RELATIONSHIP BETWEEN BALANCE AND ANKLE RANGE OF MOTION IN ADULTS AGED 60 YEARS AND ABOVE

RELAŢIA DINTRE ECHILIBRU ŞI MOBILITATEA GLEZNEI LA ADULŢII DE PESTE 60 DE ANI

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Key Words: ankle range of motion, balance, elderly population, activity levels

Abstract.
Background and Purpose. This study investigates the relationship between balance measures and ankle range of motion (ROM) in geriatric population. Identification of modifiable factors associated with balance may enable clinicians to design treatments to help reduce risk of falls in elderly people.
Methods. Correlation study was carried with 34 subjects between the ages of 60-86 years (71.9±6.3). Goniometry was used for ankle active ROM. Balance capabilities were measured with Multidirectional Reach Test (MDRT), Dynamic Gait Index (DGI), Tinetti Performance Oriented Mobility Assessment (POMA). Balance data and activity levels were correlated with ankle ROM using Pearson's correlation coefficient.Subjects weregrouped according to their scores on POMA and DGI. ANOVA and Post Hoc Analysis was done to find statistical difference in ankle ROM of those at risk of falls according to POMA and for DGI unpaired t-test was done.
Results. Correlation values for balance measures and activity levels were higher for planer and total ROM.Correlation values were higher for sagittal plane than frontal for MDRT, but for DGI, POMA, the correlation values were higher for frontal plane.Also, there existed a significant difference in the ankle ROM between those at risk of falls and safe ambulators as per DGI. And groups for POMA showed statistically significant difference in ankle ROM between those at high and low risk of falls. **Discussion.** Correlations exists between ankle ROM and balance and activity levels in elderly. Additional research is needed to determine whether treatment directed at increasing ankle ROM can improve balance.

Cuvinte cheie: mobilitatea gleznei, echilibru, persoane vâstnice, nivele de activitate

Rezumat
Introducere şi Scop: Acest studiu investighează relaţia dintre echilibru şi amplitudinea de mişcare a gleznei la persoanele vârstnice. Identificarea factorilor ce pot fi modificaţi, asociaţi cu echilibrul, poate permite clinicienilor să conceapă tratamente care să reducă riscul căderii la aceste persoane.
Metode: Studiul de corelare s-a realizat pe un număr de 34 de subiecţi, cu vârste între 60-86 ani (71.9±6.3). Pentru măsurarea amplitudinii s-a folosit goniometrul. Echilibrul s-a evaluat cu ajutorul Testului Multidirecţional (MDRT), Dynamic Gait Index (DGI), Tinetti Performance Oriented Mobility Assessment (POMA). Datele referitoare la echilibru şi nivelele de activitate au fost corelate cu mobilitatea gleznei, folosind coeficientul de corelaţie Pearson. Subiecíi au fost grupaţi în funcţie de scorurile POMA şi DGI. Analizele ANOVA şi Post Hoc s-au folosit pentru a determina diferenţele statistice privind mobilitatea gleznei celor cu risc crescut de cădere conform POMA iar pentru DGI s-a folosit *testul t.*
Rezultate: Există o corelaţie puternică între echilibru, nivele de activitate şi amplitudinea de mişcare. Valoarea corelaţiei a fost mai mare pentru planul sagital decât pentru cel frontal pentru MDRT, dar pentru DGI, POMA, valoarea corelaţiei a fost mai mare pentru planul frontal. De asemenea, există o diferenţă semnificativă în ceea ce priveşte mobilitatea gleznei, între persoanele cu risc de cădere şi persoanele fără risc, comparativ cu DGI. Există diferenţe semnificative între scorurile POMA privid mobilitatea gleznei la persoanele cu risc crescut de cădere şi cele fără risc.
Discuţii: Există corelaţii semnificative între mobilitatea gleznei, echilibru şi nivelul de activitate la persoanele vârstnice. Sunt necesare studii suplimentare pentru a determina dacă îmbunătăţirea mobilităţii gleznei poate îmbunătăţi echilibrul.

