"THE EFFECTIVENESS OF PROPRIOCEPTIVE NEUROMUSCULAR FACILITATION (PNF) STRETCHING TECHNIQUE OF CALF MUSCULATURE ON ANKLE RANGE OF MOTION (ROM) AND GAIT PARAMETERS AMONG COLLEIGIATE STUDENTS"

A Dissertation

Submitted

In Partial Fulfillment of the Requirements

For the Degree of

MASTER OF PHYSIOTHERAPY

In

Neurology

Submitted by

ANUM MUKARRAM

Under the Supervision of

Prof. (Dr.) A.M.H. INAM (PT)

Department of Physiotherapy

Faculty of Medical Sciences

INTEGRAL UNIVERSITY, LUCKNOW, INDIA

June, 2022

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This is to certify that **Ms. Anum Mukarram** (Enroll. No.-1500100832) ha**s** carried out the research work presented in the thesis titled **"The effectiveness of Proprioceptive Neuromuscular Facilitation (PNF) stretching technique of calf musculature on ankle range of motion (ROM) and gait parameters among Collegiate Students"** submitted for partial fulfillment for the award of the **Degree of Master of Physiotherapy in Neurology** from **Integral University, Lucknow** under my supervision.

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DR ABDUR RAHEEM (PT)

PHD

Professor, HOD,

Integral University,

Lucknow.

ACKNOWLEDGEMENT

First and foremost, I like to thank the ALMIGHTY GOD, the most beneficial and merciful for giving me the courage, strength and will power to embark upon and accomplish this thesis. I am extremely thankful to **Prof**. (**Dr). Ashfaque Khan ,** Director IIHMS Integral University, Department of Physiotherapy, Faculty of Medical Sciences, for their expert guidance and advice.

I am also extremely thankful to**, Prof (Dr**) **Abdur Raheem, Head** of department, Integral University, Department of Physiotherapy, Faculty of Medical Sciences, for their expert guidance and advice.

I express my deep and sincere gratitude to my co-guide, teacher, **Prof** (**Dr.) Neeraj Maurya** (PT)**,** Assistant professor, Integral University for his valuable guidance, precious advice, and constant encouragement.

I am also extremely thankful to my guide, teacher and supervisor **Dr. Ahmad Merajul Hasan Inam (PT),** Assistant professor, Integral University, Department of Physiotherapy, Faculty of Medical Sciences, for their expert guidance and advice.

I am also extremely thankful to **Dr. Javed Iqbal (PT), Dr. Ammar Faisal Khan (PT), Dr. Sadiya Begum (PT), Dr. Shohaim Shaikh (PT)** Assistant professor, Integral University, Department of Physiotherapy, Faculty of Medical Sciences, for their expert guidance and advice.

'Last but not least' I am grateful to my parents, especially my parents and my friends for their constant encouragement, help and emotion support.

Anum Mukarram

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LIST OF ABBREVIATIONS

Abbreviation	Full form
F	Female
M	Male
BMI	Body Mass Index
ROM	Range Of Motion
SS	Static Stretching
PNF	Proprioceptive Neuromuscular Facilitation
MVIC	Maximum Voluntary Isometric Contraction
ADF	Ankle Dorsi-Flexion
GTO	Golgi Tendon Organ
SD	Standard deviation

ABSTRACT

BACKGROUND: Muscle tightness can be considered as one of the most commonly occurring disorder in normal healthy individuals Calf Muscles are generally prone to tightness as they are anti-gravity muscles which manifests in the form of decreased ankle dorsiflexion ROM which may lead to difficulty in maintaining balance thereby resulting in imbalances and dispose towards risk of injury. Stretching has been used as a therapeutic exercise technique used to improve muscle's extensibility and correct muscle tightness.

PURPOSE OF THE STUDY: The Purpose of the study is to explore the effectiveness of Proprioceptive Neuromuscular Facilitation technique of stretching of Calf Musculature on Ankle Range of Motion (Dorsiflexion) and Gait Parameters(Step length, Stride length and Walking Velocity).

MATERIALS AND METHOD: 40 participants (n=40) between age group 20-30 years(male and female) with calf tightness(measured through restricted Ankle dorsiflexion ROM-,<=15 degrees) were randomly divided into control and experimental group. Each group consists of 20 participants. Participants of experimental group were given PNF Stretching while those of control group were given home advice(hot packs etc)..Treatment was given for 15 days.

RESULTS: The experimental group showed significant improvements in both mean active (left-19.05 and right-22.65)and mean passive ROM(left-26.95 and right-28.35) which were greater than the control group(active-/left-13.7 and right-15.75: and passive –left -18.15and right -20.8).as well as baseline measurements. While there were no significant improvements in the values of Step length, Stride length and Walking Velocity.

CONCLUSIONS: The study concludes that PNF technique is effective in improving calf muscle flexibility and ROM of ankle joint (here Dorsiflexion.) while it could not translate these improvements into the gait parameters

KEY WORDS:PNF STRETCHING, STRETCHING,ANKLE ROM,GAIT PARAMETERS

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CHAPTER-1

INTRODUCTION

Muscle tightness can be described as a common component of the motor system ,affecting Gait or Balance where the ability of the muscle to contract and relax decreases thereby leading to narrower ROM for the said joint than normal and shortening of muscle length resulting in limited movement. [1].

Muscle tightness commonly occurs due to sedentary lifestyle or incomplete rehabilitation after muscle injuries. Tightness can result in greater susceptibility of muscle or tendon injuries as well as functional problems due to decreased ROM. In lower limb, muscle tightness frequently manifests itself in the form of hamstring or calf muscle tightness. As both of these are two-joint muscle therefore, it might lead to detrimental effects on gait parameters.[2,3].

Calf Muscles are generally prone to tightness as they are anti-gravity muscles which manifests in the form of decreased ankle dorsiflexion ROM which may lead to difficulty in maintaining balance [2-4]. It can also result in difficulty in heel pushing the ground during walking, running, jumping or stair climbing thereby affecting physical activities and walking, and may present as increased risk of falls [5], decreased walking speeds[6] and heel rise during early stance[7].therefore, flexibility exercises are generally introduced in order to improve muscle tightness.

According to Carolyn Kisner, flexibility can be defined as the ease of performing movement on a specific joint or a group of joints smoothly and through painfree ROM.[8]. Flexibility exercises can lead to an increase in the elasticity as well as length of muscles and peri-articular structures thereby reducing the risk of injuries. They also help in increasing the ROM of the restricted joints due to tightness of the soft tissue structures.

Stretching has been used as a means to increase flexibility or ROM, thereby improving performance and reducing the risk of injuries . Generally four different types of stretching techniques are used which are Static, Dynamic, Ballistic and Proprioceptive Neuromuscular facilitation techniques respectively [9] There are several studies which have compared the effects of static stretching and pnf stretching and have found that both may be equally effective in enhancing the joint ROM. [10,11] However, others have

reported a superior effects of PNF stretching on Static Stretching(SS).[12]. A simple explanation for this could be the fact that SS involves passive elongation of the tissue whereas PNF includes both stretching as well as a phase of contraction of the muscle.[13]

PNF Stretching can be described as a therapeutic approach which utilizes alternating episodes of contraction and relaxation of agonistic and antagonistic muscles .It finds its basis on the fact that muscle relaxation increases after the contraction of both agonists as well as antagonist muscles [14]

According to literature, Contract-Relax Method (CR) and Contract-Relax-Antagonist-Relax methods are seen to be more effective in increasing the ROM and muscle performance. The theoretical mechanism proposed for the results include: Autogenic Inhibition, Reciprocal Inhibition, Stress Relaxation and Gate Control Theory. There are researches which support that PNF technique does increase muscle elasticity ,passive and active ROM as well as muscular performance when performed with relation to exercise. [15].

Rom changes after PNF stretching may be due to the observed decrease in passive resistive torque (PRT) at the same joint angle as pre-intervention [16,10]. Differences observed in the torque-angle curve of the PRT indicates a depreciation in the soft tissue component of the muscle (for e.g., muscle stiffness) [10]; tendon stiffness [16.] found a higher end ROM after PNF stretching and a simultaneous higher passive peak torque values at the maximal joint position [17]. This finding is indicative of an increased tolerance to stretch (for example: less pain sensitivity. [18].

Effects of a single PNF session might last up to 90 min or more post-session. This duration can vary depending upon changes in the percentage on Maximum Voluntary Isometric Contraction (MVIC) , Contraction duration of the TM.(with best effects achieved when contraction is held for a total of 4-10s). PNF showed a decrease in Strength, Power Output and Muscle Activation [19].Similar decrease in

Ground reaction time as well as jump height etc. was seen. However, PNF has been effective in increasing stride length, frequency and ROM [20].

The factors affecting the effects of PNF stretch include the following: Age, Gender, type of muscle being stretched, the technique used, stretch duration and MVIC percentage [15].

The effects of PNF Stretching have been studied in terms of its effect on ROM, power output, muscle strength , vertical jump height, performance etc. and on various muscle groups at that. However, there is paucity of data which describes the effect that performing PNF stretching has on calf musculature on various parameters like Step Length, Stride Length, Walking Velocity and Ankle Dorsiflexion ROM.

Various studies have shown improvements in the values of ROM, endurance, flexibility, vertical jump height etc. and it has also been shown to be effective in gait rehab in patients with stroke, Parkinson's etc. The extensive use of Stretching as a popular and effective therapeutic method to improve muscle flexibility is one of the compelling reasons to perform this study.

The study is performed with the objective of studying the effects that PNF Stretching of Calf Musculature has on Ankle Dorsiflexion ROM, and gait parameters in healthy college students.

HYPOTHESIS

NULL HYPOTHESIS

There is no effect of PNF Stretching of calf musculature on Ankle Dorsiflexion ROM, Step Length, Stride Length and Walking Velocity.

ALTERNATE HYPOTHESIS

PNF stretching of calf musculature leads to improvements in gait parameters such as Step Length, Stride length, Walking velocity as well as Ankle Dorsiflexion ROM.

STATEMENT OF QUESTION

To investigate if Proprioceptive Neuromuscular Facilitation (PNF) technique of calf stretching is effective in improving Ankle ROM and Gait Parameters ?

AIM OF THE STUDY: To determine the effect of PNF Calf Stretching on Ankle Dorsiflexion Range, Step Length, Stride Length and Walking Velocity.

OBJECTIVES OF THE STUDY

1) To study the effect of PNF on Ankle ROM (Dorsiflexion)
2) To study the effect of PNF stretching on Gait parameters such as step length, stride length and walking velocity.

OPERATIONAL DEFINITIONS

1) STRETCHING : It can be defined as a therapeutic procedure which is used in order to increase the extensibility of soft tissue structures thereby improving the flexibility of the structures by lengthening (elongating) the structures which have shortened adaptively and became hypo-mobile.(CAROLYN KISNER- 5^{TH} EDITION)
2) PNF STRETCHING: It is an advanced form of flexibility exercise which involves interspersion of stretching with isometric contraction of the muscle in order to achieve greater increase in ROM than traditional methods.

3) RANGE OF MOTION: It can be defined as the measure of movement around a specific joint or body part. In other words it can be defined as the extent to which a body part can be moved around a joint. At ankle joint, dorsiflexion and planter flexion are the two main ROM that occur. Dorsiflexion refers to flexion of foot in the dorsal(upward) direction (Normal Range : 25-30 degrees) whereas Planter Flexion refers to flexion of foot or toes towards the sole(Normal Range:40-50degrees) .
4) STEP LENGTH: It is the linear distance between two successive points of contact of opposite extremities. On average females-26 inches, males-31 inches
5) STRIDE LENGTH: It is the distance between successive points of initial contacts of the same foot. On average 52 inches for females and 62 inches for males
6) WALKING VELOCITY: The rate of change of linear displacement along the direction of progression measured over one or more strides, expressed in meters per second (m/s).it is often referred to as the functional vital sign. Normal ranges include: Males: 1.3-1.6 m/s; Females: 1.3-1.5 m/s.

CHAPTER: 2 REVIEW OF LITERATURE

ANATOMY OF CALF MUSCULATURE

The calf (Latin: sura) refers to the posterior portion of the lower leg. The two largest muscles in this region include the gastrocnemius and the soleus. The gastrocnemius is the most superficial of the muscles and has two heads, medial and lateral. The two heads of the gastrocnemius converge and form a confluent muscle belly. The lateral head originates from the lateral surface of the lateral femoral condyle and the medial head from the posterior, non-articular aspect of the medial femoral condyle. The muscle belly of the gastrocnemius joins the soleus muscle distally to form the calcaneal tendon (i.e. the achilles tendon), which inserts onto the posterior calcaneus

The calf muscle plantar flexes the ankle joint and is innervated by the tibial nerve. The soleus is a large, flat muscle located deep to the gastrocnemius. The plantaris is a relatively small muscle with an appreciably long tendinous portion. The tendinous portion can easily be mistaken for a nerve. The plantaris muscle arises from the lateral supracondylar line of the femur and is completely absent in up to 10% of the population. The muscle descends medially, eventually forming into a tendon that runs down the leg, between the gastrocnemius and soleus. This tendon blends with the calcaneal tendon.

STRUCTURE AND FUNCTION

The calf muscles are responsible for plantar flexion the foot and ankle. The calf muscles are engaged in activities such as running and jumping

BLOOD SUPPLY AND LYMPHATICS.

The blood supply of the calf muscles is derived from the popliteal artery, which divides into the anterior and posterior tibial arteries. The fibular (or peroneal) artery originates from the posterior tibial artery. The posterior tibial artery accompanies the tibial nerve and enters the plantar aspect of the foot through the tarsal tunnel. The anterior tibial artery runs anteriorly between the tibia and fibula through a gap in

the interosseous membrane. It extends down the entire length of the leg and into the foot becoming the dorsalis pedis artery.

The venous supply of the calf can be divided into the superficial and deep veins. The superficial veins consist of the greater saphenous vein and the small saphenous vein. The deep veins include the popliteal vein, the anterior tibial vein, the posterior tibial vein, and the fibular vein. The greater saphenous vein is the longest vein in the body and runs the entire length of the lower extremity. Cardiothoracic surgeons commonly use this vein during coronary artery bypass grafting. The small saphenous vein is actually a relatively large vein that runs along the posterior aspect of the calf and passes between the heads of the gastrocnemius muscle and usually drains into the popliteal vein. The popliteal vein is formed when the anterior and posterior tibial veins merge. The popliteal vein becomes the femoral vein as it extends into the femoral region. The anterior tibial veins drain the knee joint, ankle joint, tibiofibular joint, and part of the anterior leg. The posterior tibial vein gets blood from the lateral and medial plantar veins and drains the posterior muscles of the lower leg and the plantar surface of the foot. The fibular veins, also known as the peroneal veins, transport blood from the lateral compartment of the leg and drain into the posterior tibial vein.

NERVES

The tibial nerve (S1, S2) innervates the majority of the muscles of the calf. The tibial nerve passes through the popliteal fossa and gives off branches to the gastrocnemius, popliteus, soleus, and plantaris muscles. There is also a cutaneous branch that will become the sural nerve.

MUSCLES

The lower leg consists of four compartments: anterior, lateral, superficial posterior, and deep posterior.

