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Effect of ankle rom on balance performance of elderly people residing in old age homes of Surat: a cross sectional study.

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Abstract

Background: It is a balance which enables an individual to maintain a steady state doing their activities. Also, with advancing age there is increasing risk of balance impairment. Various body systems are responsible for maintaining balance. These systems function together in coordination to maintain optimum balance.

Purpose: To study the relationship between balance impairment and changes in ankle range of motion (ROM) in elderly.

Method: Correlation study was conducted with sixty-five subjects aged between 60 - 80 years of elderly population who agreed to participate in this research. The study participants were categorized into high risk of fall, moderate risk of fall, low risk of fall. Balance / fear of fall was measured using Tinetti Performance Oriented Mobility Assessment (POMA) (balance and gait), multidirectional Reach Test (MDRT), and Dynamic Gait Index (DGI). Goniometer was used to measure the active range of motion of the ankle joint. Balance measures and ROM were correlated using Pearson's correlation coefficient.

Results: Frontal plane ROM has equal correlation with balance measures. However sagittal plane ROM has greater correlation with balance measures of DGI and MDRT (FR, BR) and mild correlation with POMA and MDRT (RR, LR). There exists a difference in ankle ROM between those who were at high risk and low risk of fall. And there was no significant difference between high and moderate risk groups.

Conclusion: Mild correlation exists between ankle ROM and balance measures in elderly. Improving ankle ROM with balance training in elderly may prevent risk of fall and its related injuries

Keywords: Ankle Range of motion (ROM), Balance in elderly, Multidirectional reach test, Tinetti performance-oriented mobility assessment, Dynamic gait index.

Introduction

Balance is a term by which the individual maintains their body position in equilibrium state. Maintaining balance is one of the major factors to prevent falls and consequent injuries in elderly people. It is an important ability to maintain upright posture during static standing [1]. It is required to maintain an equilibrium while moving from one place to another [2]. However, it is required to conduct daily living activities steadily as well as to move freely in the community. For this to be achieved it is important for the balance system to function properly in coordination, so it can help humans to have a clear vision during movement and can make postural adjustments according to the demand of activities of daily living [4].

For effective balance, individuals COG and COM should be maintained at BOS. COM is a point that refers to the center of total body mass [4].

COG is a point that refers to vertical projection of COM to the ground. It is located anterior to second sacral vertebrae. Position of COG varies; it depends on the anatomical structure of the individual. COG is higher in men and children than women because women carry greater weight in the upper half of the body [5]. Balance is greatest when the body's COM and COG is maintained over its BOS [4].

BOS refers to the contact area between the body and its support surface [4]. In stride standing, an area as wide as feet and distance between its outer border forms a base [5]. Foot placement may alter the BOS and change a person's stability. A wide stance is seen in many elderly individuals which increases stability [6], whereas a narrow BOS such as tandem stance or walking reduces it [4].

There are two types of balance:

1. Static balance
2. Dynamic balance

1. Static balance: it is term which describes that body position is maintained in steady state example: standing, sitting

2. Dynamic balance: it is a term which describes that body position is maintained in a dynamic state (individual's body is moving or surface is moving) example: walking, sit to stand, stair climbing, and turning around obstacles.

Balance control - balance is maintained by the nervous system, musculoskeletal system, and contextual factors.

Nervous system: it conducts sensory processes. Perception of the body is provided by visual, vestibular, somatosensory systems. This nervous system sends signals for motor response to maintain balance.

Musculoskeletal System: it includes ROM, joint integrity, and flexibility

Contextual factor - it includes environmental factors such as gravity, light, support surface [4].

Gravity- It places stress on structures that are responsible for maintaining the body upright and therefore provides a challenge for maintaining erect posture against gravity. So, there are forces which

Counteract the moment caused by gravity and these counterforces are provided by antigravity muscles to maintain erect position against gravity [5].

However, humans use hip, ankle, and step strategies to maintain upright position and equilibrium of the body to meet the demands of motor tasks to be done against gravity [7]. Flexion and extension of the hip is the component of hip strategy to maintain COM within BOS. In the forward sway of the body muscles are activated from proximal to distal sequence, in the beginning abdominal muscles activate first followed by quadriceps muscle. And in the backward sway of the body, paraspinal muscles are activated first followed by hamstrings [4]. To maintain balance in antigravity position muscles that activate are gluteus Medius, tensor fascia late, iliopsoas to prevent hyperextension of the hip [4].

