To Assess Ankle Flexibility in Sedentary Population by Weight Bearing Lunge Test

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***Abstract*- Background: Limited ankle movements (dorsiflexion and plantarflexion) are mainly due to soft tissue restriction. Primary limitation to dorsiflexion is due to tension in Triceps Surae which consists of Gastrocnemius and Soleus. A disturbance of ankle ROM, resulting from muscle tightness during gait, may affect not only the ankle-foot complex, but also the remaining joints of the lower extremities and causes several compensatory changes leading to ankle and foot problems.**
Aims and Objective: The objective of this study was to assess ankle flexibility in sedentary population by weight bearing lunge test.
Methods: A total of 134 participants participated in the study out of which 100 participants met the criteria. The International Physical Activity Questionnaires (IPAQ) was used to measure health-related physical activity. The Weight Bearing Lunge Test (WBLT) was performed to measure ankle flexibility.
Results: The ankle flexibility was decreased in 81% of participants. There is linear correlation between the ranks of IPAQ score and WBLT distance. As a result, decreased level of physical activity leads to decreased ankle flexibility.
Conclusion: On the basis of our analysis, it concludes that there was positive correlation found in between ankle flexibility (Weight Bearing Lunge Test) and Sedentary lifestyle (International Physical Activity Questionnaire).

***Keywords*- Ankle Flexibility, Weight Bearing Lunge Test, Sedentary, International Physical Activity Questionnaire**

I. INTRODUCTION

The key role of Ankle/Foot complex is to bear weight.[1] The harmonized structures of ankle and foot complex allows both stability and mobility.[1] Dorsiflexion and Plantarflexion occurs at ankle joint.[1] According to ACSM, flexibility is the ability to move a joint through a complete ROM. Tightness of soft tissue affects ROM. Laboratory tests assess flexibility with regard to ROM by use of various common devices like goniometer, tape measures, inclinometer, etc.[2]

According to ACSM, normal ranges of dorsiflexion and plantarflexion are 15-20 degrees and 30-50 degrees respectively.[2] Around 10 degrees of dorsiflexion is necessary for ambulation.[3] Functional activities such as running, ascending and descending stairs and normal gait necessitate adequate ankle ROM.[3]

Limited ankle movements (dorsiflexion and plantarflexion) are mainly due to soft tissue restriction.[1] Primary limitation to dorsiflexion is due to tension in Triceps Surae which consists of Gastrocnemius and Soleus.[1] A disturbance of ankle ROM, resulting from muscle tightness during gait, may affect not only the ankle-foot complex, but also the remaining joints of the lower extremities and causes several compensatory changes leading to ankle and foot problems.[3]

According to ACSM, Physical activity (PA) is defined as any bodily movement produced by the contraction of skeletal muscles that results in a substantial increase in caloric requirements over resting energy expenditure.[2] Exercise is a type of PA consisting of planned, structured, and repetitive bodily movement done to improve and/or maintain one or more components of physical fitness.[2] Physical fitness has been defined in several ways, but the generally accepted definition is the ability to carry out daily tasks with vigor and alertness, without undue fatigue, and with ample energy to enjoy leisure-time pursuits and meet unforeseen emergencies.[2]

There are four common categories of causes of muscle tightness.[4] First, as people ages, there is general decrease in activity leading to limited exposure to ROM and failure to reach ultimate length of muscle-tendon unit with regularity. According to Law of Davis, soft tissue contracts to shortest position possible, given the opportunity. Ankles are in relaxed equinus position while sitting or sleeping causing the calf to tighten.[4] Second, physiological changes to muscles and tendons due to ageing. Genetics would lead to possible predilection to calf tightness. Calf tightness is seen more in some people than other and genetics would be the cause.[1] Reverse evolution: Human influence and the Predilection pattern could be one of the reasons for tightness. Evolution purpose that humans evolved from quadrupeds to bipedal species but bipedal gait evolved late as primary method of locomotion. Earlier only part time bipedal gait was used. Therefore, to evolve to bipedal gait, calf muscle which were earlier in shortened form has to be lengthen. They tighten as person ages because they got adapted later in process[4].

