. Morris [22]	Male -4.4 (±1.2)	Female - 4.2 (±1.5)	Electro goniometer incorporated in the knee feedback monitor.	Standing
5.	Khushboo Dalal [23]	Pre 8.67	Post 3.87	Videotaped analysis Kinovea (version 0.8.15).	Walking
6.	R. Gross [24]	Pre 7.8^0	Post 7.8^0	K3< 0 using the K3 parameter, ELITE system (BTS,Milano, Italy), and a force platform.	Stance Phase
7.	Allison Cooper [17]	-	-	Computerized movement analysis soft-ware using video tape of gait.	Walking
8.	Frederic Catherine [25]	-	-	Observation.	Walking
9.	Dong Yun [18]	8.40^0		Human Motion Device.	Walking
10.	Toshiki Kobayashi [26]	5^0		Vicon 10-camera motion analysis.	Stance Phase
11.	Portnoy [10]	$6\text{-}7^0$		Computational gait analysis.	Walking
12.	Edward [27]	$4\text{-}5^0$		Visual 3 D motion Analysis.	Walking

DISCUSSION

Previous reviews of GR involved measures, such as prevalence, treatment strategies, prevention and impairments related to it, though many didn't consider crucial components of assessment and evaluation. The current systematic review is thus first mainly focusing on assessment aspects of GR, in patients with Stroke. Studies have demonstrated GR as one of the prevalent complications resulting from stroke. [9,11] Different authors have provided different causes of Genu Recurvatum.[10,12] There are different views on causes but almost all the studies have mentioned that, irrespective of cause GR increases with weight bearing. [9,15] Though occurrence of GR is very common in patients with Stroke, there is limited evidence that provides detailed information about it.

4.1 Degree of Genu Recurvatum

The result of SR indicated that average GR after stroke is $7\text{-}8^0$, it has been found minimum 4^0 and maximum 15^0, however most of the studies haven't mentioned degrees of GR. Paul G. Peters et.al., in their study found degree of GR 6.3 (3.0), [28] and Sun-hee Ahn et al. found it around 7.18 ± 2.42, [29] which is consistent with present review, they mentioned that the relative strength of the two muscles, rather than the strength of each one individually, was found to be a factor driving a shift in the GR angle. The muscle strength ratio has a stronger impact on the increased GR angle. Few studies have reported that involvement of opposing muscle group is commonly present in patients with Stroke. Higginson et al. found that knee hyperextension dramatically increases upto $20\text{-}30^0$ with increasing the plantarflexion at ankle joint during stance phase of gait cycle. [14] Various studies have already suggested that increased plantarflexion and restricted dorsiflexion is one of the common findings in patients with stroke. Anupama et al., found 30^0 degrees of GR in their case study.[30] Bogardh et al., have shown that the Peak amplitude of Knee Hyperextension (PKH) can range as high as 22^0 in stroke patients, however difference in position of assessment could be the reason behind such vast difference as both the studies has measured GR during stance phase of gait cycle. [31]

4.2 Device / Instrument Used to Measure

There is wide variation in instruments or device utilized for measurement. In present

review, devices and instruments used are visual estimation method i.e., clinical observation of patient by therapist, radiographic approach (taking Xray scan of knee joint in different planes), electric goniometer and videotaped analysis of gait by different software have been used. Maximum number of studies have utilized software for evaluation as it is reliable and provide accurate data. Mark H. Trimble et.al., measured it using a modified universal goniometer with the modification of arms. [32] Sun-hee Ahn et.al., has measured GR angle using a Smart KEMA motion sensor which is a tri-axillar gyroscope, magnetometer, and accelerometer sensor that measures angles of the movement. [29] Jennifer M et al., measured it with universal Goniometer in quite standing position, Shultz SJ et al., has already reported this method to have a good ICC and Intrarater reliability. [33]

4.3 Position for Assessment

Most of the studies have measured GR during stance phase of gait cycle, some studies have measured it during quite standing and one of the studies has measured it in supine lying position by taking radiographs. Paul G. Peters et.al., obtained goniometric measurement in supine lying position by placing the heel on a small, 12-cm bolster.[28] Janice K. Loudon et al., has assessed it by visual estimation in quite standing position and they said that it is best assessed in sagittal plane though it could be seen in frontal plane. Anupam Datta Gupta et al., measured it in supine lying by calculating the angle formed by the intersection of the long axis of tibia and femur on radiograph. [30] Shultz SJ et al., measured it with the subject in supine; a 4-inch bolster was placed under the distal tibia. With the axis over the Lateral Joint Line (LJL), the angle formed by a line from the LJL to the greater trochanter, and a line from the LJL to the lateral malleolus was measured to the nearest degree. [33] John B. Meding, et.al, has mentioned that GR has been best measured in weight bearing position as biomechanics changes during maximum loading at knee. [34]

4.4 Study limitation

The current review is the first systematic literature review focusing on the assessment and evaluation of GR. It was conducted following steps of PRISMA-2020 statement. However, some limitations must be addressed, almost all the study design are different and the sample size were low, therefore the result needs to be treated with caution because of risk of bias in the analysis. Two full text articles had to be excluded as they weren't available in English, hence selection bias may have occurred.

CONCLUSION

This review revealed that despite being crucial part of rehabilitation, assessment aspects of GR isn't much reported in studies. Most of the studies have failed to mention range of Knee hyperextension, only limited studies have mentioned the exact degree of GR. Assessment methods and instruments used, shows wide variation out of which digital analysis of gait cycle is the commonest. It also provides range of knee hyperextension and is found reliable. Visual estimation being the least used method and it is subjective and reliability is questionable. Given that only few studies have reported detailed information about the knee hyperextension range the estimated range couldn't be drawn from results. Hence further research is necessary to determine the best method for evaluation of GR and it would be interesting to find out range of GR in different positions during weight bearing and non-weight bearing.

Declaration by Authors

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