The foot is able to sustain large weight bearing forces and able to accommodate on variety of surfaces and while walking on different surfaces The structural design of ankle and foot complex is such that it promotes stability as well as mobility to fulfill the goal of balance body's COM should be kept within the BOS and for that ankle strategy is used. However, the foot has multiple functions like providing BOS, working as a rigid lever to enhance pushing off during walking, running, and jumping and shock absorption thus preventing undue joint stresses. It also responds to GRF and imposed forces from spine, pelvis, hip, and knee [4].

To fulfill the goal of balance, the body's COM should be kept within the BOS and for this ankle strategy is used. In ankle strategy, muscles surrounding the ankle joint that are plantar flexors, dorsiflexors, investors and evertors are automatically activated against body sway in different directions. These muscles are activated in the opposite direction of body sway or to the perturbation [7]. During forward motion of the body, muscles are activated in distal to proximal direction. In beginning gastrocnemius muscle activates followed by hamstrings muscle. During backward motion of the body, the first tibialis anterior is activated followed by quadriceps muscle [4].

Further when balance is challenged with large perturbation the step strategy is utilized to maintain balance. In the incidence of perturbations by taking steps in the direction of perturbations [7]. However, in certain cases when COM displaces beyond limits of stability, forward or backward step is used and this allows maintaining COM within the BOS and counteracting the external forces that disturb balance [4,7].

Aging is a process in which there is a slow and progressive decline in multiple body systems [6]. Balance impairment is a major health issue in elderly people that can lead to fall and its related injuries [3]. Impairment in the postural control system can lead to instability and falls in elderly people [6]. Falls are common with aging. Instability and falls in elderly people [17,18] are associated with many risk factors. Common risk factors are muscle weakness, balance deficit, gait deficit, visual and vestibular deficit, use of assistive devices, fear of fall [3].

Fear of fall is a major negative consequence of balance impairment [1]. Fear of fall leads to loss of confidence in an ability to perform tasks and activities [3].

To utilize explained strategies of maintaining COM within BOS optimum ROM seems necessary. Optimum ROM needed for normal walking pattern and a certain amount of ankle ROM is needed for functional activities [9]. In the sagittal plane, during beginning of gait cycle in initial contact or in heel strike 20 degree of ankle dorsiflexion is required. And during foot flat, the hip requires 15 degree of flexion, 15 degree of knee flexion and 5 degree of plantar flexion and in the midst, knee requires 5 degree of flexion and 5 degree of ankle dorsiflexion [4].

In heel off and toe off ankle dorsiflexion needed minimum plantar flexion and that is 0 degree and 20 degrees of plantar flexion respectively [4].

Also, joint range of motion tends to decline with age related changes and changes might occur in joint structure [10,20].

With aging range of motion in lower extremity such as hip, knee and ankle may get reduced or altered. These altered range of motion may change movement patterns and these altered movement patterns may compromise balance and thus limit functional activities like ambulation and postural control and increase the risk of fall [6].

In view of this ankle ROM was taken along with balance and functional outcome measures. And to find if there is any relationship between ankle ROM and balance in elderly this study was done. Further, if any correlation gets established between ankle ROM and balance then we can aim for a future study to find treatment and intervention strategies to prevent incidences of loss of balance and frequent falls; thereby reducing functional impairments in elderly population.

However, there is a lack of enough data and research done to find correlation between ankle ROM and balance in elderly population of our region. Considering that with elderly population and the risk of frequent falls in them. This study is done to find if there is correlation among ankle ROM and balance.

Aims

This study aimed to assess correlation between ankle ROM and dynamic balance in elderly.

Objective

To assess mobility of ankle joints in elderly.
To assess scores of MDRT, POMA, DGI in elderly.

Methodology

Source of data: Two Old age homes
Study design: Cross-sectional study
Sampling technique: Convenient sampling
Study Duration: 6 months

Selection Criteria:

Inclusion criteria:

Age: 60 to 80 years
Subject who was able to walk with or without assistive devices.

Exclusion criteria:

History of stroke or any other neurological problem, malignancy. Any recent history of fracture or surgery in lower extremity Subject with Psychological disorder, Uncooperative subject.

Materials

Consent form, Measure-tap fifteen' walkway, Pen, Goniometer, twenty' walkway, Pencil, Chair, Micropore Shoebox, Sketch-pen, Measuring Scale.

Intervention

Correlation study was conducted with subjects between the ages of 60 to 80 years. Goniometry was used for ankle range of motion [11, 15]. Balance abilities were measured with multidirectional reach test (MDRT), Dynamic gait index (DGI), Performance oriented mobility assessment (POMA). The source of data collected for study were elderly individuals from two old age homes in Surat who fulfilled inclusion criteria.