Sedentary behavior commonly is defined as a MET of 1.5 or less (sitting activities – watching TV, absolute still standing).[5] A study conducted physical activity and inactivity patterns in four regions of India (Tamil nadu, Maharashtra, Jharkhand and Chandigarh representing the south, west, east and north of India respectively) with a combined population of 213 million people.[6] Among these, more than half of the population was physically inactive with major population of inactive was in urban areas. More than 90% of the population did no recreational physical activity.[6]

IPAQ-LF (International Physical Activity Questionnaire long form) is widely used to measure health-related physical activity. Test-retest reliability data for the long IPAQ questionnaires by spearman correlation coefficient were around 0.8 indicating very good repeatability.[7]

To assess Dorsiflexion at ankle, Weight bearing lunge test is used by two methods one from distance from the foot to the wall or angle of tibial shaft from the vertical using a gravity goniometer and has good inter-rater and intra-rater reliability.[8] A weight bearing examination measures dorsiflexion of the foot on the lower leg rather than dorsiflexion isolated to the tibio-talar joint proportional to the patient's body weight rather than the examiner's applied force.[9] It is therefore arguably more clinically relevant as it more closely reflects the load during gait and the position of a person's foot during loading.[9] Advantage of weightbearing is that a torque is applied to apply which is greater than in non- weightbearing and results may be more indicative for range available for functional tasks.[8]

Tri-planar motions of foot and ankle promotes interdependence of joint movement.[10] These are Pronation (abduction, dorsiflexion, eversion) and Supination (adduction, plantarflexion, inversion).[10] In stance phase of gait, pronation exists for shock absorption, ground terrain changes and equilibrium.[10] Four forces act on foot and ankle (compression, rotation, anterior and medial shear forces) from heel strike to toe off phase.[10] To diminish this forces, normal pronation is necessary.[10] Abnormal pronation brings about lack of ability of the foot to functionally absorb the forces of weightbearing.[11] One of the causes for this is tight achilles tendon which is commonly seen in sedentary population.[11] In patellofemoral pain, one of the remote contributing factor is abnormal pronation.[3] Thus, for functional activities such as running, ascending and descending stairs and normal gait necessitate adequate amount of ROM at ankle.[11] Adequate 10 degrees of dorsiflexion necessary for tibia to move over foot during midstance for forward body propulsion.[11] Compensatory changes occurs if there is inadequate ROM such as Genu recurvatum, early heel lift or abnormal pronation at subtalar joint which puts undue stresses on other structures which can result in foot pathologies such as chronic myofascial pain[3], plantar fasciitis[11] and achilles tendonitis[11]. This inadequate ROM at ankle is usually appreciated in sedentary population due to decrease in activity leading to physiological change in muscles and tendons, genetics and predilection pattern in reverse evolution.[4,11]

So current study is planned to assess the ankle flexibility in sedentary population by weight bearing lunge test.

Abbreviations and Acronyms

IPAQ – International Physical Activity Questionnaire
WBLT – Weight Bearing Lunge Test
MET- Metabolic Equivalent
PA – Physical Activity
ACSM – American College of Sports Medicine

II. Objectives

To evaluate sedentary population by International Physical Activity Questionnaire (IPAQ). To assess degree of dorsiflexion in weightbearing with knee flexed in lunge position in sedentary population. To assess tricep surae/ tendoachilles tightness in sedentary population.

III. Materials and Methods

This study is descriptive observational study where 100 healthy consenting adults were recruited into the study using convenience cluster sampling. Participants who agreed to participate between the ages of 40 and 60 years old with low International Physical Activity Questionnaire (IPAQ) score were included in the study. Exclusion criteria were any ankle and foot problem, recent trauma or surgeries of lower limb and with any cognitive and neurological impairments. Standard demographics were recorded via a brief questionnaire. This included name, age, gender, occupation, medical and surgical history. Materials used in the study included a consent form, demographic data and case record form, IPAQ sheet and measuring tape.

IV. Procedure

Ethical clearance from the ethical committee was taken. Willing participants was screened for inclusion and exclusion criteria. The purpose of the study and procedure was explained The International Physical Activity Questionnaire was explained. The International Physical Activity Questionnaires (IPAQ) comprises a set of 4 questionnaires. Long (5 activity domains asked independently) and short (4 generic items) version. After filling questionnaire by participants, MET minutes values were calculated and classified as low, moderate and high physically active.