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Introduction

Aging, the inevitable, is a result of slow and progressive decline in multiple body systems. The biggest achievement of this century has been longevity. But adding years to life still questions the quality of life lived by the aged population with increase in the number of disabilities and injury and consequently institutionalization.The ability to maintain balance is often taken for granted, yet it is the foundation for mobility and overall functional independence throughout the lifespan [1].Impairment in any component of postural control system can lead to instability and falls in older people. Falls in elderly is a challenging problem with potentially serious consequences and morbidity. Falls can result from many factors including both extrinsic and intrinsic factors such as deficits in sensory, cognitive, central integration and musculoskeletal abilities [2,3]. Fall prevention depends on a clear understanding of risk factors associated with falls. Not all risk factors can be eliminated but modification of even one risk factor can be worthwhile therapeutic goal even for people with multiple problems [4].

The human foot plays an important and complex role in the maintenance of efficient locomotion. The foot provides the only source of direct contact with the ground during walking; it contributes to both the absorption of impact after heel contact and generation of power required for forward momentum. Flexibility at the ankle joints provides an important contribution to safe execution of many functional tasks and added efficiency on maintenance of postural stability [5]. Thereby, decreased ankle range may require altered movement patterns and these altered movement patterns may compromise balance, thus limiting functional activities [3].Therefore, the purpose of this study was to examine the relationship between balance and ankle range of motion in elderly population. These results may serve in clarifying specific components to incorporate into future intervention studies for reducing falls in elderly people.

Methods

Subjects

The source of data collected for the study, were elderly, aged 60 years and above who fulfilled the eligibility criteria of the study. Subjects were recruited from the community and old age homes in Pune.A Correlation study was carried out with a sample of 34 subjects between the ages of 60 and 86 years (Mean = 71.9 years, SD= 6.3) with 14 males and 20 females.Subjects with the following criteria were included for the study:

1) Elders with the age 60 years and above with no health problems; 2) who are ambulatory with or without assisted device; 3) with the score of above 23 out of 30 on mini mental status examination[6]; 4) grade of 4 or more on manual muscle testing of ankle.

Following was the exclusion criteria:

1) History of stroke or any other neurological problems; 2) uncorrected visual problems [7];
3) severe ankle edema or other foot abnormalities; 4) abnormal or absent sensations in the lower extremities; 5) any previous orthopedic problems of lower extremities; 6) limb length discrepancies; 7) any medical or surgical conditions that might affect balance or ankle range;
8) elderly with high levels of activity, that is physically elite group [8].

Subjects who participated in the study were offered individualized feedback on their scores for balance and ankle range of motion and simple ankle stretches and balance exercises were demonstrated.

Instrumentation

Multidirectional Reach Test (MDRT) was used to measurepatient's voluntary postural control in antereo-posterior and medio-lateral direction.It evaluates the maximal distance that a person is able to or willing to reach with theoutstretched arm forward (FR), to the right (RR), left (LR) and leaning backward (BR) with feet flat on the floor and at shoulder width apart.Previous research has established the reliability and validity of MDRT[9], measurements were obtained from 254 community dwelling older persons with the reliability analysis (Cronbach's Alpha, 0.842).

Tinetti Performance Oriented Mobility Assessment (POMA) measures patients gait and balance. It has two subtests. Reliability[10,11]of this scale was found in previous researches and agreement was found on over 85% of the items and items that differed never did so by more than 10%.

Dynamic Gait Index (DGI) assesses the likelihood of falling in older patients and tests eight facets of gait. Preliminary research has shown that test has good inter rater and test retest reliability and can be used as a predictor of falls among the elderly [8,11].

For assessing activity levels Life Space Assessment [12] was used which refers to activities just within past month. Reliability of this scale has been proved by Baker et al., in a study where test retest reliability was established. Intraclass correlation coefficient = 0.96 [12,13].

Measurements for dorsiflexion, plantar flexion, inversion and eversion were obtained using a 360 degree universal goniometer.

Active range of motion were measured in 2 positions [14,15]

- knees flexed at 90 degrees (sitting).
- knees extended with subject supine and feet over the edge of the supporting surface (supine).

Reliability of ankle ROM has been established [16,17,18].

Also, attempt was made to minimize error in measurement by having a single observer, using a standardized technique with the same goniometer [19,20].