Prior to examination the purpose and procedure of the study were explained to the subjects. Consent was taken from the subjects. Administration of various scales were conducted with subjects being barefoot. MDRT was first administered.

Next to a wall to avoid but not to touch a wall and to keep feet with normal stand MDRT was used to evaluate the maximum distance that the person can reach with outstretched arm forward (FR), backward (BR), right (RR), left (LR) with fixed base of support. It measures the postural control of a person in antero-posterior and medio-lateral direction [6].

In this test a 60 - inch measure-tape was mounted to a wall at a height of the subject's acromion. The subject was instructed to stand next to a wall to avoid but not to touch a wall and to keep feet with normal stance width and weight should be equally distributed on both feet. The subject was instructed to flex shoulder at 90 degrees with elbow extended and with a closed fist. Then the first measurement was recorded from the starting position at the third metacarpal on the measure-tape [12].

Then for the forward reach, the subject was instructed to reach forward as far as possible without taking a step. A second measurement was recorded at the third metacarpal on the measure-tape. And then this measurement was subtracted from the first one. Thus, the scores were assessed by the difference between starting and end position in inches.

For Backward Reach: In this subject was instructed to stand in the reverse direction of mounted measure-tape. This subject was instructed to reach backward as far as possible without taking a step and the rest of the instructions were the same as FR.

For Lateral Reach: This subject was instructed to face away from the wall and to reach sideways (to the right or to the left) and the rest were the same as FR. In all the components of MDRT, differences between the first and the second measurement were recorded in inches and three trials were done and an average of three trials were recorded at the end. And before the start of three trials, one practice trial was allowed.

Next POMA (balance and gait subsets) and DGI were administered. POMA was used to measure the balance. POMA has two subsets.

The Balance subset requires an individual to perform balance maneuvers such as sitting, moving from sitting position to standing position, standing with eyes closed and turning 360 degrees.

The Gait subset requires an individual to ambulate at a "usual" pace and at a "rapid, but safe pace. Scores on this assessment categorizes individuals as having a "low risk for falling," or "high risk of falling".

DGI Assesses the likelihood of falling in older subjects and this scale tests eight components of Gait Ankle ROM were assessed to prevent any bias [6].

Measurements for Dorsiflexion, Plantarflexion, Eversion, and Inversion were obtained using 180-degree stainless steel Goniometer.

Active ankle ROM was assessed in knee extended position [6]. Subject is in supine position with knee extended and feet over the edge of supporting surface. Prior to examination ankle ROM was proved to the subject. Then Goniometer was placed to examine the ankle range.

For DF and PF: Fulcrum was placed over lateral malleolus and stationary arm was aligned with fibular shaft and moving arm was parallel to the fifth metatarsal [11].

For IV and EV: Fulcrum was placed between two malleoli and stationary arm was aligned with midline of leg and moving arm was aligned with midline of the calcaneus. [11]

Statistical Analysis

The whole statistical analysis was done by using the JASP version 0.16. All statistical analysis was calculated using p value <0.05Pearson correlation test was applied to check correlation between ankle ROM & MDRT, Ankle ROM & DGI & POMA respectively

RESULTS

Pearson correlation coefficient study was used to calculate correlation. Ankle ROM data includes right and left side of dorsiflexion, plantar flexion, inversion, eversion motions. The mean scores and standard deviation for each motion are summarized in below Table

Ankle Range	Mean		SD	
	Rt	Lt	Rt	Lt
Dorsiflexion	10.76	10.76	3.97	3.97
Plantarflexion	38.69	38.30	3.77	3.22
Eversion	17.15	15.69	7.12	5.92
Inversion	9.5	9.6	2.75	2.91

Table 1: The mean scores and standard deviation for each motion

Since there were no significant differences between the right and left side ankle range of motion, therefore only the right side of ankle ranges were taken into consideration for data analysis. Right side of ranges were correlated with the balance measurement data which includes MDRT, DGI, POMA. Pearson correlation coefficient was used to calculate correlation. Subject were categorized based on their scores of MDRT, DGI, POMA scale measurement. Multidirectional reach test:

The mean scores and standard deviation are summarized in below table

MDRT	Mean	SD
FR	7.83	1.51
BR	3.83	0.53
RR	6.81	0.68
LR	6.80	0.71

Table 2: MDRT mean scores and standard deviation

There was no significant difference between RR and LR values, therefore only RR was taken into consideration. According to the scores of MDRT subjects were grouped as: High risk of fall (0-6 inches), Moderate risk of fall (6-10 inches), Low risk of fall (>10 inches) One subject had a score below 6 inches, which is a sign for risk of fall.