Testing procedure

The participant with low score were than proceeded for Weight Bearing Lunge Test (figure 1). Weight bearing lunge test is cost and time efficient and requires minimal equipment. Participant was taken in front of wall and foot was placed perpendicular to a wall and to lunge their knee towards the wall. The foot was then moved away from wall perpendicularly until heel was lifted. The distance from great toe to the wall was measured by tape. Results were calculated.

Figure 1WEIGHT BEARING LUNGE TEST WITH TAPE[15]

V. Statistical Analysis

The objective of this study was to assess ankle flexibility in sedentary population by weight bearing lunge test. In this study, we screened 134 participants, 100 participants were included according to inclusion and exclusion criteria between the age of 40-60 years and data was collected on the Microsoft excel sheet and encoded for computer analysis. Computerized statistical analysis is done using Microsoft Excel Data Analysis. Initially, data were screened for normality assumption using Box Plot method which showed data was not normally distributed. Hence, non-parametric test was used. Data was expressed as mean ± SD. Correlative analysis was done for Weight Bearing Lunge Test (WBLT) distance in cm and International Physical Activity Questionnaire (IPAQ) score using Spearman's rank correlation formula.

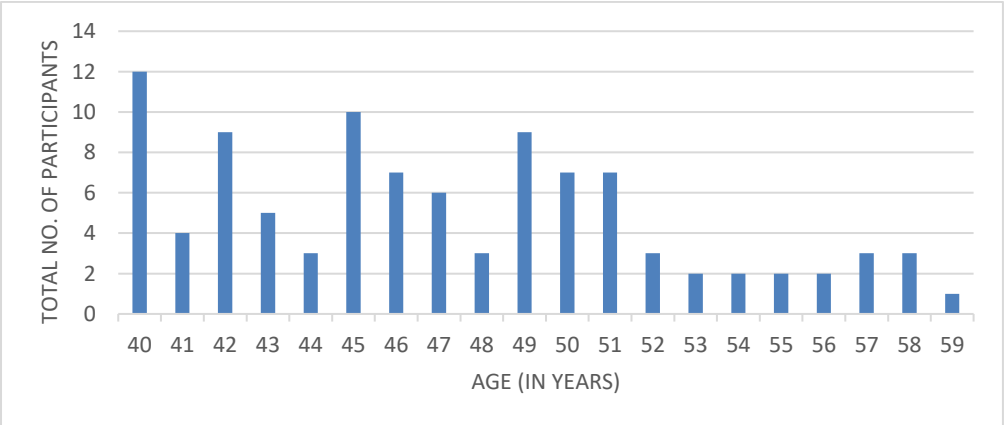
VI. Result

The objective of this study was to assess ankle flexibility in sedentary population by weight bearing lunge test. A total of 134 participants participated in the study out of which 100 participants met the criteria.

Table 1. Mean (SD) for participant's data

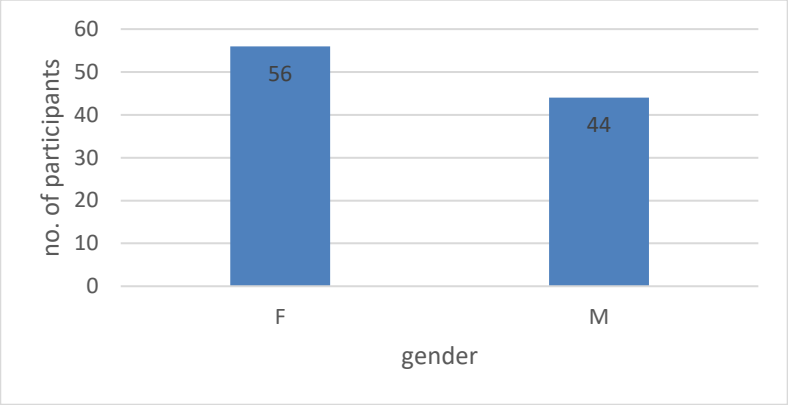
Characteristics	**Age**	**IPAQ score (in MET)**	**WBLT distance (in cm)**
Mean ± SD	47.1±5.19	323.24±111.5	6.96±2.5

Table 1 represents the mean ± SD (standard deviation) for participant's data. The mean age of the participants was 47.1±5.19 years. The International Physical Activity Questionnaire score is calculated in MET which ranges from 198 to 594 METs. The mean IPAQ score was found to be 323.24±111.5 MET. There was wide distribution in values of ankle dorsiflexion in WBLT ranging from 3cm to 14 cm. The mean ankle dorsiflexion in 100 feet with WBLT was found to be 6.96±2.5 cm.