Procedure

Prior to testing the purpose and procedure of the study were explained to the subjects. Each subject was asked to sign an informed consent form. Subjects were screened for general health questions and administered general and ankle and foot examination to determine eligibility of the subject. After testing general fall related questions and mobility levels using life spaceassessment were assessed.Entire examination and administration of various scales used in the study werecarried out with the subjects barefoot to exclude the influence of footwear. MDRT was then administered. Next DGI and POMA balance and gait were administered by reading instructions from a script.Subject was asked to perform POMA gait subtest twice in order for the tester to change position for scoring the performance from side, front and back of the subject.

Then ankle ROM were recorded in two positions.Ankle ROM was assessed last to prevent any bias in the study.The method used to measure ROM is outlined in Measurement of Joint Motion: A Guide to Goniometry by Norkin and White and has been described by previous researchers.

Data analysis

Ankle ROM data was considered as (1) individual ROM, (2) planar ROM in the sagittal (dorsiflexion and plantar flexion) and frontal (eversion and inversion) planes, and (3) total ankle ROM. Each of these conditions was correlated with the balance measurement data forthe MDRT, the POMA balance subtest, the POMA gaitsubtest, and the POMA total score and DGI. The Pearson productmoment correlation coefficient (PCC) was used to calculatecorrelations. For a sample size of 34, minimum value of 'r' is 0.34 for it to be statistically significant ($p<0.05$).

Balance is acomplex phenomenon, influenced by many factors; therefore, relatively small correlation coefficients mayrepresent statistical significance.

Subjects were then categorized based on their scores on POMA and DGI.Means of ankle ROM (planer) and total ROM were compared between the groups to find out if a significant difference existed between the groups.

According to the scores on POMA subjects were grouped as: High risk for falls (<19/28),moderate risk for falls (19-24/28) and low risk for falls (25-28/28)

To find out if there was any difference in the ankle ROM between the groups, anAnalysis Of Variance (ANOVA) for single factor ($p<0.05$) was done. To further see where in the three groups the difference in the ankle ROM liedTukey's Post Hoc Analysiswas done.

According to scores on DGI, subjects were grouped as:At risk for falls (<19/24) and Safe ambulators (>22/24). For comparison between the 2 groups to see if any difference existed in the ankle AROM, an unpaired t-test ($p<0.05$) was used.

Range of motion of only right side was taken into consideration for data analysis as there were no differences between ROM of both the sides. Also in MDRT only RR was taken into consideration as the values for RR and LR were the same.

Results

The demographic data is as presented in Table 1

Table 1

Gender	**Age** $\overline{X}$	**SD**
Males(n= 14)	71.6	5.6
Females(n= 20)	72.2	7.0

Multidirectional reach test

The mean scores found were as following: FR-8.81in (SD 1.32) (range= 6 - 11.5 in); BR-4.56 in (SD 0.89) (range= 3 – 6.5 in);RR-5.82 in (SD 0.77) (range= 4 – 7 in);LR-5.85 in (SD 0.75) (range= 4 – 7 in).

Tinetti Performance Oriented Mobility Assessment

The mean scores of POMA_T were 22.8/28 (SD 3.09) with a mean POMA_B subtest of 12.8/16 (SD 1.42) and POMA_G subtest of 10.0/12 (SD 2.12).

Four subjects had total scores below 19, indicating that they were at "high risk of falls",sixteen had scores between 19-24 indicating that they were at "moderate risk of falls" and fourteen had scores above 24 indicating "low risk of falls".

Dynamic gait index

The mean DGI scores found were 19.03/24 (SD 4.1).

Twelve subjects had scores below 19 which is predictive of falls in the elderly and eight had scores above 22 which indicates that they were safe ambulators.

Life space assessment

The mean activity levels found were 33.8 (SD 12.7) and range 8-60.

Goniometry measurements

The means and standard deviations for individual ranges and planer ranges in both sitting andsupine positions are summarized in Table 2. Since there were no differences between the right and left side ankle range of motion, therefore only right side ranges were taken into consideration for data analysis.

Table 2.