1) The anterior compartment includes the tibialis anterior, extensor hallucis longus, extensor digitorum longus, peroneus tertius, tibialis anterior and the deep peroneal nerve

2) The lateral compartment contains the peroneus longus and brevis and also the superficial peroneal nerve

3) The deep posterior compartment consists of the tibialis posterior, flexor hallucis longus, flexor digitorum longus, popliteus, and the tibialis nerve

4) The popliteus muscle solely acts at the knee by internally rotating the tibia relative to the femur, thus its function is to "unlock" the knee joint during the initiation of flexion

5) The popliteus is located behind the knee joint and forms the base of the popliteal fossa

6) The tibialis posterior is the deepest of the four muscles and originates from the interosseous membrane between the tibia and fibula. It inverts and plantar flexes the foot and maintains the medial arch of the foot. The flexor digitorum longus (FDL) is located medially in the posterior leg and is responsible for flexing the lateral four toes. The flexor hallucis longus is located on the lateral side of the leg and flexes the great toe. The superficial posterior compartment has the gastrocnemius, soleus, plantaris, and the sural nerve.The tibial nerve innervates all of the superficial and deep muscles of the calf.

CLINICAL RELEVANCE

When the leg veins clot, thrombosis can result with a potential for pulmonary embolus. If the lower leg arteries are stenosed or occluded, a cold ischemic leg can occur which requires immediate intervention to salvage the leg. If nerve injuries occur, the patient may be left with various types of neurological deficits. Compartment syndrome is a surgical emergency and requires prompt fasciotomy. Compartment syndrome results when the increased pressure within the compartment causes the tissues to be hypoperfused. Since the fascia that surrounds the compartment does not stretch, any swelling of the

muscles or bleeding within the compartment can cause an increase in the pressure within the compartment

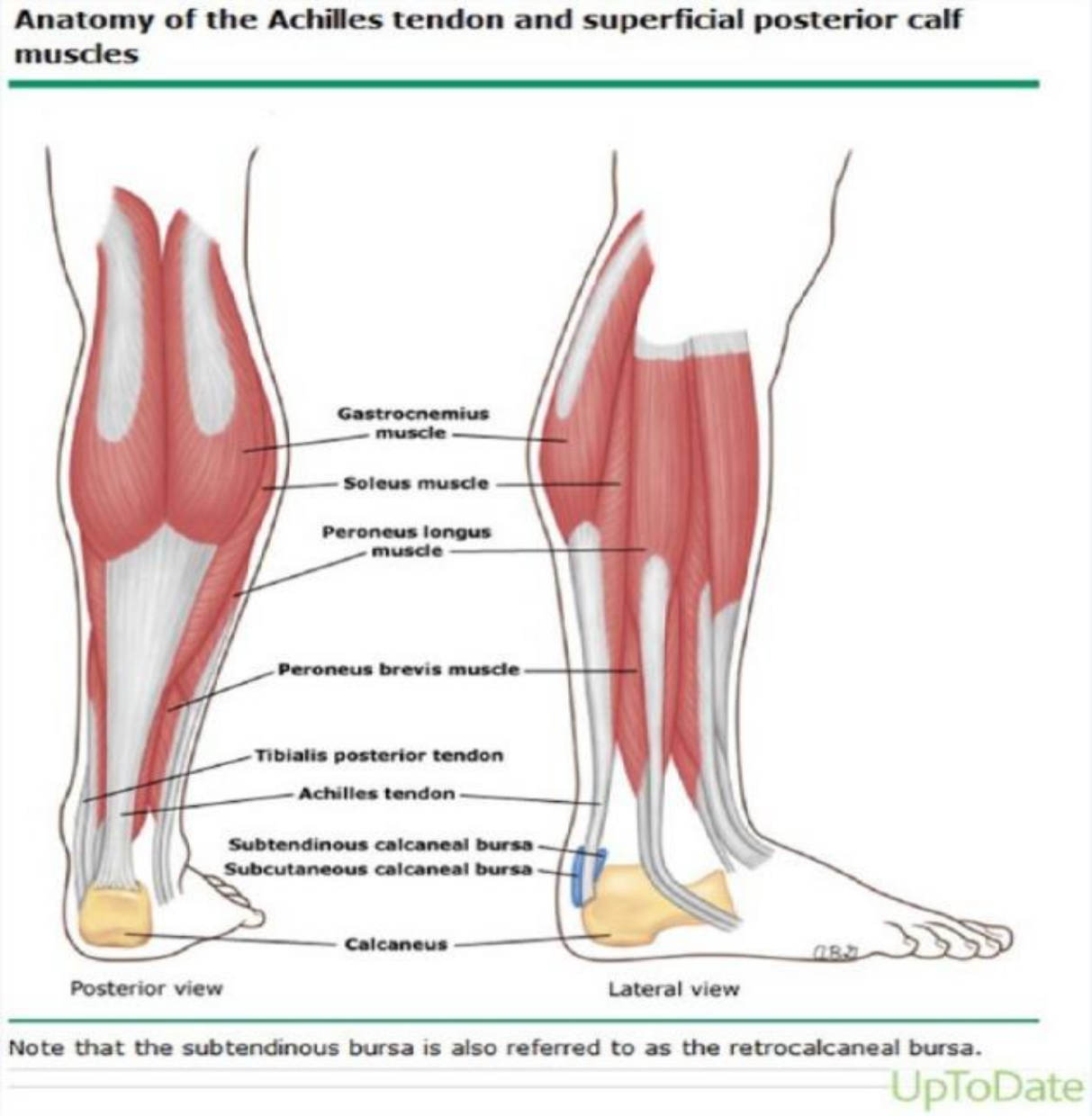

Figure: 2.1 calf muscles anatomy

ANKLE ROM- BIOMECHANICS

MAKO FUKANO ET.AL.(OCTOBER2018) has studied the differences that occurs in ankle ROM as a result of gender and found that range of Dorsi /Planar flexion and Inversion/Eversion is more in females as compared to males.[21]

CLAIRE L. BROCKETT ET.AL.(2016) in the article **'B**iomechanics of the Ankle', provides an insight into the anatomical complexity of the ankle joint and its influence on the biomechanics of the joint. It also describes the movements involved in a normal gait cycle.**[22]**

SEBASTAIN F BOMBAUSH ET.AL (JUL-2016) performed a study to define norm values for ADF(ankle dorsiflexion) using a standardized examination procedure which were used to define a decision pathway for diagnosing impaired ADF and MGT. Physiological values for ADF were assessed in a large asymptomatic population. This allowed the definition of a decision pathway to diagnose impaired ADF and MGT. This systematic approach provides a consistent definition of impaired ADF and MGT, which is the prerequisite to study the effectiveness of treatment strategies for MGT.This systematic approach provides a consistent definition of impaired ADF and MGT, which is the prerequisite to study the effectiveness of treatment strategies for MGT.[23]

DICHARRY, JAY. (2010) describes in detail the kinetics and kinematics involved in gait cycle. The article identifies the gait cycle so that common terminology can be used to discuss and compare walking and running.[24]

CALF STIFFNESS

JEONHYEONG LEE et.al. (Dec 2019) studied the effect of calf stiffness on gait, foot pressure and balance in adults.. The result depicted a significant difference in the length of COP, Single Limb Support and loading response was observed between the groups and it was found that COP Length and Single Limb Support ratio was greater in normal group but the experimental group

showed a higher ratio for loading response in the gait ratio thereby indicating that calf stiffness has negative impact on gait ability and balance therefore, it is important to carry out assessment of muscle tightness during exercise and treatment prescription.[1]

EFFECTS OF STRETCHING ON MUSCLE EXTENSIBILITY AND GAIT

EHSAN EBRAHMIPOUR et.al. (April 2019) performed a study on whether static- stretching exercises acutely affect gait parameters in older adults or not and found a significant increase in walking velocity and step length following single session of static stretching ex, thereby concluding that stretching exercises if given on a systematic basis may result in adaptations in gait indicative of decreased risk of fall.[25]

SHADI POUREBRAHIM AHVAZI et al.2014 did a study on the effects of eight weeks of flexibility training on step length, range of motion and balance of middle-aged men and woman with ectomorph and endomorph body types. No significant differences were found between the Ectomorphic and Endomorphic groups in the pre-test. However, significant differences in the post-test values were observed between the two groups in step length, range of motion, and dynamic balance. Hence, the results showed that step length, range of motion, and balance can be improved by flexibility training. The endomorphic group had better results in step length whereas ectomorphs fared better in balance and ROM. Also a significantly better performance was observed in women. [26]

WILLIAM E PRENTICE, M.H (2011) has stated that stretching has been used as a means to increase flexibility or ROM, thereby improving performance and reducing the risk of injuries . Four different types of stretching techniques are used which are Static, Dynamic, Ballistic and Proprioceptive Neuromuscular facilitation techniques respectively.[9]

CAROLYN KISNER (5TH EDITION 2007) . Flexibility exercises can lead to an increase in the elasticity as well as length of muscles and peri-articular structures thereby reducing the risk of injuries.

They also help in increasing the ROM of the restricted joints due to tightness of the soft tissue structures.[8]

PNF STRETCHING

MASATOSHI NAKAMURA et.al (2021) compared the acute effects of 120s of Hold-Relax and Static Stretching on Ankle Dorsiflexion ROM (DFROM) and muscle stiffness and the results showed that both hold-relax and static stretching interventions were effective in improving DFROM. While Static stretching was required to decrease muscle stiffness in older adults.[27]

MARIINA REINER ET.AL (SEPT 2021) concluded that PNF stretching if used in combination with Post stretching activities in a warm up will provide the benefits of increased ROM and will also not hav any detrimental effect on immediate muscle performance.[13].

AARTI PANCHAL ET.AL.(NOV 2019). in her comparative study of the effect of pnf stretching versus static stretching on calf muscle flexibility concluded that though both techniques are effective in improving calf muscle flexibility but PNF stretching is more effective.[28]

LANDON LEMPKE ET.AL.(2018) performed a study to compare the effectiveness of PNF Stretching to that of Static Stretching on increasing hip flexion range of motion and found that the results are inconclusive in determining whether PNF is more superior than Static Stretching in improving hip flexion ROM or not. The reviewed literature suggested that both Static and PNF stretching will improve hip flexion ROM regardless.[29]

KONRAD ET.AL (JUL2017) as investigated the influence of a single static, ballistic, or proprioceptive neuromuscular facilitation (PNF) stretching exercise on the various muscle-tendon parameters of the lower leg and to detect possible differences in the effects between the methods.it was deduced that although ROM increased in all but muscle pennation angle decreased only in PNF.. Multivariate analysis showed no clinically relevant difference between the stretching groups. **)** [11]

ASHLESHA SIRARI ET.AL (2015) in her study comparing the effectiveness of PNF versus Cyclic stretching in calf stiffness among college going girls found that though both cyclic and PNF stretching are effective to improve calf muscle flexibility but PNF stretching is more effective compared to Static stretching[30]

TANER AKBULUTET.AL.(DEC 2015), studied the effects of an Eight-Week Proprioceptive Neuromuscular Facilitation Stretching Program on Kicking Speed and Range of Motion in Young Male Soccer Players and concluded that an 8-week unassisted PNF-CR improved on the ROM of particular lower extremity joints and the kicking speed in the young male soccer players. These results provide strength and conditioning coaches with a practical way to use unassisted PNF-CR in warm-up for positive improvements in the ROM of the hip and ankle and the applications of the kicking speed.[31]

DONG KO HWAK ET.AL(JULY 2015) conducted a study to examine the effect of intensity of contraction on ROM while applying PNF Stretching and found that changes in ROM were larger for the 60% and 100% groups as compared to the 20% group and the lowest for control group without any isometric contraction. The results indicate that while applying the PNF stretching, it is not necessary to apply the maximum intensity of muscle contraction. Moderate isometric contraction intensities may be optimal for healthy young males, while a sufficient effect can be obtained even with a low contraction intensity ([32]

MADDIGAN ME et.al.(May 2012) A comparison of assisted and unassisted proprioceptive neuromuscular facilitation techniques and static stretching and found that all 3 types of active stretching provided similar levels of improvements in ROM and post stretching performance decrements in Muscle tension and angular velocity. Thus, individuals can use PNF stretching techniques either with a partner or alone with the help of a strap to improve ROM, but athletes should avoid using these techniques before important competitions or training because of the impairment of limb velocity and Muscle tension.[33]

MIYAHARA ET.AL (2013) studied PNF stretching and compared the effects of proprioceptive neuromuscular facilitation (PNF) stretching and static stretching on maximal voluntary contraction (MVC) and suggested that, PNF stretching increases ROM more than static stretching. **)**[12].

MECHANISM OF PNF

KAYLA B HINDLE et.al (March 2012) studied the mechanism and effect PNF has on ROM and muscle function and identified four mechanisms behind the improved ROM which are: Autogenic Inhibition, Reciprocal Inhibition, Stress Relaxation and Gate Control theory.[34]

KARIM KHAN 2008 (3RD EDITION) describes the possible underlying mechanism of improvements seen after PNF stretching.[14].

MEASUREMENT METHODS

DENISE M. PETERS et.al.(2013) examined the reliability and concurrent validity of gait speed measurements obtained from a 4-Meter Walk Test compared with the commonly used 10-Meter Walk Test as well as to compare 2 different timing methods: stopwatch and automatic timers and recommended the use of 10m walkway to attain most valid clinical assessment of walking Velocity in older adults and the study also deduced that stopwatch method is as reliable and valid as automatic timers in measuring walking speed. **(35)**

J W YOUDAS et.al. (1993) examined intratester and interstater reliability for goniometric measurements of ankle dorsiflexion (ADF) and ankle plantar flexion (APF) active range of motion (AROM) and concluded that AROM measurements of dorsiflexion and planter flexion done by the same therapist has good reliability.[36]

ALEXANDRA HERRERO LARREA ET.AL (September 2018) performed a study to establish the normal limits of the spatial gait parameters of the elderly, when walking at home and analyse the relationship between the spatial gait parameters to other health variables. This study was performed

using ink footprint method as a reliable method of measuring gait parameters like step length, stride length etc. [37]

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CHAPTER:3 MATERIALS AND METHODS

STUDY DESIGN: Pre and Post Experimental Design

SAMPLE SIZE: 40 students of Integral University

. Each student has active dorsiflexion range of motion between 0-15 degrees in either one or both ankles.

SAMPLE COLLECTION: Purposive Sampling

POPULATION AREA: The subjects were taken from Integral University, Lucknow , U.P., India.

STUDY POPULATION: The target population are adults between the age group of 20-30 years.

SOURCE OF SUBJECT: The subjects were taken from Integral University from the Department of Physiotherapy.