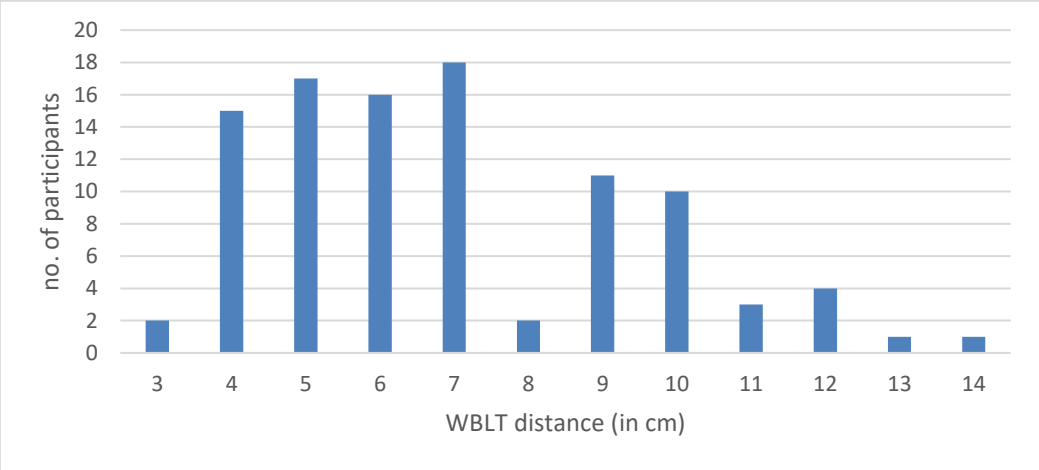
Graph 1: Total number of participants according to their age

Chart 1 represents number of participants are distributed in above graph according to their age. With highest number of participants is of 40 years and lowest number of participants is of age 59.



Graph 2: Gender distribution in the study

Graph 2 represents the total number of males and females participated in the study. 56 females and 44 males participated in the study.



Graph 3: The variance in the range of dorsiflexion in WBLT

The graph 3 represents number of participants are distributed according to result of their weight bearing lunge test distance. 7cm of WBLT distance was seen in maximum of 18% of participants and 14 cm of WBLT distance was seen in 1% of participants.

Table 2: Relation between dorsiflexion and tightness

DORSIFLEXION	**TIGHTNESS**	**RANGE**	**TOTAL**
Decreased	Increased	<10cm	81
Normative	No tightness	10cm-14cm	19
Increased	No tightness	>14cm	0