Ankle range	Sitting		Supine	
	$\overline{X}$	SD	$\overline{X}$	SD
DF	17.0	5.3	11.8	4.5
PF	38.2	5.3	37.6	5.5
INV	24.9	4.7	24.7	4.6
EVR	14.8	2.4	14.8	2.4
FRONTAL	39.6	6.5	39.6	6.6
SAGITTAL	55.3	9.4	49.4	9.1
TOTAL	94.9	14.8	89.0	13.9

Referring to Table 3, it clearly demonstrates that there exists a negative correlation between age and ankle ROM i.e. both individual and planer ranges (sagittal, frontal and total ROM). There exists a strong correlation of age withtotal ROM (r =-0.73) and with sagittal ROM(r =-0.72), though with frontal ROM there exists a moderate correlation (r =-0.61).

Referring to Table 3, it clearly demonstrates a positive correlation between activity levels and ankle ROM with strong correlation values for both frontal plane ROM and total ROM(r =0.73) for both. Activity levels show a moderate correlation with sagittal plane ROM (r =0.64).

Table 3.

RANGE	AGE	ACT LEV	ACT LEV	AGE	RANGE
Sitting					**Supine**
DF	-0.63	0.60	0.38	-0.59	**DF**
PF	-0.65	0.54	0.51	-0.62	**PF**
INV	-0.60	0.72	0.75	-0.58	**INV**
EVR	-0.51	0.59	0.60	-0.50	**EVR**
SAGITTAL	-0.72	0.64	0.50	-0.67	**SAGITTAL**
FRONTAL	-0.61	0.73	0.74	-0.59	**FRONTAL**
TOTAL	-0.73	0.73	0.68	-0.72	**TOTAL**

For further data analysis only planer (sagittal and frontal) and total ROM were taken into consideration. This was due to the fact that correlation values were higher for planer and totalROM as compared to individual ankle ROM and also goniometric measurements are more accurate in planer ranges than individual ranges as it rules out variations which might reflect on individual ranges but not on planer and total ROM.

Also there are not much difference in correlation values with knee extended (supine) or knee flexed to 90 degrees (sitting), though the latter shows slightly higher magnitude as illustrated in Figure1-2.Therefore ankle ROM for knee flexed position was taken into consideration for further data analysis.

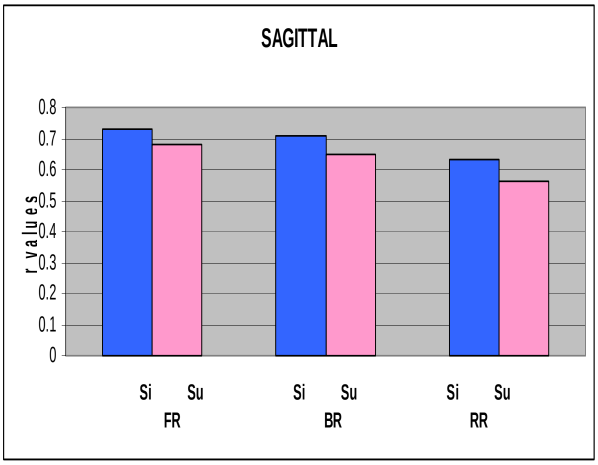

Figure1. Correlations between MDRT and ankle ROM in sitting (Si) and supine (Su) in SAGITTAL Plane

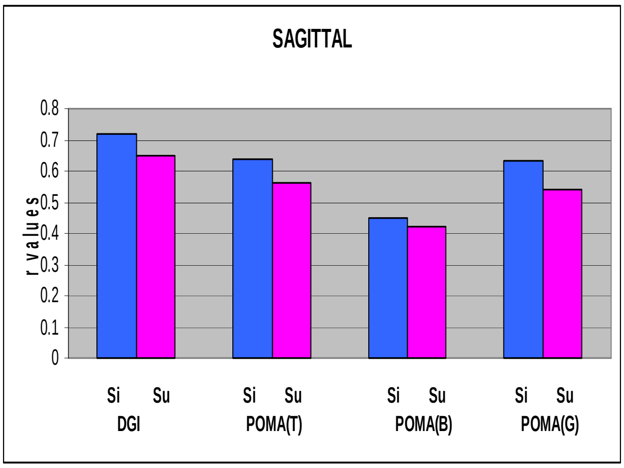

Figure 2.Correlations between balance measures and ankle ROM in sitting (Si) and Supine (Su) in SAGITTAL Plane