Dynamic Gait Index:

The mean scores for DGI were 21.06 (SD 2.42). According to the DGI balance measurement scores subjects were grouped as: Predictive of falls (<19), Safe ambulators (>22).12 subjects were scored below 19 showing predictive of fall.

Tinetti Performance Oriented Mobility Assessment: The mean scores for POMA were 24.06 (SD 1.77). According to the scores of POMA measurement scale subjects were grouped as: High risk for fall (<19/28), Moderate risk for fall (19-24/28), Low risk for fall (25-28/28)

One subject had a score below 19 showing high risk of fall.

"r" values ($p<0.05$)

Range	MDRT				DGI	POMA
	FR	BR	RR	LR		
DF	0.28	0.19	0.14	0.15	0.25	0.23
PF	0.29	0.18	0.13	0.11	0.47	0.23
IV	0.25	0.09	0.28	0.32	0.30	0.31
EV	0.32	0.32	0.26	0.18	0.4	0.38

Table 3: Correlation between ROM and MDRT

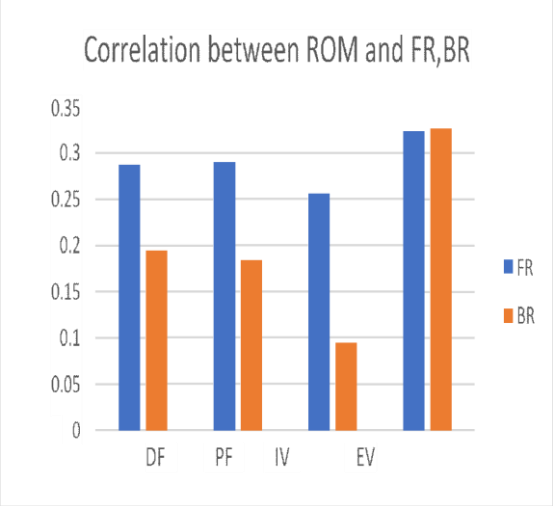


Figure 1: correlation between ROM and FR, BR

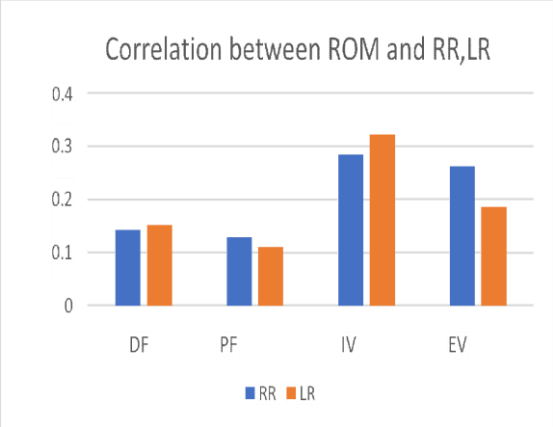
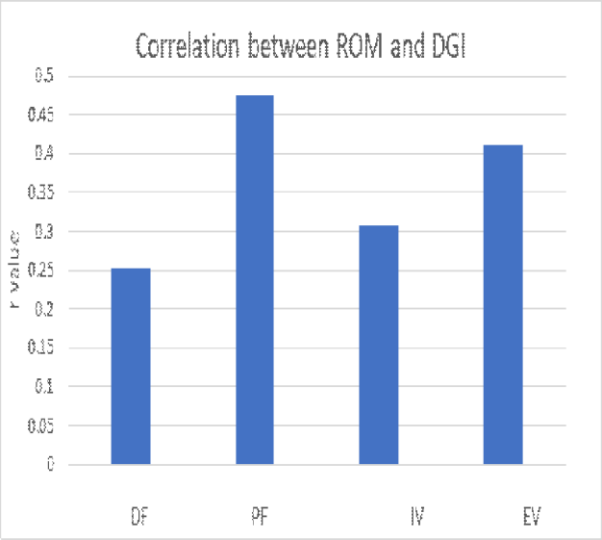


Figure 2: Correlation between Rom &RR, LR

Range	DGI
DF	0.25
PF	0.47
IV	0.30
EV	0.41

Table 4: Correlation between ROM and DGI



"r" values ($p < 0.05$)