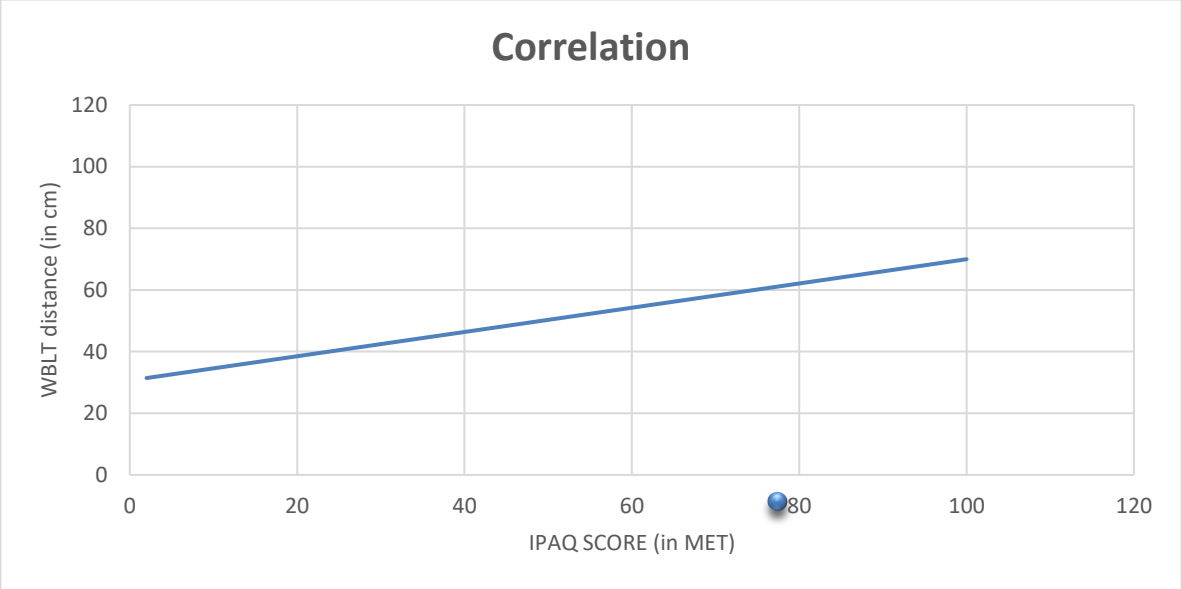
Table 2 represents decrease in dorsiflexion in WBLT leads to decrease in ankle flexibility which indicated the tightness of triceps surae muscle in the ankle which was seen in 81% of participants.

Table 3: Spearman's rank correlation calculation

Spearman’s Coefficient (ρ)	**0.395493**		
N	100		
T statistic	4.262725		

Df(difference)	98		
p value	4.65E-05	α=0.05	

The data relating to WBLT distance and IPAQ score was not normally distributed (box plot method) thus non parametric analysis was undertaken (spearman's rank correlation). Correlation analysis is done using Spearman's rank correlation test. Coefficient in excel is calculated by using CORREL function on Ranks of variable.
N= No. of observation
T statistic is calculated to calculate p- value
degrees of freedom(df)= n-2
p value is calculated by using TDIST (T-distribution) function with T statistic, DF, two tailed tests.
Here we consider α=los= 5%. As it is ideal error.



Graph 4. Correlation between IPAQ score and WBLT distance

Since p value < α, there is linear correlation between the ranks of IPAQ score and WBLT distance but weak as correlation coefficient is small. And the ρ indicates a positive correlation between IPAQ score and WBLT distance. Since p value is <0.05 indicating a significant association between physical activity and ankle flexibility. As a result, decreased level of physical activity leads to decreased ankle flexibility.

VII. Discussion

The objective of this study was to assess ankle flexibility in sedentary population by weight bearing lunge test. A cross sectional study was carried out for period of 18 months. The study consisted of 134 participants, out of which 100 participants met the inclusion and exclusion criteria. However, the mean age was 47.1±5.19 years. Out of all participants, 43% are between the ages 40-45years, 32% are between the ages of 46-50years, 16% are between the ages of 51-55years and 9% are between the ages of 56-60years. A subjective assessment was done to measure health- related physical activity by International Physical Activity Questionnaire (IPAQ) and to measure ankle flexibility by weight bearing lunge test was performed.
The study carried out by categorising population as low physically active by International Physical Activity Questionnaire (IPAQ) and then performing the Weight Bearing Lunge Test. WBLT is easy test to perform and also clinically relevant test. Advantage of weightbearing is that a torque is applied to apply which is greater than in non- weightbearing and results may be more indicative for range available for functional tasks.[8] Weight bearing lunge test was then performed and 3 trials of test was done and data was collected. A face to face interviewed based questions were carried out for the questionnaire and any uncertainties the respondents had regarding the question were cleared out. The questionnaire consists of 5 activity domains and total of 27 questions which took 10-15mins to fill. After filling the questionnaire, calculation of MET mins is carried out and individual with less than 600 METs or who didn't fulfil the criteria of high or moderate physical activity as categorised as low physically active. Time taken for calculation of the MET was 5mins.
Results from the current study found that sedentary lifestyle was found more in women than in men. 56% of participants in the study were female.
Praween Agrawal et al[12] demonstrated effects of sedentary lifestyle and dietary habits on body mass index change among adult women in India. In the midst of demographic, epidemiological and nutritional transition, India has a growing population and increasing urbanisation, there are different changes in the lifestyle and patterns of disease. Many lifestyles related chronic diseases such as obesity, cardiovascular disease have been dramatically increased in the past decade. Obesity, diet and physical activity

works hand-in-hand. High level of saturated fats and sugar have been found in western food cultures which can cause obesity. Obesity can lead to decrease in physical activity which shows Sedentary lifestyle patterns.