INCLUSION CRITERIA:

1. Student of Integral University
2. Both Genders
3. Age between 18-30 years
4. BMI 18.5-29.9
5. Ankle Dorsiflexion range (0-15 degrees) in either or both LL

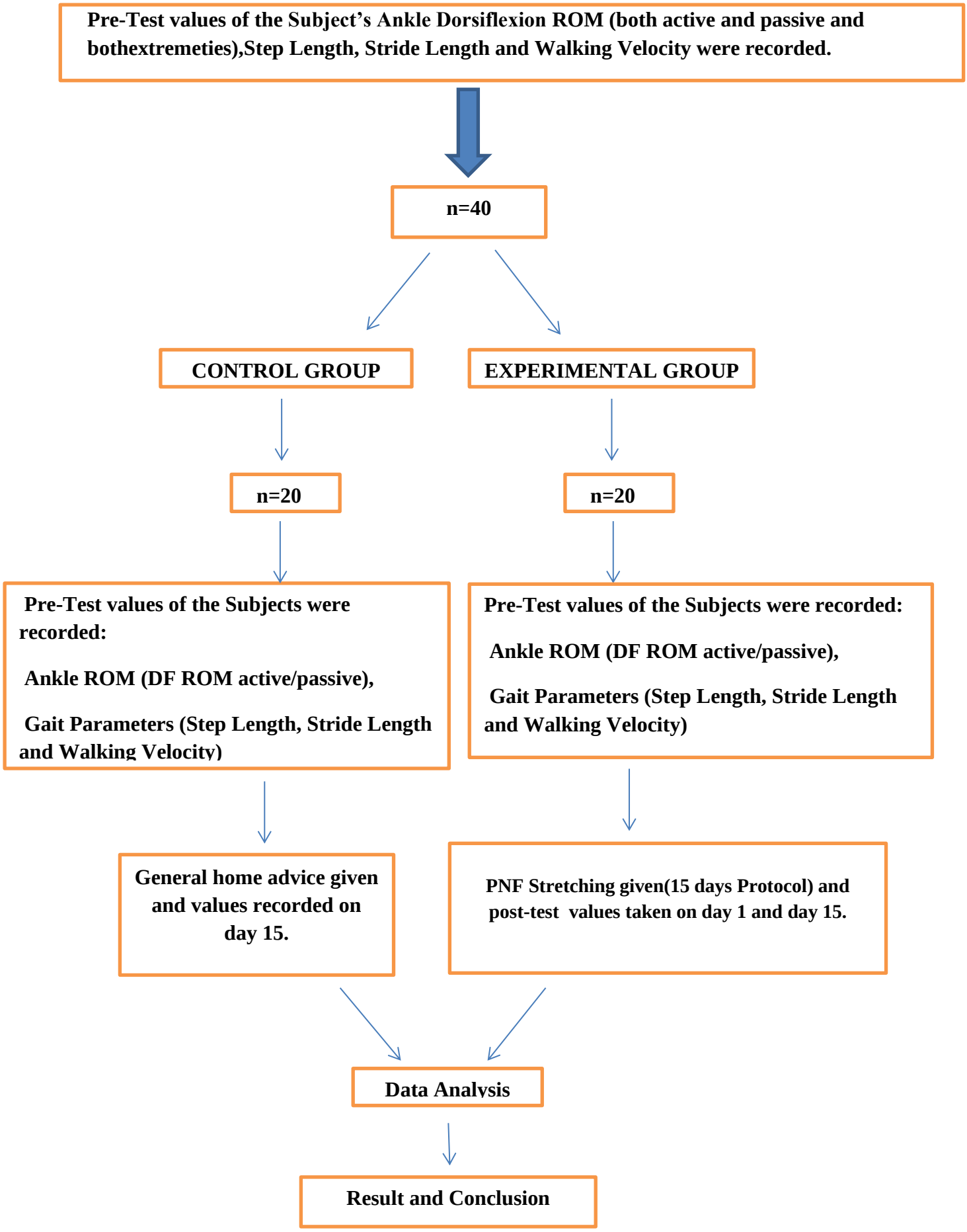
EXCLUSION CRITERIA

1. Any professionals
2. Age <18 and > 30
3. BMI <18.5 and> 29.9
4. Ankle Dorsiflexion range above 15 degrees in both the LL
5. History of recent injury in around ankle joint

6. History of acute or chronic pain in and around ankle joint
7. Psoriatic Arthritis
8. Joint Instability
9. Edema in and around Ankle Joint
10. Hypo mobile joints resulting from sources other than biomechanical causes
11. Spondylo-arthropathy
12. History of Cardiovascular or Respiratory problems.

PARTICIPANTS: This study was conducted on 40 subjects who are students at Integral University. The Participants were divided into two groups Control and Experimental randomly through chit method. All subjects were fully briefed about the nature of the study, its purpose, benefits and risks prior to taking consent.

PROTOCOL


Pre-Test values of the Subject's Ankle Dorsiflexion ROM (both active and passive and bothextremeties),Step Length, Stride Length and Walking Velocity were recorded.
n=40
CONTROL GROUP
EXPERIMENTAL GROUP
n=20
n=20
Pre-Test values of the Subjects were recorded:
Ankle ROM (DF ROM active/passive),
Gait Parameters (Step Length, Stride Length and Walking Velocity)
Pre-Test values of the Subjects were recorded:
Ankle ROM (DF ROM active/passive),
Gait Parameters (Step Length, Stride Length and Walking Velocity)
General home advice given and values recorded on day 15.
PNF Stretching given(15 days Protocol) and post-test values taken on day 1 and day 15.
Data Analysis
Result and Conclusion

DURATION OF STUDY: 2-3 months

VARIABLES

INDEPENDENT VARIABLES

1. **PNF Calf Stretching**

DEPENDENT VARIABLES

1. **Step Length**
2. **Stride Length**
3. **Walking Velocity**
4. **Ankle Dorsiflexion ROM**

PROCEDURE

Participants were recruited from /integral University. Subjects with calf tightness were selected based on inclusion and exclusion criteria. The Participants were priorly provided with a consent sheet outlining the purpose of the study, benefits and risks associated with the study. The same was explained verbally and assessment and protocol was performed only after receiving their consent.

Participants were encouraged to ask questions and standard answers to common questions were used by researcher to ensure consistency of information.

MEASURING TOOLS

1) **Measuring Ankle Dorsiflexion ROM-**

   with the help of universal goniometer(Both **Active** and Passive ROM are measured).

2) **Measuring Step Length and Stride Length-**

   Ink Footprint Method is used for the purpose of measuring the above mentioned gait parameters.

3) **Measuring Walking Velocity-**

   Stop Watch is used to measure the time required to cover the predetermined distance including the acceleration and deceleration phases (2.5+10+2.5)m.

MEASUREMENTS

1) MEASURING ANKLE DORSIFLEXION ROM:

Dorsiflexion ROM occurs in the sagittal plane around a medial-lateral axis. The mean dorsiflexion ROM is 20 degrees (**ACCORDING TO AAOS, AMA, NOVACHECK ET.AL.1988)[38].**

Dorsiflexion range measurement is also affected by whether the measurement was taken in weight-bearing or non-weight bearing position. Ranges measured with knee flexion were usually greater as compared to that done in knee extended position. As knee flexion slackens up the gastrocnemius muscle which eliminates interference from passive tension**.(NORKINS AND WHITE 3RD EDITION)[39].**

A goniometer was used to check the ROM. The subject was placed in the Supine Lying position with knee flexed up to 30 degrees and supported by a pillow. The center of the fulcrum was placed at the lateral aspect of the lateral malleolus. The stationary arm was placed with the lateral midline of fibula, using fibular head as reference. The moving arm was placed parallel to the lateral aspect of the fifth metatarsal.

The therapist stands by the side of the subject on the testing side. Stabilizing the tibia and fibula to prevent knee flexion and hip rotation. The ankle was first positioned in the neutral position (90 degrees).the subject was asked to perform Dorsiflexion from this position. Active range was measured and passive overpressure was applied by the therapist to asses Passive ROM. The data obtained was sorted randomly into control and experimental group.

FIGURE 3.1- HALF-CIRCLE GONIOMETER

2) MEASURING GAIT PARAMETERS

a) Measuring step length and stride length

Gait Parameters included in the study such as Step Length and Stride Length were measured using the ink footprint method. Foot Print method of gait analysis is a standard as well as a conventional method for measurement of spatial parameters of gait.

The Soles of the feet of the participants was stained with washable blue ink and the participants were instructed to walk on a smooth 10m walkway at a comfortable speed. Only middle 10 steps were used to avoid variability in steps due to initiation and termination of gait. . Step length was measured from the geometrical heel center of the current footprint to that of the previous footprint. While Stride length was measured from the progression line of the heel centers of the consecutive footprint of the same foot **(**Sumandeep Kaur Et.Al. June 2014**)**[40] 3 measures of Step length and stride length were recorded and their mean value was calculated and used in the study

B) Measurement of Walking Velocity

Walking velocity was measured using smartphone stopwatch. The ideal distance used to measure walking speed is 10m (A.Middleton Et.Al. April2015) [41]**.** Based on this a central straight path of10m is used in the study. Along with this an acceleration and deceleration phase distance of 2.5m each was provided at the beginning and ending of the path apart from the 10 m pathway so as to avoid variations in the speed because of the same.

FIGURE 3.2: WALKWAY TO ASSESS GAIT PARAMETERS

FIGURE 3.3: MEASUREMENT PROCEDURE

FIGURE 3.4: GAIT ANALYSIS USING INK FOOTPRINT METHOD

The participants had to cover a total distance of 15m at their self-selected comfortable speeds. However the distance outside of the 10 m path for acceleration and deceleration phases was not timed. The tester started the time measurement using the stopwatch when the participant's leading leg had completely entered the timing zone, and stopped the measurement when the leading leg had completely reached the end line. Each participant completed two consecutive with a rest period of 2 min between evaluations **(**Jun Hyunbae Et.Al June 2019)[42]**.** The reading was recorded and mean of the two were taken which was divided with the distance .The result was recorded.

INTERVENTIONAL PROCEDURE

Subjects with limited dorsiflexion ROM were selected for the study.40 subjects (male and female) were included. The subjects were randomly divided into 2 groups by using random sampling method. Each group had 20 subjects each. Treatment was given for 15 days. Prior consent of subject was taken before assessment. Experimental group subjects who received PNF stretching technique, where the subject is in supine lying position with knee extended. The researcher moves the leg of the subject in the direction of dorsiflexion to the point of discomfort. This is immediately followed by the isometric contraction of restricting muscle for; at this point the patient is instructed to 'try to gently take the foot up, against my resistance, using your maximal strength.' The therapist should apply just enough force so that the foot remain static.no motion is intended by either patient or therapist. This is the hold phase and last for 6seconds. After holding the contraction for enough time he researcher instructs the subject to relax and the foot is repositioned passively to the new limit of range and held for 30s and this is followed by isometric contraction. Then again take the foot passively to the new barrier point and repeat the procedure. This whole procedure is repeated 3 times per sets of 4 reps for 15 days. Control group consists of 20 subjects who received Home Advice including conventional treatment methods like hot packs twice a day for 10 min for the treatment duration, along footwear

correction such as used of flats with comfortable insoles instead of heels and wedges etc. Lifestyle modifications like increasing physical activity..

PRE-TEST values of the outcome measures were taken for both the groups and on the same day post-test treatment measures was also taken.

Follow up values were collected after 15 days of treatment session and based on the findings data analysis was performed.

DATA-ANALYSIS

Descriptive Statistics was performed to find out mean, range, standard deviation for demographic variables as well as outcome variables. Excel Analysis Tool Pack 2019 software was used for data analysis. Single factor ANOVA test was used. Alpha value was kept at 0.05, therefore,($P < 0.05$). Paired t-test is used compare the group results..

CHAPTER: 4 RESULTS

40 Participants including 24 females (60%) and 16 males(40%) of mean age 23.4±2.414 of Experimental and 23.5±2.351 of Control group. The mean, Standard Deviation, p-value and t-value of both the groups are given in table 4.1.

GROUP	Experimental	Control	t- value	p- value
	Mean +/- SD	Mean +/- SD		
Age	23.4±2.414	23.5±2.351	2.02	0.895
Height	1.67±0.079	1.653±0.093	2.02	0.584
Weight	63.3±10.638	58.55±9.064	2.02	0.137
BMI	22.84±3.414	21.39±2.759	2.02	0.148

TABLE 4.1: MEAN, STANDARD DEVIATION p –value AND t-value of AGE, HEIGHT, WEIGHT AND BMI OF BOTH CONTROL AND EXPERIMENTAL GROUP

GENDER CHART

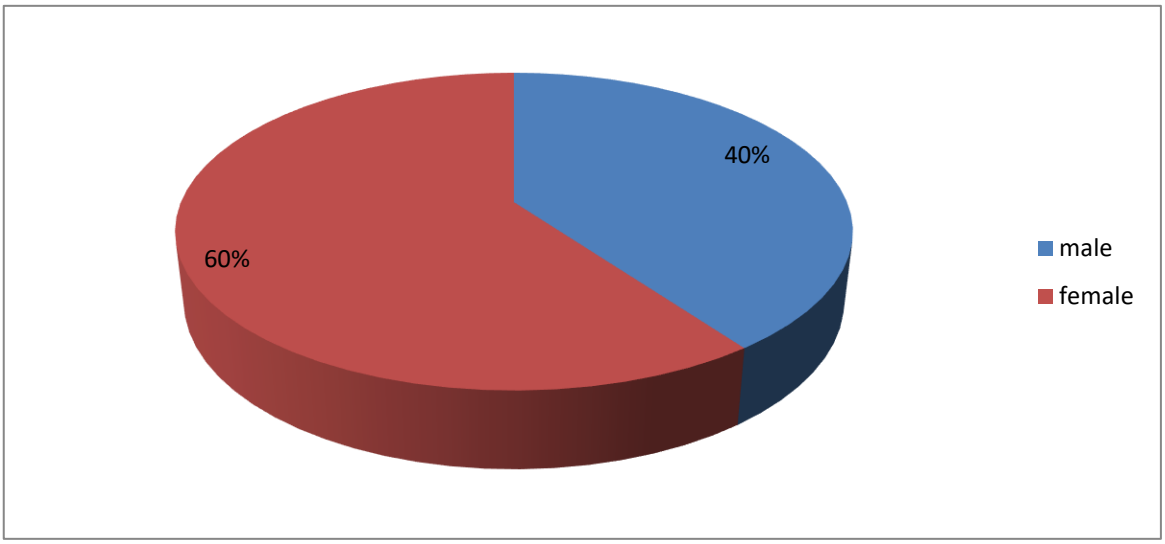


FIG:4.1GENDER REPRESENTATION PERCENTAGE CHART. ABOUT 60% WERE FEMALES AND 40% WERE MALES

TABLE 4 : PRE, POST AND DAY 15 VALUES OF LEFT AND RIGHT ACTIVE ANKLE DORSIFLEXION ROM.AND THEIR p-VALUE AND f-VALUE

	AROM (experimental)				
ROM	Pre	Post	day 15	f- value	p- value
Left	12.5	15.7	19.05	19.41	0.0000003
Right	16.1	19.65	22.65	12.52	0.00000031