Table 5
" r" values (p<0.05)

RANGE		MDRT			DGI	POMA (T)	POMA (B)	POMA (G)
		FR	BR	RR				
SAGITTAL	Sitting	0.73	0.71	0.63	0.72	0.64	0.45	0.63
FRONTAL		0.70	0.58	0.52	0.75	0.71	0.60	0.63
TOTAL		0.78	0.71	0.63	0.79	0.72	0.55	0.68
SAGITTAL	Supine	0.68	0.65	0.56	0.65	0.56	0.42	0.54
FRONTAL		0.70	0.59	0.50	0.75	0.71	0.61	0.62
TOTAL		0.78	0.71	0.61	0.78	0.71	0.56	0.65

Correlations between ankle ROM andbalance measurements are summarized in Table 5 and Figures 3-4.Sagittal plane ROM has a strong correlation with FR(r=0.73), DGI(r=0.72) and also with BR(r=0.71). Frontal plane ROM demonstrates a strong correlation with DGI(r=0.75) and with POMA_T(r=0.71). The strongest correlation exists between total ROM and DGI(r=0.79) and with FR(r=0.78). Also total ROM has a strong correlation with POMA_T(r=0.72)and BR(r=0.71).

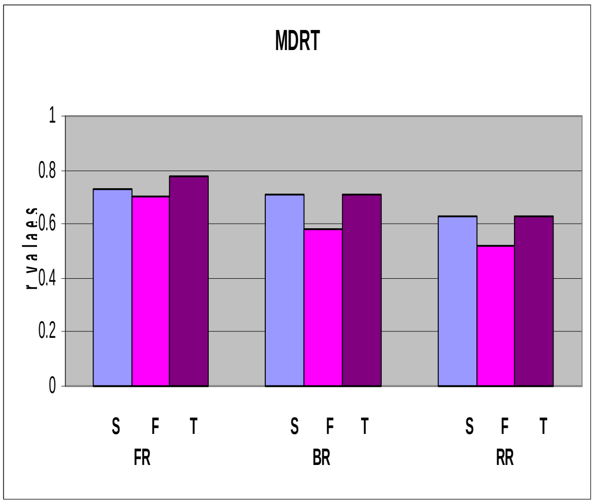

Figure 3. Correlations between MDRT (FR, BR, RR) and ankle ROM (planer)i.e Sagittal (S), Frontal (F), and Total (T) ROM

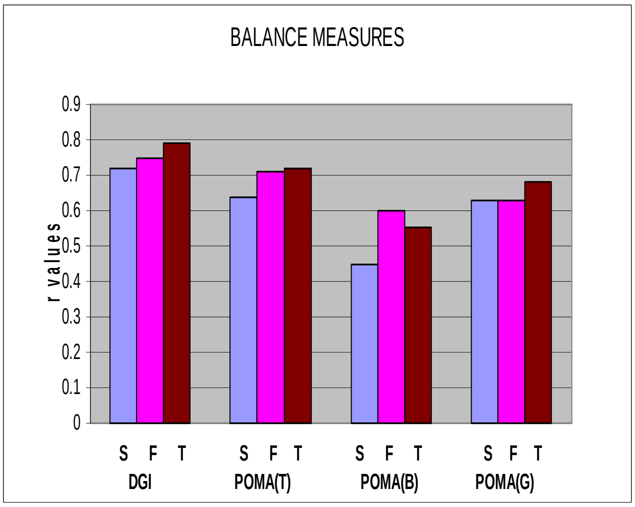

Figure 4. Correlations between BALANCE MEASURES (DGI,POMA(T), POMA(B), and POMA(G)) and ankle ROM (planer) i.e. Sagittal (S), Frontal (F), and Total (T).