Results from the current study found a decrease in the ankle flexibility in 81% of the participants. The positive correlation between the ranks of WBLT and IPAQ score suggests that decrease in the physical activity leads to decrease in ankle dorsiflexion ROM which indicated tightness of the triceps surae muscles.

As James Aims[4] demonstrated that as there are decreases in physical activity, people have limited range of motion and muscle-tendon unit becomes inadequate to reach their ultimate length with regularity. Thus, if these sedentary habits occur persistently over a long period of time, there will be shortening of the muscle-tendon unit.

According to law of Davis[4], the soft tissue contracts to the shortest possible position over a period of time, given the opportunity. Also, sedentary lifestyle includes sitting for a longer period of time or sleeping or any relaxed positions. The ankles are in relaxed equinus in such positions, leading to tightness in muscle-tendon unit of triceps surae in the calves.

Tightness of triceps surae is likely to be caused due to physiological changes with ageing.[4] There is increase in cross-linking of the collagen and decrease in compliancy of the connective tissue leading to shortening of the muscle when kept in such position for long. Also, the percent of the elastin in the connective tissue decreases. Other cause of the tightness is the Genetics.

In the process of evolution from quadruped to bipedal gait, the muscles in the calves along with hip flexors and hamstring are all shortened in quadruped where knee is flexed and ankle is planterflexed. In order to evolve to bipedal, these muscles had to lengthen while opposing muscle had to shorten (quadriceps and tibialis anterior). Due to late adaption in the evolution, these muscles tighten backward with ageing to their prior position. This is known as Predilection pattern. Other epidemiologic factors are also responsible for tightness such as obesity, shoe wear, concrete floors, overuse issue, etc. Later during long course, this tightness may cause a silent contracture especially gastrocnemius.[4]

Oliver Chan et al[9] conducted study on "Gastrocnemius tightness: A population based observational study". He demonstrated an association between gastrocnemius tightness as measured by the ADI and sex, height and body weight. The results of this study show that ADI varies according to age, ethnicity and physical activity. It has been postulated that as people age, activity decreases and with limited exposure to range of motion, muscle tendon units fail to reach their ultimate length with regularity The majority of the population had some degree of gastrocnemius tightness and values of ADI greater than 13 (>2 SD of the mean), as measured by the lunge test, may be considered abnormal.

Achilles tendinopathy, metatarsalgia, plantar fasciitis, hallux valgus, knee pain and back pain are such musculoskeletal pathologies which can be associated with the tightness of muscle and reduced ankle flexibility. Compensatory changes occurs if there is inadequate ROM such as Genu recurvatum, early heel lift or abnormal pronation at subtalar joint which puts undue stresses on other structures which can result in foot pathologies.[13] Early heel off while walking, climbing stairs are seen with severe tightness of the muscle.

Many therapeutic techniques such as static stretching, dynamic stretching, Muscle energy technique have shown to decrease tightness and improve flexibility at the ankle joint.

VIII. Conclusion

On the basis of our analysis, it concludes that there was positive correlation found in between Ankle flexibility (Weight Bearing Lunge Test) and Sedentary lifestyle (International Physical Activity Questionnaire).

IX. Limitation

Study was solely conducted in metropolitan city.
Particular age group was selected.
Other epidemiological factors such as obesity, shoe wear was not considered.
The study was limited to interview and clinical test and no investigations were done.

X. Further Scope

A similar study can be done including Ankle Dorsiflexion Index (ADI), weight bearing test in knee extension with inclinometer.
This study could be done to a specific group based on their profession, comorbidities like obesity or sport.

XI. Clinical Implication

An implication of the present study's finding would be to create awareness about health hazards due to sedentary lifestyle.
Implementing yoga, static and dynamic stretching in their daily routine.
Promoting importance of physical activity.

XII. Acknowledgement

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