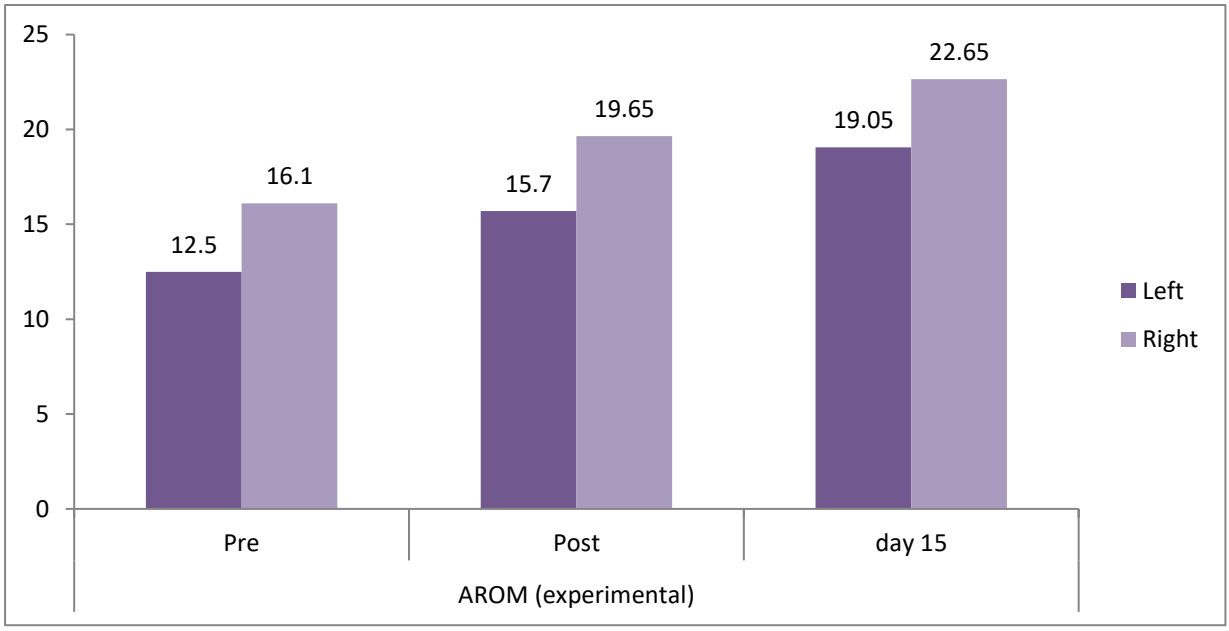


FIG4. 2: depicts the mean values of pre, post and day 15 of left and right active ankle dorsiflexion ROM and shows improvements gained from D-0 to D-15

TABLE 4.3 PRE, POST AND DAY 15 VALUES OF LEFT AND RIGHT PASSIVE ANKLE DORSIFLEXION ROM.AND THEIR p-VALUE AND f-VALUE

	PROM (experimental)				
	Pre	Post	day 15	f- value	p- value
Left	14.7	19.05	26.95	68.685	<0.00000011
Right	19.45	25.75	28.35	24.78	0.00000017

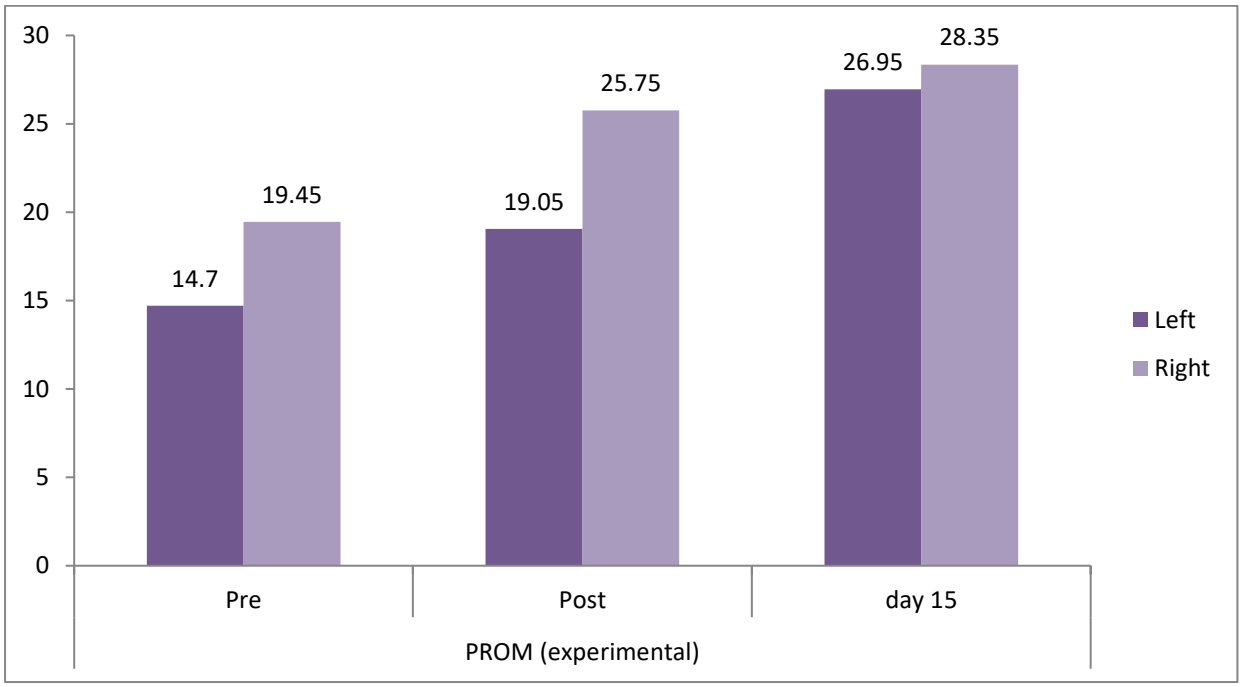


FIGURE 4.3: depicts the mean values of pre, post and day 15 of left and right Passive ankle dorsiflexion ROM and shows improvements gained from D-0 to D-15 in the experimental group

TABLE 4.4 MEAN, STANDARD DEVIATION, f-VALUE AND p-VALUE OF STEP LENGTH OF EXPERIMENTAL GROUP.

	Step length (experimental)				
	Pre	Post	day 15	f- value	p- value
Step length	64.033	66.18	65.212	0.216	0.806

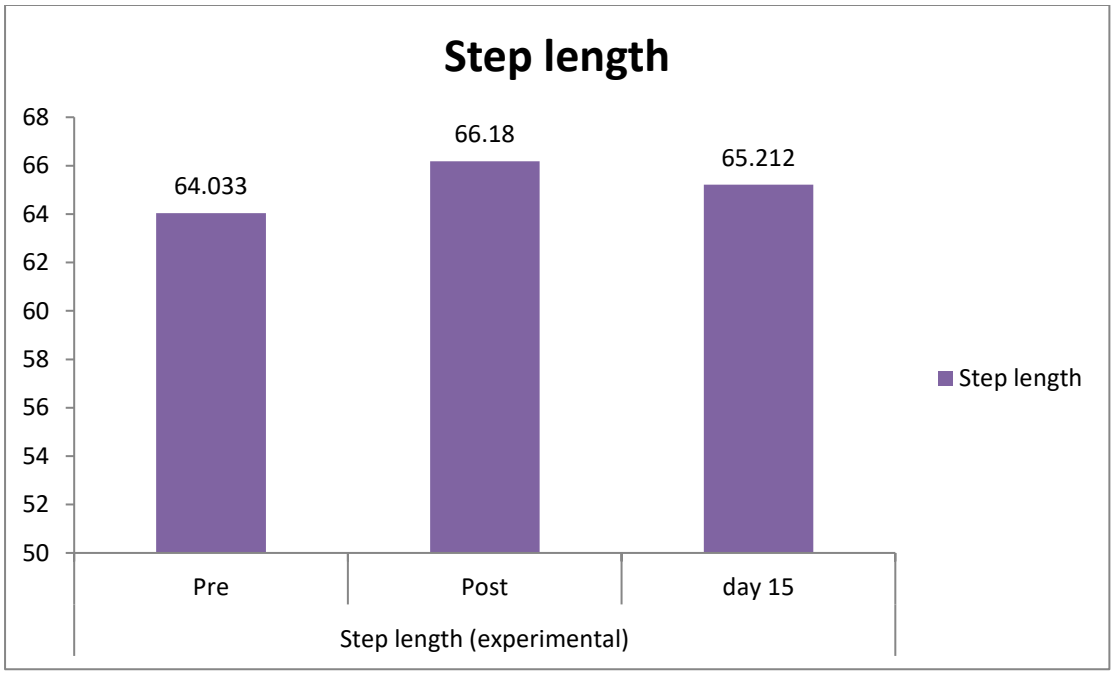


FIGURE4.4: According to the graph no significant improvement has been seen in step length from pre i.e. D-0 to D-15 in the experimental group.

TABLE 4.5 MEAN, STANDARD DEVIATION, f-VALUE AND p-VALUE OF STRIDE LENGTH OF EXPERIMENTAL GROUP

	Stride length (experimental)				
	Pre	Post	day 15	f- value	p- value
Stride length	129.145	132.313	130.417	0.115	0.891

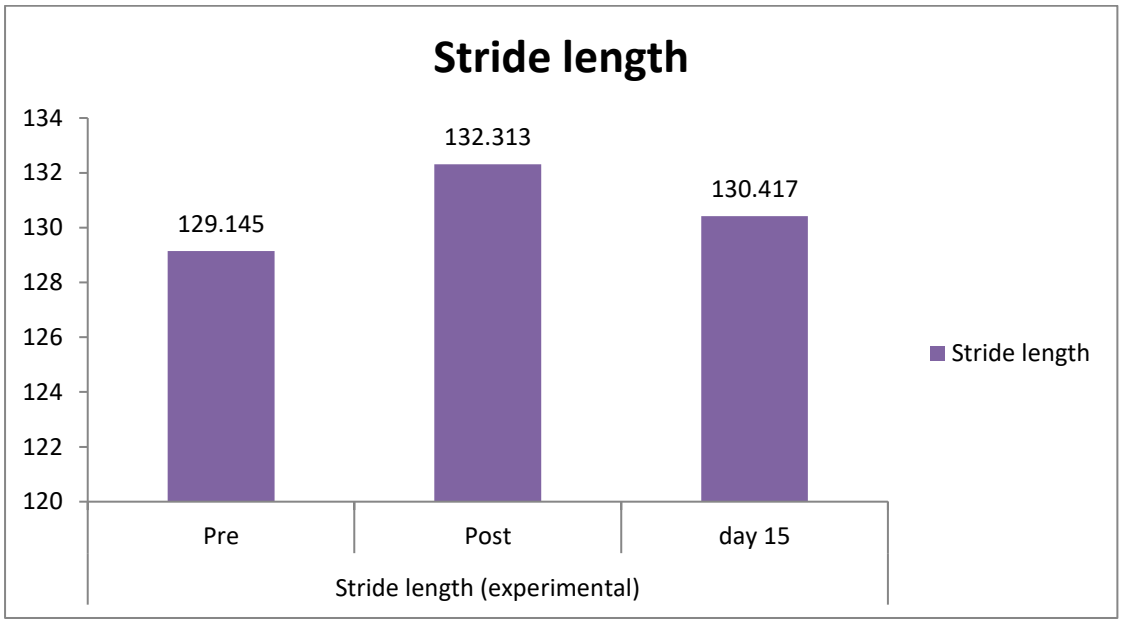


FIGURE4. 5: According to the graph no significant improvement has been seen in Stride length from pre i.e. D-0 to D-15 in the experimental group.

TABLE 4.6 MEAN, STANDARD DEVIATION, f-VALUE AND p-VALUE OF WALKING VELOCITY OF EXPERIMENTAL GROUP.

	Walking Velocity (experimental)				
	Pre	Post	day 15	f- value	p- value
Walking Velocity	1.34	1.339	1.422	0.848	0.434

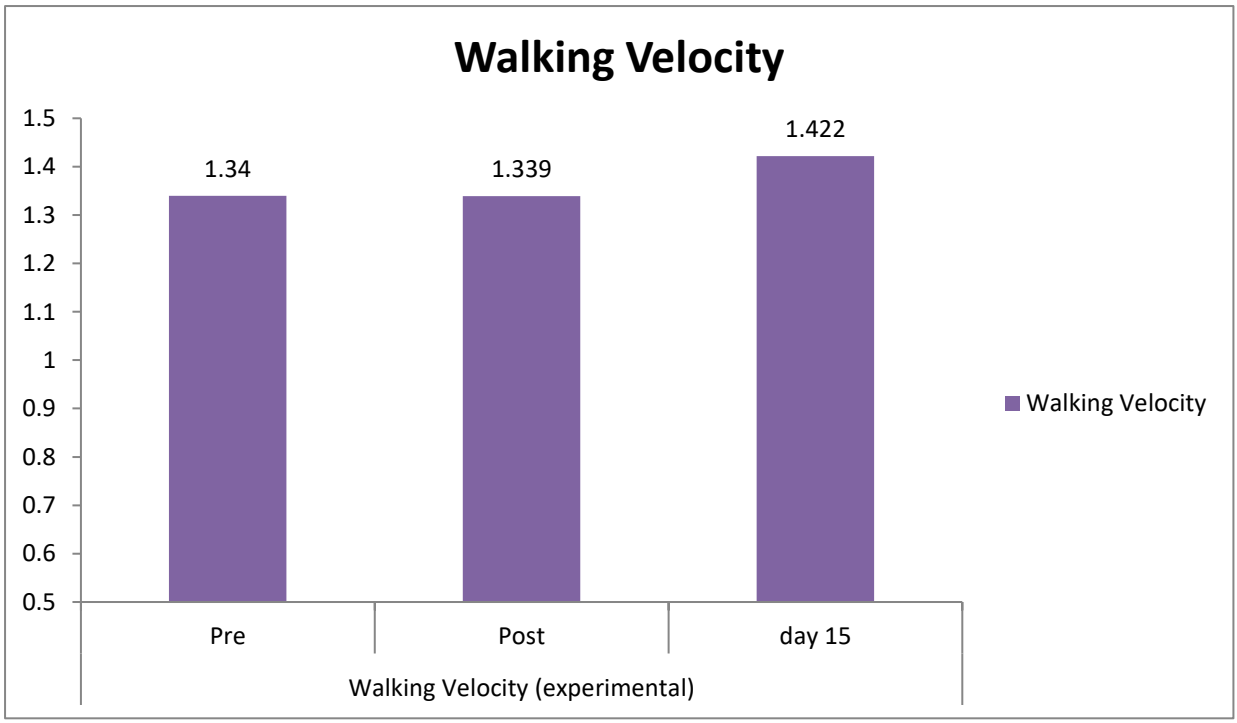


FIGURE 4.6: According to the graph no significant improvement has been seen in walking velocity from pre i.e. D-0 to D-15 in the experimental group.

TABLE 4.7 PRE AND DAY 15 VALUES OF LEFT AND RIGHT ACTIVE AND PASSIVE ANKLE DORSIFLEXION ROM.AND THEIR p-VALUE AND t-VALUE IN CONTROL GROUP.