Figure 3: Correlation between ROM and DGI

Range	POMA
DF	0.23
PF	0.23
IV	0.31
EV	0.38

Table 5: Correlation between ROM and POMA

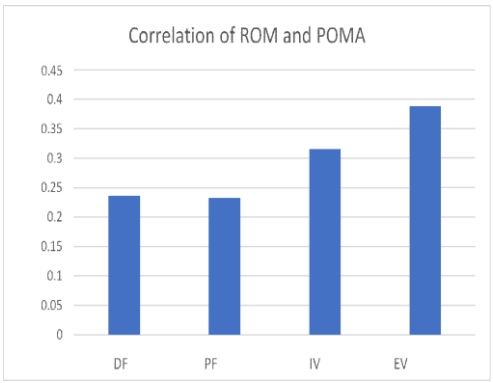


Figure 4: Correlation between ROM and POMA

Discussion

As there is no normative data for active ROM goniometric measurements for subjects in these age groups, we cannot make comparisons. This may show the fact that our measurements were active and not active assisted or passive which is maximal range. Where active motion is dependent on the subject's force generating ability [1,6].

In this study ankle ROM was examined in knee extended position and balance ability of subjects were assessed through balance measurement scales in sixty-five elderlies out of seventy-two aged 60-80 years. It has been proved in the study by Mecagni and O'Sullivan, (two thousand) that restricted ankle ROM in knee extended position is due to non-contractile tissue such as capsule, ligament and bone rather than short gastrocnemius muscle length [1].

In our study two subjects used assistive devices and their ankle ROM were less compared to others. Our study proves positive but lesser correlation between the ankle ROM as a whole and balance measures (table 3,4,5). However, there is more correlation between plantar flexion and eversion ROM with DGI compared to other scores.

In MDRT FR ($r = 0.32$, $p < 0.05$) and BR ($r = 0.32$, $p < 0.05$) have greater correlation with EV. RR ($r = 0.28$, $p < 0.05$) and LR ($r = 032$, $p < 0.05$) have greater correlation with IV. DGI has greater correlation with PF ($r = 0.47$, $p < 0.05$) and EV ($r=0.41$, $p < 0.05$). POMA has greater correlation with IV ($r = 0.31$, $p < 0.05$) and EV ($r=0.38$, p

< 0.05).

Sagittal plane:
Sagittal plane ROM has greater correlation with DGI and MDRT (FR, BR) and mild correlation with MDRT (RR, LR) and POMA (graph 1,2,3,4). This may show that sagittal plane motion correlates with balance measures during ambulation (gait) or in other activities (ADLs).

Frontal plane:
Frontal plane ROM has greater correlation with POMA, MDRT, DGI (graph 1,2,3,4). This shows that frontal plane ROM correlates with balance measures.

Therefore, both sagittal and frontal plane motions are important. Both have some correlation with balance measures during ambulation (gait) and other activities (ADLs). All ankle ROMs contribute to keeping balance during ambulation and other daily living activities where there is a change in BOS and in activities where there is fixed BOS. Thus, all motions of the ankle joint are important to keep balance during walking and they make the interaction between the feet and the ground. They are essential for walking and balance.

On comparison between high, moderate, minimal risk groups based on their scores on MDRT, POMA, there was found a difference in ankle ROM between high and low risk groups and there was no significant difference between high and moderate risk groups.

According to the scores on DGI there was a difference in the ankle ROM between those who were safe ambulators and those at risk. If ankle ROM decreases, then it may lead to instability and risk of fall thus limiting functional activities [16].

However, a further study is needed to establish correlation among ankle ROM in various body positions. Also, the study can be done to set up correlation between balance and ankle ROM based on gender.

Conclusion

In this study we found that a very mild relationship exists between the ankle ROM and balance in elderly subjects. The study suggests that age-related decline in ankle ROM is very less so it may result in decline of functional activities and balance abilities to a lesser extent.

The study does suggest mild correlation between ankle ROM and balance. Thereby, improving ankle ROM with balance training strategies in the elderly may help to improve balance and functional activities in elderly and may reduce risk of fall and its related injuries. And keeping length of gastroc-soleus muscle and other non-contractile structure should also be taken into consideration to ensure optimum ankle ROM. We also find future scope is there to undertake measurement of muscle strength of the same group and set up relationship with balance [19,20].

Limitation & Future Recommendations

Limitation:

1. Subjects were only taken from two old, aged homes of Surat.
2. Only ankle complex i.e., talocrural and subtalar ROM was taken into consideration [6].

Future recommendations

A further study is needed to establish correlation among ankle ROM in various body positions. Also, the study can be done to set up correlation between balance and ankle ROM based on gender. We also find future scope is there to undertake measurement of gastroc-soleus muscle strength and set up a relationship with balance.

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