		CONTROL GROUP			
		DAY 0	DAY 15		
		MEAN±SD	MEAN±SD	t-value	P- value
AROM	LEFT	20.25±3.581	20.25±4.290	2.093	0.046
	RIGHT	22.1±3.323	22.5±2.965	2.093	0.836
PROM	LEFT	24.05±3.720	23.7±4.167	2.093	0.05
	RIGHT	27.3±3.226	26.65±3.014	2.093	0.05

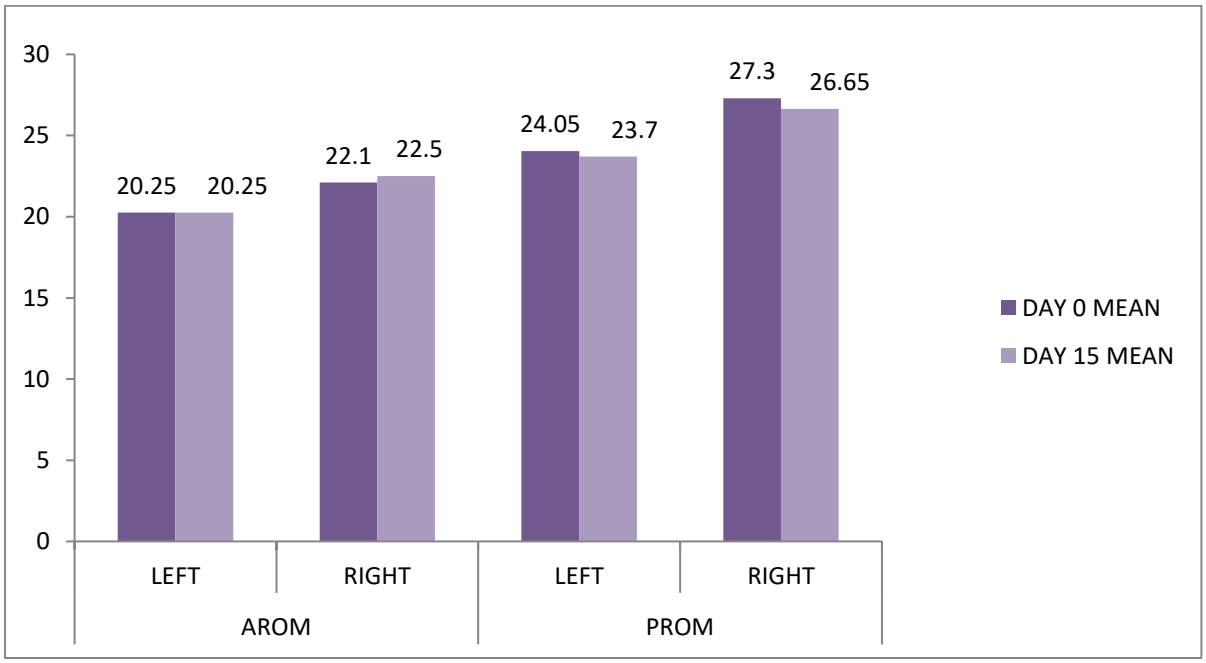


FIGURE4. 7:It is depicting the mean values of active and passive ROM in control group.

TABLE 4.8: PRE (D-0)AND POST(D-15) MEAN, STANDARD DEVIATION ,p-VALUE AND t-VALUE OF STEP LENGTH OF CONTROL GROUP.

	Control- group			
Step Length	Mean	±SD	t-value	p-value
Day-1	64.4365	5.057	2.093	0.297
Day-15	63.8525	5.632		

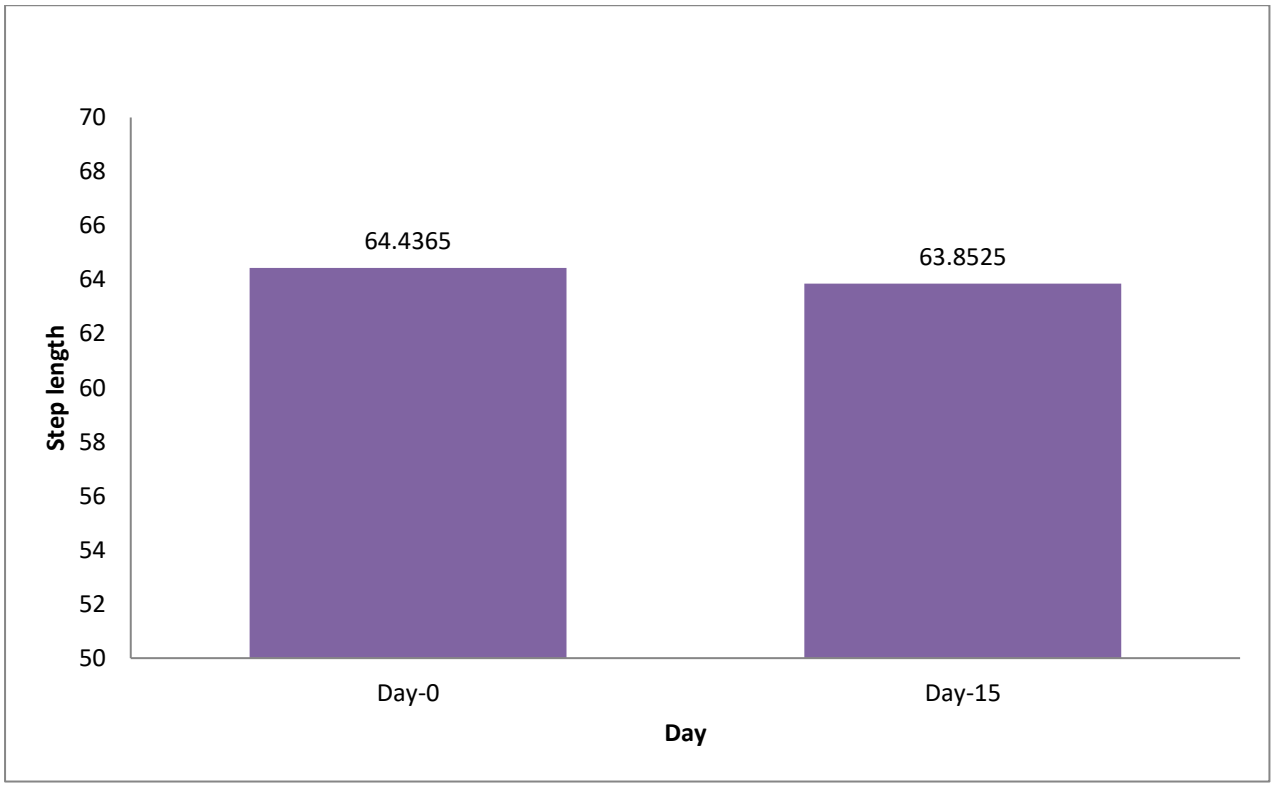


FIGURE4.8: It shows that no significant changes have been seen in the control group in step length from day0 to day 15.

TABLE 4.9: PRE (D-0)AND POST(D-15) MEAN, STANDARD DEVIATION ,p-VALUE AND t-VALUE OF STRIDE LENGTH OF CONTROL GROUP.

	Control -group			
Stride length	mean	±SD	t-val	p-val
D-1	129.383	3.900	2.093	0.297
D-15	128.735	9.878		

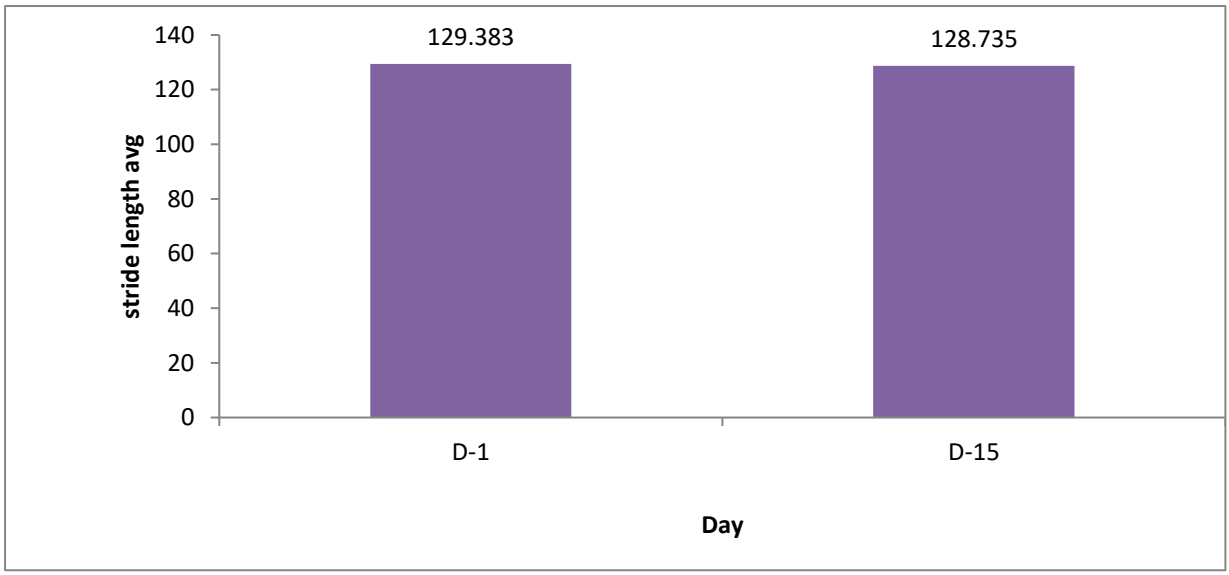


FIGURE4. 9: It shows that no significant changes have been seen in the control group in Stride length from day0 to day 15.

TABLE 4.10: PRE (D-0)AND POST(D-15) MEAN, STANDARD DEVIATION ,p-VALUE AND t-VALUE OF WALKING VELOCITY OF CONTROL GROUP.

CONTROL GROUP- WALKING VELOCITY

	mean	± SD	t- value	p-value
D-1	1.42	0.263	2.093	0.34
D-15	1.465	0.161		

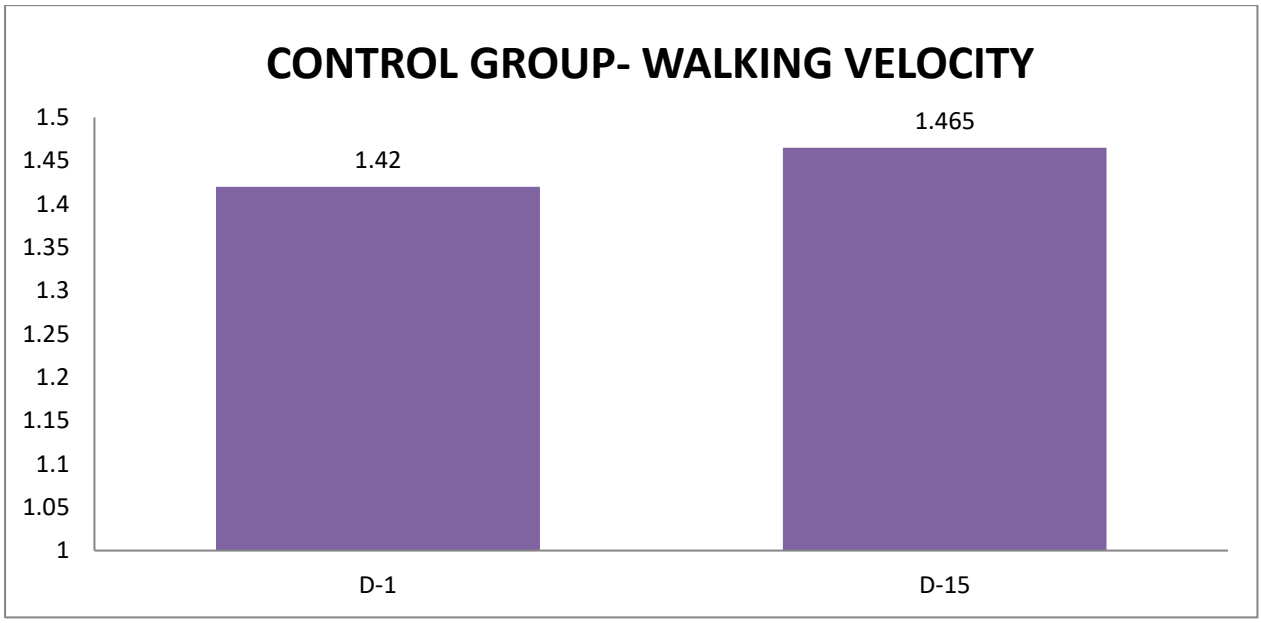


FIGURE4.10: It shows that no significant changes have been seen in the control group in Walking Velocity from day0 to day 15.

TABLE 4.11 MEAN, STANDARD DEVIATION ,p- VALUE AND t-VALUE OF ACTIVE AND PASSIVE DORSIFLEXION ROM OF BOTH LEFT AND RIGHT JOINTS OF BOTH EXPRIMENTAL AND CONTROL GROUP ON DAY-0.(BETWEEN GROUP ANALYSIS)

	ROM	ACTIVE				PASSIVE			
		LEFT		RIGHT		LEFT		RIGHT	
		MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD
EXP	D-0	12.5	±2.48	16.1	±5.2	14.7	±2.39	26.95	±3.54
CONTROL	D-0	14.5	±3.41	15.85	±4.51	17.9	±4.19	19.95	±4.59
	p-value	0.040		0.872		0.005		0.768	
	t-value	2.024		2.024		2.024		2.024	

TABLE 4.12 MEAN, STANDARD DEVIATION ,p- VALUE AND t-VALUE OF ACTIVE AND PASSIVE DORSIFLEXION ROM OF BOTH LEFT AND RIGHT JOINTS OF BOTH EXPRIMENTAL AND CONTROL GROUP ON DAY-15.(BETWEEN GROUP ANALYSIS)

GROUP	ROM	ACTIVE				PASSIVE			
		LEFT		RIGHT		LEFT		RIGHT	
	DAY								
		MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD
EXP	D-15	19.05	±4.39	22.65	±4.8	26.95	±3.53	28.35	±2.41
CONTROL	D-15	13.7	±2.56	15.75	±4.11	18.15	±4.16	20.8	±4.57
	p-value	0.0000334		0.0000194		0.000000145		0.000000167	
	t-value	2.024		2.024		2.024		2.024	

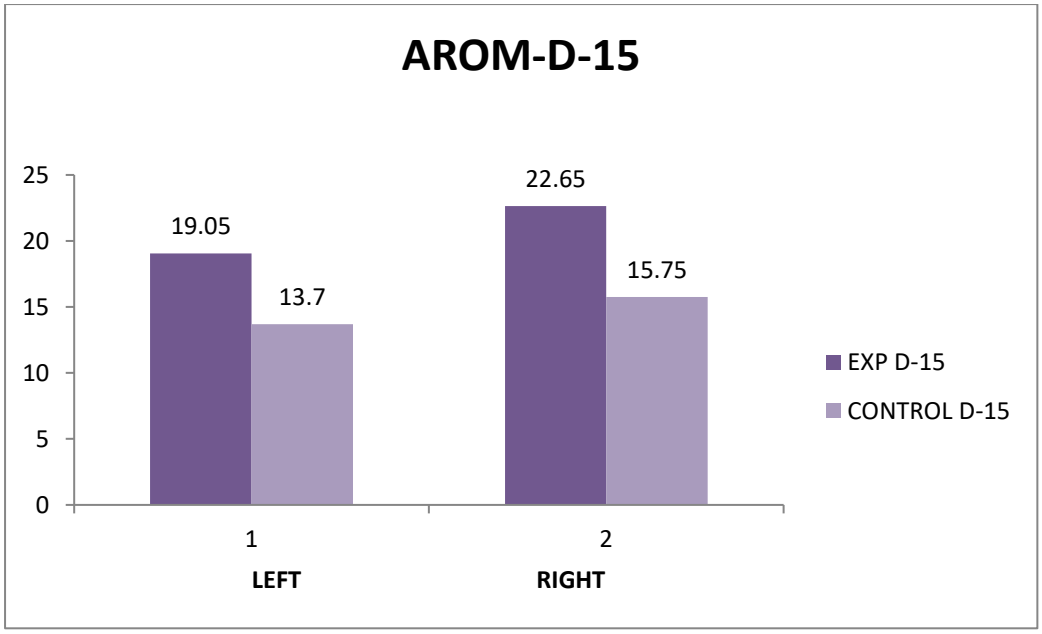


FIGURE4.11:It shows that the mean values of active dorsiflexion ROM has improved significantly more in experimental group as compared to control group on day -15 measurements.

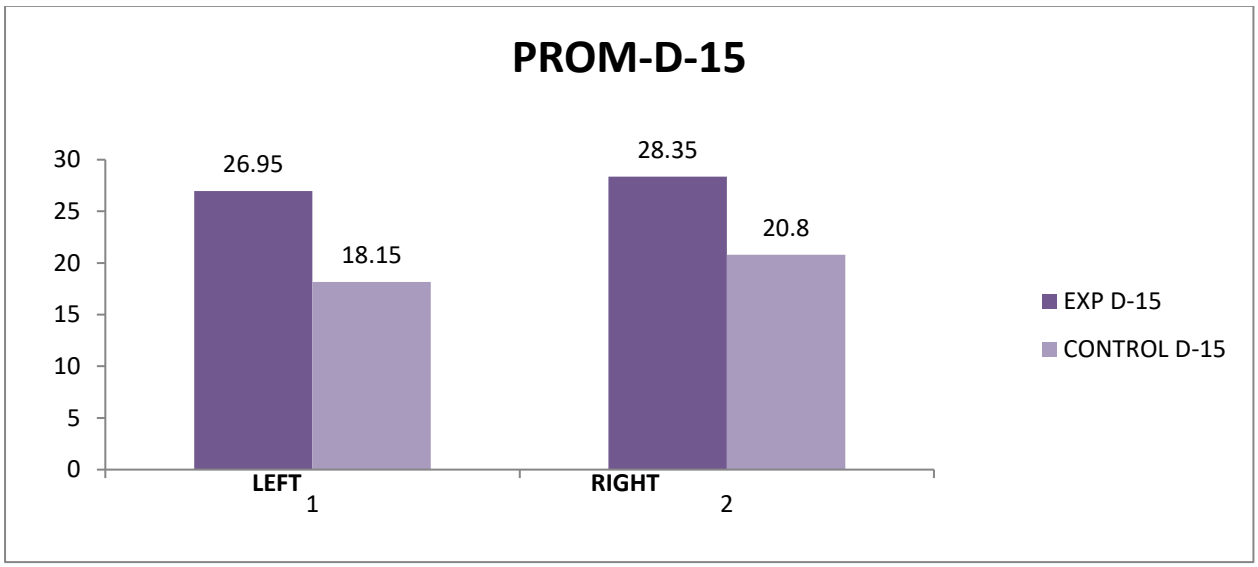


FIGURE4.12:It shows that the mean values of Passive dorsiflexion ROM has improved significantly more in experimental group as compared to control group on day -15 measurements.

TABLE. 4.13 : MEAN, STANDARD DEVIATION ,p- VALUE AND t-VALUE OF STEP LENGTH OF BOTH EXPRIMENTAL AND CONTROL GROUP OF DY-0 AND DAY-15.(BETWEEN GROUP ANALYSIS.

STEP LENGTH / GROUP	DAY	MEAN	±SD	p-value	t-value
EXP	D-0	64.033	±6.75	0.832	2.024
CONTROL	D-0	64.436	±5.05		
EXP	D-15	65.212	±15.24	0.710	
CONTROL	D-15	63.852	±5.63		

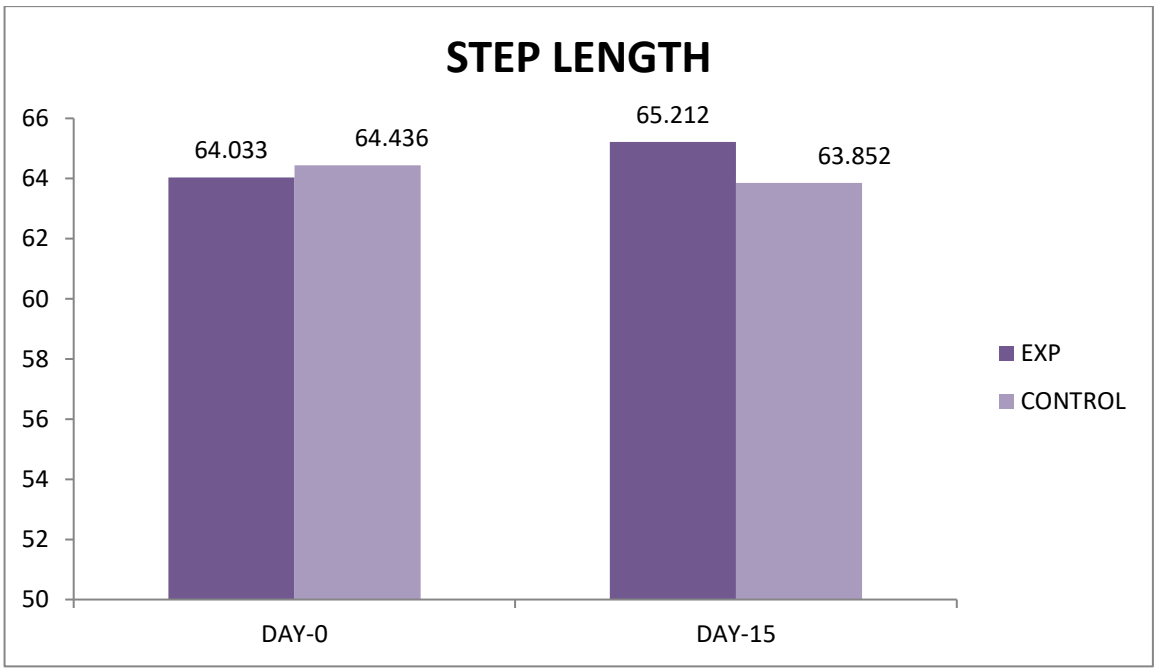


FIGURE4. 13: It shows no statistically significant effect on mean values of step length in both groups.

TABLE 4.14 MEAN, STANDARD DEVIATION ,p- VALUE AND t-VALUE OF STRIDE LENGTH OF BOTH EXPRIMENTAL AND CONTROL GROUP OF DY-0 AND DAY-15.(BETWEEN GROUP ANALYSIS)

STRIDE LENGTH GROUP	DAY	MEAN	±SD	p-value	t-value
EXP	D-0	129.144	±13.31	0.295	2.024
CONTROL	D-0	129.38	±3.90		
EXP	D-15	130.417	±30.84	0.82	
CONTROL	D-15	128.735	±9.88		

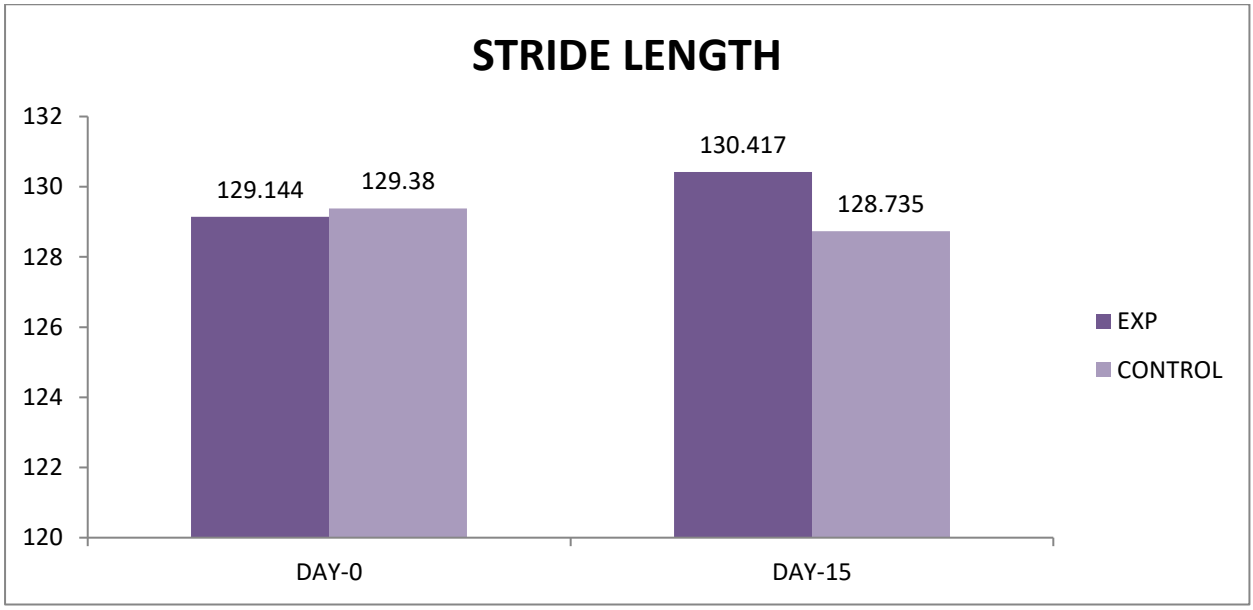


FIGURE 14: It shows no statistically significant effect on the mean of stride length in both groups

TABLE 4.15 MEAN, STANDARD DEVIATION ,p- VALUE AND t-VALUE OF STRIDE LENGTH OF BOTH EXPRIMENTAL AND CONTROL GROUP OF DY-0 AND DAY-15.(BETWEEN GROUP ANALYSIS)

WALKING VELOCITY GROUP	DAY	MEAN	±SD	p-value	t-value
EXP	D-0	1.34	±0.206	0.384	
CONTROL	D-0	1.42	±0.263		2.024
EXP	D-15	1.42	±0.159	0.406	
CONTROL	D-15	1.46	±0.161		

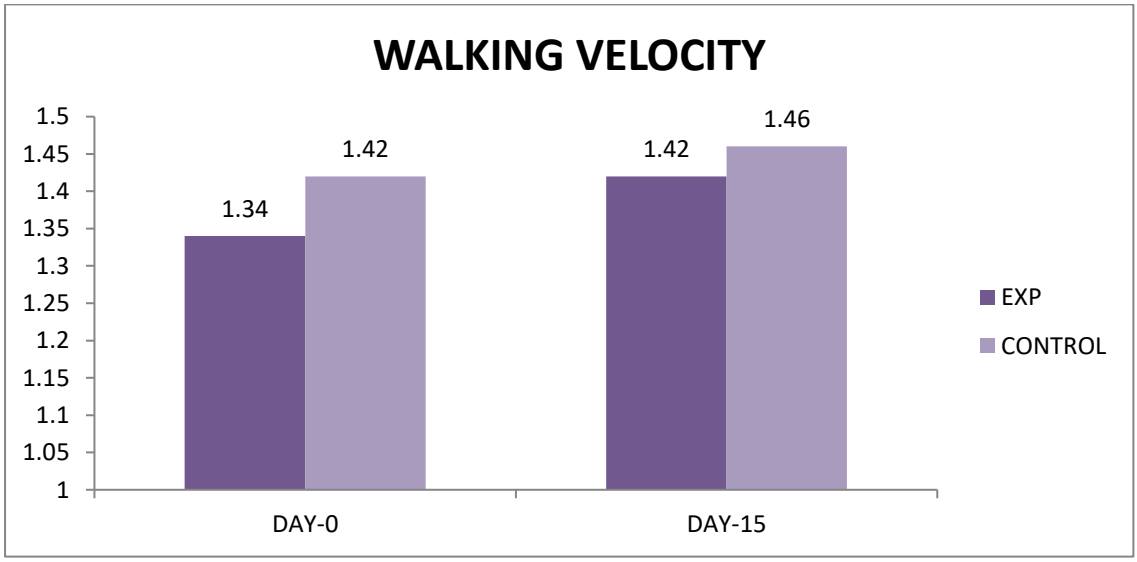


FIGURE 15: It shows no statistically significant effect on the mean of walking velocity in both groups.

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CHAPTER:5 DISCUSSION

The present study is conducted to analyze the effectiveness of PNF technique of stretching of calf musculature and the effect it has on its flexibility and whether it has any effect on ankle ROM as well as Gait parameters. As discussed earlier, calf muscles are very prone to muscle tightness due to their function as anti-gravity muscles and sedentary lifestyles (with prolonged sitting periods) and footwear choices also impact muscle length. Muscle tightness and adaptive changes in the muscle tissue can impact a person's gait, undermining their biomechanical efficiency and predisposing them to injuries.

In this study a total of 40 participants were recruited among the students at Integral University by purposive sampling based on inclusion and exclusion criteria out of which 16 were male and 24 were female and were in the age group of 20-30 years and had a BMI ranging between 18.5 and 29.9 .They were randomly assorted into control and experimental group by chit method. The Participants in the Experimental Group received PNF Stretching of calf musculature while those in the Control group received home advice including hot packs, lifestyle modifications etc.

Demographic details of the participants were recorded including Age, Gender, Height, Weight as well as BMI. Pre-test values of active and passive ankle Dorsiflexion Range of Motion of both the ankles and gait parameters including Step length, Stride length and walking velocity were recorded for both the groups . Post test values were recorded on the same day for experimental group and for both the groups on the 15^{th} day. The data collected was analyzed to find out the effect (if any) the treatment technique had on the participants outcome measures.

On comparing the results obtained after statistical analysis, it was found that there was no statistically significant effect of demographics on the groups outcome measures. Though demographic details have a significant impact on both ROM and Gait characteristics as both of these tend to deteriorate with advancing age. ROM measures and Gait parameters are also affected by gender .According to Mako Fukano Et.Al.(Aug 2018)**[21] ,**Young and healthy females tend to have shorter stride length, slower gait speed (Cho, Park, & Kwon, 2004)**[43],** and greater ankle flexion/extension range of motion (ROM)

(Bruening, Frimenko, Goodyear, Bowden, & Fullenkamp, 2015)[44]**.**compared to healthy young men while walking at Self-selected speeds and adult females ranging from 23 to 62 years old had more plantar flexion at toe-off and early swing than males (Roislien et al., 2009**)**[45]**.** However the outcome measures in the preset study were not statistically affected by the same .this could be because of the small sample size or lesser variability in demographics.

The chief objective of the study was to check if PNF technique improves calf muscles flexibility and if this improvement translates into improvement in the outcome measures. In the Control Group, there is no statistically relevant improvement in the active and passive ranges of ankle dorsiflexion range which can be seen from the table(4.7). However, the Experimental group shows significant improvement in the mean value of both active and passive ROM both within the group in pre, post as well as day 15 reading. With f-value of intra group(Experimental) comparison of Active ROM (left – 19.41; right 12.52) and Passive ROM (left-68.685 and right-24.78). and p-value (left-0.0000003: right- 0.0000003) and Passive ROM(left- <0.00000011; right-0.00000017).However, on comparing the Experimental group and Control group .It can be clearly seen that the experimental group not only showed greater improvements but also a high level of consistency of t-value(2.024) as can be seen from table(4.12, 4.13).

Both intra and inter group analysis indicate towards an increase in ROM of dorsiflexion movement from the baseline measurements in the Experimental group. This increase in ROM is due to improvement in the extensibility of calf musculature and is in agreement with the previous studies Authors generally argue over the fact that if the structural parameters have not been altered and still changes in joint ROM is seen, it is believed to be due to an increased stretch tolerance. It is considered that stretching alters the point at which stretch is perceived or tolerated and that PNF stretching may influence this to a greater extent than other stretching techniques.(Sharman et.al.2006)[46]**.** He described the mechanism as a result of Autogenic Inhibition in the contracted or stretched muscle due to decreased excitability as result of inhibitory signals from Golgi Tendon Organs (GTO) of the same muscle. PNF takes advantage of the

viscoelastic properties of the musculotendinious unit thereby allowing the muscle to creep and elongate, thereby increasing ROM(Jayaram M. et.al. Aug 2015) [47].

There have been various studies which have found that PNF significantly improves calf flexibility and thus the present study is in agreement with the results of these studies.

Gait Parameters included in the study are Step Length, Stride Length and Walking velocity. With regards to this there are not many research articles which study the effect of pnf calf stretching on gait parameters in healthy adults. It is believed that the improvements in the muscle flexibility does translate into improvements .however, there is still no strong evidence for the same.

The present study attempts to figure out if Pnf stretching of calf musculature impacts step length stride length and walking velocity or not. Studies have shown that performing pnf stretching just before any athletic activity might result in decrease in speed and muscle performance.(M. Reiner et.al 2021)**[13]**.

Step Length, Stride Length and Walking Velocity measurements in both control and experimental groups are recorded both pre and post and on day 15.

Step length measurements in control group did not sh ow any statistical improvement from day 0 to day 15. With the mean being (D-0-64.436: D-15-63.8525) and Standard Deviation (D-0-5.632: D-15-5.632) p value of 0.297 and t-value of 2.093.Table (4.8).

Between group measurement of step length also did not show any significant improvement on d-15as can be deduced from table (4.13) ,fig (4.13).with mean values being (exp-65.212 and control group-63.852).

Similarly no significant statistical changes were recorded within or between groups in case of stride length and walking velocity as .Possible cause of this finding could be the short duration of the treatment protocol , less participants and high variability in the data collected. Also a possible reason as to why ROM improvements did not translate into functional gait could be the act that gait changes are

more closely associated with higher joint musculature.i.e. hip, knee etc. In order to study its impact on these parameters future studies of longer treatment durations should be taken.

The results of this are significant at $p<0.05$ and the alternative hypothesis is accepted as there is significant improvement in the ROM of the experimental group. While further research is required to determine if Pnf has any impact on gait parameters.

LIMITATIONS OF THE STUDY

1) The scope of the study was limited due to shorter duration of treatment cycle.

2) The study was limited to only Healthy individuals.

3) The sample size was limited.

FURTHER SUGGESTIONS AND RECOMMENDATIONS

1) In further studies, it may be recommended that the treatment duration can be kept more than 15 days to properly study the effect of the treatment.
2) Different treatment techniques can be used to compare their effectiveness .
3) More high evidence studies need to be done to study the impact on the gait parameters.

CHAPTER:7 CONCLUSION

The study shows that PNF calf muscle stretching was effective in improving calf muscle flexibility and hence improvement in the Active and Passive Dorsiflexion ROM of ankle joint. However, the effect of the treatment module on gait parameters like Step Length, Stride Length and walking velocity does not hold any statistically significant view.

Therefore it can concluded from this study that Proprioceptive Neuromuscular Facilitation technique of stretching calf musculature was effective in increasing ROM of ankle Dorsiflexion but does not have any significant effect on gait parameters.

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CHAPTER: 8

APPENDIX-I

CONSENT FORM

Consent Form

- Title of study – **the effect of PNF calf muscle stretching on Ankle Dorsiflexion ROM, Step length/ Stride length, walking velocity in Young College Students.**
- Principal Investigator –
- Name **– Anum Mukarram**
- Department/ university -Physiotherapy/ Integral University, Lucknow, UP., India.
- Purpose of study – to determine the effects of PNF stretching of calf muscles on ankle dorsiflexion ROM, Step length , Stride length and walking velocity.
- Risk – There is negligible physical, mental, emotional, psychological or social risk associated with the study.
- Benefits –The study will help the participants in understanding the positive effects of pnf stretching on calf musculature and how that affects their gait function. .
- Confidentiality – Participants data will be kept confidential.
- Declaration of participants –
- I confirm that I have read and understand the information sheet for the above study.
- I understand that my participation is voluntary and I am free to withdraw at any time.
- I understand that any information given by me may be used in future reports, articles.
- I agree to take part in the above study.

- Name of participant Signature date

- Researcher Signature date

DATA COLLECTION FORM

NAME:
AGE:
GENDER:
HEIGHT:
WEIGHT:
BMI:
CONTACT NO:
E-MAIL ADDRESS: **GROUP:**

	PRE-TEST			POST - TEST			DAY 15		
ROM(DF)	AROM		PROM	AROM		PROM	AROM		PROM
LT									
RT									
STEP LENGTH	R1	R2	R3	R1	R2	R3	R1	R2	R3
STRIDE LENGTH	R1	R2	R3	R1	R2	R3	R1	R2	R3
WALKING VELOCITY	R1	R2	R3	R1	R2	R3	R1	R2	R3

APPENDIX-111

MASTER CHART

EXPERIMENTAL GROUP

AGE	GENDER	HEIGHT	WEIGHT	BMI	PRE- TEST(DAY -1)							POST -TEST(DAY-1)							DAY-15						
(in years)	(M-male) (F-female)	(in m)	(in kg)	(in k/m^2)	ROM(IN DEGREES)				STEP LENGTH	STRIDE LENGTH	WALKING VELOCITY	ROM(in degrees)				STEP LENGTH	STRIDE LENGTH	WALKING VELOCITY	ROM(in degrees)				STEP LEGTH	STRIDE LENGTH	WALKING VELOCITY
					ACTIVE LEFT	ACTIVE RIGHT	PASSIVE LEFT	PASSIVE RIGHT	(in cm)	(in cm)	(in m/sec)	ACTIVE LEFT	ACTIVE RIGHT	PASSIVE LEFT	PASSIVI RIGHT	(in cm)	(in cm)	(in m/sec)	ACTIVE LEFT	ACTIVE RIGHT	PASSIVE LEFT	PASSIVE RIGHT	(in cm)	(in cm)	(in m/sec)
20	M	1.77	64	20.4	12	20	15	25	68.8	138.87	1.49	12	15	14	25	69.16	140	1.49	20	20	25	25	72.16	144.32	1.56
26	F	1.62	51	19.5	10	12	12	14	54	107.13	1.03	14	18	15	22	54.13	105.47	1.03	17	18	20	24	60.66	120.63	1.25
26	F	1.62	57	21.8	14	11	15	14	62.9	126	0.32	15	20	16	25	63.23	127	1.4	17	20	22	28	65	130.5	1.42
27	F	1.59	60	23.9	20	14	22	15	58.6	134.33	1.53	22	20	25	22	66.16	139.3	1.44	22	24	30	30	65.23	137.9	1.42
24	F	1.65	75	27.7	11	8	14	12	69.03	138.1	1.48	15	20	25	25	72.4	143.45	1.49	25	30	30	30	75.25	151.6	1.52
27	M	1.83	78	23.3	15	12	17	15	68.73	135.96	1.59	15	20	17	22	66.3	133.33	1.61	15	15	25	25	67.45	134.9	1.66
24	F	1.59	70	27.9	12	11	15	14	64.23	126.2	1.48	14	20	16	25	67.9	135.8	1.44	18	17	25	25	67.5	134.8	1.54
25	F	1.65	51	18.8	12	25	15	30	67	129.17	1.66	16	20	20	30	67.23	134.3	1.68	15	28	30	30	68.13	137.2	1.74
28	F	1.71	80	27.5	10	12	12	14	57.1	111.16	1.42	14	20	17	24	63.67	119.16	1.3	15	18	20	25	64.5	129.5	1.42
23	M	1.71	70	24	14	25	15	28	55	111.83	1.54	16	20	25	28	56.17	111	1.39	17	20	30	30	56.2	10.15	1.32
21	F	1.65	49	18.1	10	20	12	25	66.16	137.67	1.33	20	20	25	25	70.17	145.5	0.94	25	28	30	30	72.4	145	1.15
23	F	1.68	52	18.5	12	20	14	24	68.67	136.67	1.33	15	20	18	30	69.4	137.5	1.23	20	28	30	30	70.14	140.5	1.41
21	M	1.77	80	25.6	12	20	15	25	67.63	137.67	1.44	14	20	18	28	74.67	152.5	1.36	15	25	30	30	74.25	151.16	1.33
24	F	1.56	50	20.7	14	13	15	15	53.67	111	1.26	15	20	17	30	58.67	117.3	1.08	15	22	25	30	58.78	117.56	1.23
21	M	1.56	65	26.9	14	15	18	20	54	109	1.23	20	20	22	25	53.5	107.5	1.18	25	25	30	30	5.23	105.4	1.16
22	F	1.56	65	26.9	14	18	15	20	71.17	143.5	1.67	15	20	20	22	73.67	145.67	1.54	20	20	30	25	75.5	148.7	1.59
22	M	1.71	66	22.7	10	15	12	17	68	135.16	1.2	13	20	14	25	68.83	136.5	1.25	15	25	25	30	73.16	145.17	1.37
21	F	1.71	53	18.2	14	25	15	30	58.8	118.3	0.97	20	20	23	30	61.67	123	1.05	30	30	30	30	63.5	127	1.39
22	M	1.77	74	23.7	10	15	12	17	72.5	145	1.29	12	20	14	22	75	148	1.32	15	15	25	30	74.2	147.6	1.41
21	F	1.65	56	20.7	10	11	14	15	74.67	150.17	1.55	17	20	20	30	71.67	143.8	1.56	20	25	27	30	75	148.75	1.56

MASTER CHART

CONTROL GROUP

AGE (in years)	GENDER (M-male) (F-female)	HEIGHT (in m)	WEIGHT (in kg)	BMI (in k/m^2)	PRE- TEST(DAY -1) ROM(IN DEGREES) ACTIVE LEFT	ACTIVE RIGHT	PASSIVE LEFT	PASSIVE RIGHT	STEP LENGTH (in cm)	STRIDE LENGTH (in cm)	WALKING VELOCITY (in m/sec)	DAY-15 ROM(in degrees) ACTIVE LEFT	ACTIVE RIGHT	PASSIVE LEFT	PASSIVE RIGHT	STEP LEGTH (in cm)	STRIDE LENGTH (in cm)	WALKING VELOCITY (in m/sec)
26	F	1.59	67	26.7	15	10	20	22	63	125.3	1.48	14	10	20	25	62.5	125	1.45
21	F	1.62	56	21.5	12	18	15	25	66	132.5	1.12	10	14	15	25	66.5	134	1.2
25	M	1.8	76	23.5	20	13	22	15	57.23	118.17	1.48	19	13	22	15	57	119.5	1.5
24	M	1.59	66	26.3	11	22	14	25	62.3	127.2	0.6	11	24	15	25	61	125.5	1.48
21	F	1.52	48	20.7	15	12	18	15	71.8	140.67	1.79	15	13	18	15	70.5	140.67	1.75
27	M	1.71	60	20.6	14	15	18	20	54.3	107.67	1.27	14	14	18	20	53.5	105.45	1.25
25	M	1.77	76	24.3	18	18	25	25	70.53	140.26	1.67	15	17	25	27	70.15	139.5	1.62
25	M	1.8	65	20.1	11	20	14	24	68.17	137.16	1.47	11	20	14	24	69	138.67	1.42
21	M	1.62	50	19.1	15	23	17	27	65	131.1	1.32	15	23	17	27	65	131	1.45
22	F	1.59	46	18.3	13	25	16	28	61	126	1.29	11	20	15	30	61.5	127.16	1.25
20	F	1.59	53	19.5	13	13	15	15	60.5	112	1.35	15	15	18	20	60	112.67	1.32
25	F	1.62	51	19.5	15	15	17	20	62.1	136	1.46	13	15	17	20	54.4	128.17	1.45
24	F	1.52	60	25.8	15	19	19	21	57.3	117.67	1.37	14	15	19	21	57	117.52	1.36
25	M	1.68	66	23.5	20	11	22	15	68.3	136.67	1.48	15	11	23	15	68.5	136.83	1.46
28	F	1.62	47	18	23	10	30	15	60	121	1.69	20	12	30	17	59.67	118	1.66
22	M	1.68	51	18.1	12	13	15	15	66.2	134.8	1.52	12	15	17	20	66.16	134	1.52
24	F	1.8	60	18.6	12	14	15	18	71.8	140.65	1.76	12	14	15	18	72	141	1.64
20	F	1.71	63	21.6	14	11	17	22	68.2	135.5	1.2	14	12	17	20	68	134.67	1.25
21	M	1.71	60	20.6	10	20	13	15	69.5	135.67	1.6	12	23	13	16	69.67	132.8	1.72
24	F	1.52	50	21.5	12	15	16	17	65.5	131.67	1.48	12	15	15	16	65	132.6	1.55

THE EFFECTIVENESS OF PROPRIOCEPTIVE NEUROMUSCULAR FACILITATION (PNF) STRETCHING TECHNIQUE OF CALF MUSCULATURE ON ANKLE RANGE OF MOTION (ROM) AND GAIT PARAMETERS AMONG COLLEIGIATE STUDENTS

Anum Mukarram [1] , Dr. A.M,H.Inam [2], Dr. Neeraj Maurya[3] , Dr. Abdur Raheem[4]

1. Research student Anum Mukarram, Integral University, Lucknow.
2. Research guide Dr. A.M,H.Inam ,MPT (Musculoskeletal), Associate Professor ,Integral University, Lucknow.
3. Research co-guide Dr. Neeraj Maurya , MPT (Neurology), Associate Professor, Integral University, Lucknow.
4. Dr. Abdur Raheem ,Head of the Department ,Department of Physiotherapy, Integral University, Lucknow.

ABSTRACT

Background/ Aim: : Calf musculature is one of the most common soft tissue structure to develop muscle tightness, manifesting in the form of decreased ankle dorsiflexion ROM thereby leading to difficulty in maintaining balance and predisposing towards the risk of injury .Stretching has traditionally been used as the modality of choice for alleviating tightness .The purpose of the study is to explore the effectiveness of PNF technique of stretching of Calf Musculature on Ankle Range of Motion (Dorsiflexion) and Gait Parameters(Step length, Stride length and Walking Velocity).

MATERIALS AND METHOD: 40 participants who met the inclusion criteria were randomly divided into control and experimental group consisting of 20 participants each. The experimental group was given PNF Stretching while the control group was given home advice (hot packs etc).

RESULTS: The experimental group showed significant improvements in both mean active (left-19.05 and right-22.65)and mean passive ROM(left-26.95 and right-28.35) which were greater than the control group(active-left-13.7 and right-15.75: and passive –left -18.15and right -20.8).as well as baseline measurements. While there were no significant improvements in the values of Step length, Stride length and Walking Velocity.

CONCLUSIONS: The study concludes that PNF technique is effective in improving calf muscle flexibility and ROM of ankle joint (here Dorsiflexion.) while it could not translate these improvements into the gait parameters

KEY WORDS:PNF Stretching, Stretching ,Ankle Rom ,Gait Parameters.

INTRODUCTION

Calf Muscles are generally prone to tightness as they are anti-gravity muscles which manifests in the form of decreased ankle dorsiflexion ROM which may lead to difficulty in maintaining balance [1-3]. It can also result in difficulty in heel pushing the ground during walking, running, jumping or stair climbing thereby affecting physical activities and walking, and may present as increased risk of falls [4], decreased walking speeds[5] and heel rise during early stance[6].therefore, flexibility exercises are generally introduced in order to improve muscle tightness.

Stretching has been used as a means to increase flexibility or ROM, thereby improving performance and reducing the risk of injuries. Generally four different types of stretching techniques are used which are Static, Dynamic, Ballistic and Proprioceptive Neuromuscular facilitation techniques respectively [7]

There are several studies which have compared the effects of static stretching and pnf stretching and have found that both may be equally effective in enhancing the joint ROM. [8.9] However, others have reported a superior effects of PNF stretching on Static Stretching(SS).[10]. A simple explanation for this could be the fact that SS involves passive elongation of the tissue whereas PNF includes both stretching as well as a phase of contraction of the muscle.[11]

PNF Stretching can be described as a therapeutic approach which utilizes alternating episodes of contraction and relaxation of agonistic and antagonistic muscles .It finds its basis on the fact that muscle relaxation increases after the contraction of both agonists as well as antagonist muscles [12]

The effects of PNF Stretching have been studied in terms of its effect on ROM, power output, muscle strength, vertical jump height, performance etc. and on various muscle groups at that. However, there is paucity of data which describes the effect that performing PNF stretching has on calf musculature on various parameters like Step Length, Stride Length, Walking Velocity and Ankle Dorsiflexion ROM.

Various studies have shown improvements in the values of ROM, endurance, flexibility, vertical jump height etc. and it has also been shown to be effective in gait rehab in patients with stroke, Parkinson's etc. The extensive use of Stretching as a popular and effective therapeutic method to improve muscle flexibility is one of the compelling reasons to perform this study.

The study is performed with the objective of studying the effects that PNF Stretching of Calf Musculature has on Ankle Dorsiflexion ROM, and gait parameters in healthy college students.

METHODOLOGY

PARTICIPANTS: This study was conducted on 40 subjects who are students at Integral University. The Participants were divided into two groups Control and Experimental randomly through chit method. All subjects were fully briefed about the nature of the study, its purpose, benefits and risks prior to taking consent.

INCLUSION CRITERIA: Student of Integral University ,Age between 18-30 years ,BMI 18.5-29.9, Ankle Dorsiflexion range (0-15 degrees) in either or both LL

EXCLUSION CRITERIA : People engaged in professional activities involving prolonged sitting, Age <18 and > 30 ,BMI <18.5 and> 29.9 ,Ankle Dorsiflexion range above 15 degrees in both the LL ,History of recent injury in around ankle joint , History of acute or chronic pain in and around ankle joint, Psoriatic Arthritis, Joint Instability ,Edema in and around Ankle Joint Hypo mobile joints resulting from sources other than biomechanical causes, Spondylo-arthropathy History of Cardiovascular or Respiratory problems etc.

PROCEDURE:

Subjects with limited dorsiflexion ROM were selected for the study.40 subjects (male and female) were included. The subjects were randomly divided into 2 groups by using random sampling method. Each group had 20 subjects each. Treatment was given for 15 days. Prior consent of subject was taken before assessment. Experimental group subjects who received PNF stretching technique, where the subject is in supine lying position with knee extended. The researcher moves the leg of the subject in the direction of dorsiflexion to the point of discomfort. This is immediately followed by the isometric contraction of restricting muscle for; at this point the patient is instructed to 'try to gently take the foot up, against my resistance, using your maximal strength.' The therapist should apply just enough force so that the foot remain static.no motion is intended by either patient or therapist. This is the hold phase and last for 6seconds. After holding the contraction for enough time he researcher instructs the subject to relax and the foot is repositioned passively to the new limit of range and held for 30s and this is followed by isometric contraction. Then again take the foot passively to the new barrier point and repeat the procedure. This whole procedure is repeated 3 times per sets of 4 reps for 15 days. Control group consists of 20 subjects who received Home Advice including conventional treatment methods like hot packs twice a day for 10 min for the treatment duration, along footwear correction such as used of flats with comfortable insoles instead of heels and wedges etc. Lifestyle modifications like increasing physical activity. PRE-TEST values of the outcome measures were taken for both the groups and on the same day post-test treatment measures was also taken. Follow up values were collected after 15 days of treatment session and based on the findings data analysis was performed.

DATA ANALYSIS

Descriptive Statistics was performed to find out mean, range, standard deviation for demographic variables as well as outcome variables. Excel Analysis Tool Pack 2019 software was used for data analysis. Single factor ANOVA test was used. Alpha value was kept at 0.05, therefore,($P < 0.05$). Paired t-test is used compare the group results..

RESULTS

40 Participants including 24 females (60%) and 16 males (40%) of mean age 23.4±2.414 of Experimental and 23.5±2.351 of Control group were selected. The mean, Standard Deviation, p-

value and t-value of both the groups are given in table 1.

On comparing the results obtained after statistical analysis, it was found that there was no statistically significant effect of demographics on the group's outcome measures. Though demographic details have a significant impact on both ROM and Gait characteristics.

In the Control Group, there is no statistically relevant improvement in the active and passive ranges of ankle dorsiflexion range. However, the Experimental group shows significant improvement in the mean value of both active and passive ROM both within the group in pre, post as well as day 15 reading. With f-value of intra group(Experimental) comparison of Active ROM (left – 19.41; right 12.52) and Passive ROM (left-68.685 and right-24.78). and p-value (left-0.0000003: right-0.0000003) and Passive ROM(left- <0.00000011; right-0.00000017).However, on comparing the Experimental group and Control group .It can be clearly seen that the experimental group not only showed greater improvements but also a high level of consistency of t-value(2.024) as can be seen from table( ).

Both intra and inter group analysis indicate towards an increase in ROM of dorsiflexion movement from the baseline measurements in the Experimental group.

However, in the case of Gait parameters such as Step Length, Stride Length and Walking Velocity, no significant changes were recorded in both intra or inter group.

The results of this study are significant at $p<0.05$ and the alternative hypothesis is accepted as there is significant improvement in the ROM of the experimental group. While further research is required to determine if PNF Stretching has any impact on gait parameters.

TABLE 1 : Baseline data for demographic variables.

G	Experimental	Control	t-value	p-value
	Mean +/- SD	Mean +/- SD		
Age	23.4±2.414	23.5±2.351	2.02	0.895
Height	1.67±0.079	1.653±0.093	2.02	0.584
Weight	63.3±10.638	58.55±9.064	2.02	0.137
BMI	22.84±3.414	21.39±2.759	2.02	0.148

FIGURE 1: GENDER RATIO CHART

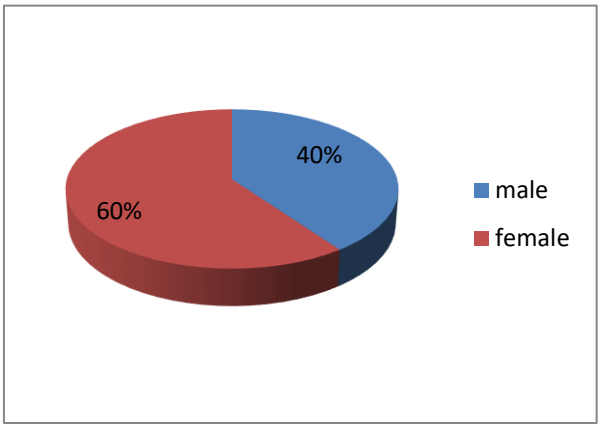


TABLE 2: Mean, standard deviation ,p- value of active and passive dorsiflexion rom of both left and right joints of both experimental and control group on day-0.(between group analysis

	ROM	ACTIVE				PASSIVE			
		LEFT		RIGHT		LEFT		RIGHT	
		M	SD	M	SD	M	SD	M	SD
EXP	D-0	12.5	±2.48	16.1	±5.2	14.7	±2.39	26.95	±3.54
CONTROL	D-0	14.5	±3.41	15.85	±4.51	17.9	±4.19	19.95	±4.59
	p-val	0.040		0.872		0.005		0.768	

TABLE 3: Mean, standard deviation ,p- value of active and passive dorsiflexion rom of both left and right joints of both experimental and control group on day-15.(between group analysis

GROUP	ROM DAY	ACTIVE				PASSIVE			
		LEFT		RIGHT		LEFT		RIGHT	
		M	SD	M	SD	M	SD	M	SD
EXP	D-15	19.05	±4.39	22.65	±4.8	26.95	±3.53	28.35	±2.41
CONT	D-15	13.7	±2.56	15.75	±4.11	18.15	±4.16	20.8	±4.57
	p-val	0.00003334		0.0000		0.000000145		0.000000167	

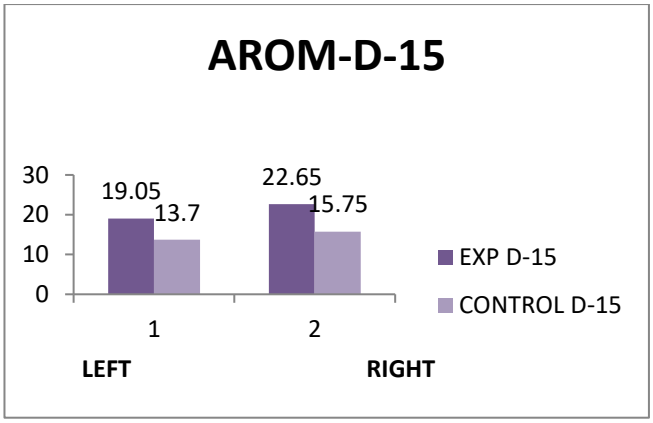
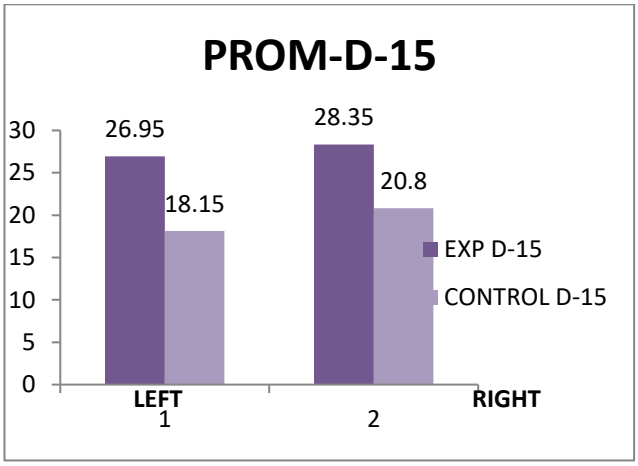


FIGURE 2:Inter-group comparison of mean of PROM of ankle Dorsiflexion of both sides on Day 15.



DISCUSSION

The chief objective of the study was to check if PNF technique improves calf muscles flexibility and if this improvement translates into improvement in the outcome measures. In the Control Group, there is no statistically relevant improvement in the active and passive ranges of ankle dorsiflexion range which can be seen from the table. However, the Experimental group shows significant improvement in the mean value of both active and passive ROM both within the group in pre, post as well as day 15 reading. With f-value of intra group(Experimental) comparison of Active

ROM (left – 19.41; right 12.52) and Passive ROM (left-68.685 and right-24.78). and p-value (left-0.0000003: right- 0.0000003) and Passive ROM(left- <0.00000011; right- 0.00000017).However, on comparing the Experimental group and Control group .It can be clearly seen that the experimental group not only showed greater improvements but also a high level of consistency of t-value(2.024) as can be seen from table 2 and 3 as well as fig and 2.

Both intra and inter group analysis indicate towards an increase in ROM of dorsiflexion movement from the baseline measurements in the Experimental group. This increase in ROM is due to improvement in the extensibility of calf musculature and is in agreement with the previous studies Authors generally argue over the fact that if the structural parameters have not been altered and still changes in joint ROM is seen, it is believed to be due to an increased stretch tolerance. It is considered that stretching alters the point at which stretch is perceived or tolerated and that PNF stretching may influence this to a greater extent than other stretching techniques.(Sharman et.al.2006)**.** He described the mechanism as a result of Autogenic Inhibition in the contracted or stretched muscle due to decreased excitability as result of inhibitory signals from Golgi Tendon Organs (GTO) of the same muscle. PNF takes advantage of the viscoelastic properties of the musculotendinious unit thereby allowing the muscle to creep and elongate, thereby increasing ROM (Jayaram M. et.al. Aug 2015).

Step length measurements in control group did not show any statistical improvement from day 0 to day 15. With the mean being (D-0-64.436: D-15-63.8525) and Standard Deviation (D-0-5.632: D-15- 5.632) p value of 0.297 and t-value of 2.093.Between group measurement of step length also did not show any significant improvement on d-15.with mean values being (exp-65.212 and control group-63.852).

Similarly no significant statistical changes were recorded within or between groups in case of stride length and walking velocity as .Possible cause of this finding could be the short duration of the treatment protocol , less participants and high variability in the data collected. Also a possible reason as to why ROM improvements did not translate into functional gait could be the act that gait changes are more closely associated with higher joint musculature .i.e. hip, knee etc. In order to study its impact on these parameters future studies of longer treatment durations should be taken.

The results of this are significant at $p<0.05$ and the alternative hypothesis is accepted as there is significant improvement in the ROM of the experimental group. While further research is required to determine if PNF has any impact on gait parameters.

LIMITATIONS OF THE STUDY

4) The scope of the study was limited due to shorter duration of treatment cycle.

5) The study was limited to only Healthy individuals.

6) The sample size was limited.

CONCLUSION

The study shows that PNF calf muscle stretching was effective in improving calf muscle flexibility and hence improvement in the Active and Passive Dorsiflexion ROM of ankle joint. However, the effect of the treatment module on gait parameters like Step Length, Stride Length and walking velocity does not hold any statistically significant view.

Therefore it can concluded from this study that Proprioceptive Neuromuscular Facilitation technique of stretching calf musculature was effective in increasing ROM of ankle Dorsiflexion but does not have any significant effect on gait parameters.

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