ROM between groups according to scores on POMA

There was a *statistically significant difference* in the mean ankle ROM between subjects at high and low risk for falls in sagittal plane (F= 3.75; p= 0.03), the Tukey's q = -3.96 ($q_{critical}$= 3.49). For frontal plane ROM, there was a significant difference in the mean ankle ROM between subjects at high and low risk for falls (F= 5.17; p= 0.011), the Tukey's q=-4.60($q_{critical}$= 3.49). However, there was no difference between the high and moderate; and moderate and low risk groups (p>0.05).For total ROM, there was a significant difference in the mean ankle ROM between subjects at high and moderate risk(F= 11.5; p= 0.0001), Tukey's q= -4.99; and also there was a significant difference between those in high and low risk groups (F= 11.5; p= 0.0001), Tukey's q= -7.48 ($q_{critical}$= 3.49). However, there was no significant difference between moderate and low risk groups (p>0.05).

ROM between groups according to scores on DGI

For sagittal plane, there was a significant difference in the mean ankle ROM between those at risk and safe ambulators ($t= -4.42$; $p= 0.0003$; $t_{critical}= 2.10$). For frontal plane, there was a significant difference in the mean ankle ROM between the two groups ($t= -3.54$; $p= 0.002$; $t_{critical}= 2.10$). For total ROM at the ankle, there was a significant difference between the two groups ($t= -4.42$; $p= 0.0003$; $t_{critical}= 2.10$).

Discussion

Although all of our elderly subjects were healthy older adults, age related reduction in postural control was none the less evident.The range of motion values in our study were found to be lower than those reported by other investigators. As there is no normative data for active ROM goniometric measurements for subjects in this age group, we cannot make comparisons.This may be attributed to the fact that our measurements were active and not active assisted or passive, which are representative of maximal possible range[21] where as active motion is dependent on the subjects force generating capacity.Lifestyle and footwear differences between the populations studied may also have contributed to the differences.

Our study demonstrates a negative correlation between age and ankle ROM. An age associated decline in joint mobility during the early and middle adult years is well documented.Vandervoot et al.[22],stated that aging substantially reduced movement capabilities, for e.g. by age 70, ROM decreases 50%, muscle strength and mass declines up to 40%, muscle activation becomes less complete and rate of tension development slows. This reduced magnitude of joint movement may exist even in the absence of pathology. There is reduction in joint ROM for all the joints in the elderly but the ankle joint being of substantial importance owing to the lesser range available in the complex joint and to the important role it plays as being the only source of direct contact with the ground during weight bearing tasks, and thus its important role in maintaining both the stability and mobility.

Our study demonstrates a positive correlation between ankle ROM and activity levels.

The correlation was higher for frontal plane ROM ($r= 0.73$; $p<0.05$) and moderate for sagittal plane ($r=0.64$; $p<0.05$).This suggests that frontal plane motions at the ankle are equally important for mobility which is important to elderly people, because it is instrumental in activities of daily living and required in many tasks for independent living.4 subjects out of 34 gave history of falls and their ankle ROM was less as compared to the others. Also, 3 subjects used assistive devices i.e. stick for ambulation and their ankle ROM was also less as compared to the other subjects. Though elite group of elderly population were excluded from the study, there were 5 subjects who participated in regular light exercise programs in form of walking and yoga and their ankle ranges were more as compared to other subjects.A decline in the mobility has been related to reduction in the ankle ROMby other researchers[14,15,23,24], they concluded that elders with reduced range at the ankle were at a greater risk of falls and fear of falling often leads to older people reducing their activity levels which in turn further reduces strength, flexibility, body awareness and balance[5,25].

There has been no difference in the mean values of ankle ROM in the two positions i.e. sitting and supine (table 2), except that differences existed in the mean values for ankle ROM only in the sagittal plane and that too primarily for the dorsiflexion range. This finding indicates that a change in position mainly affects ROM only in the sagittal plane. This may be attributed to the fact that supine position places additional stretch on the aged and somewhat stiff connective tissue within the multi-joint gastrocnemius muscle[21].The difference in the mean values of ROM in the sagittal plane also reflected difference in the total ROM. If a short gastrocnemius muscle length was the major cause of decreased ankle range, we might expect knee extended position to produce a higher correlation, which was not the situation. This finding may indicate that a short gastrocnemius muscle length may not be the main factor contributing to the decreases in the balance measurements [3]. The data suggests that decreased performance on balance measures associated with restricted ankle range may be attributed to the non-contractile tissues such as capsule, ligaments, or the articular stiffness rather than solely contributing it to the short gastrocnemius muscle length. This difference may also be due to the fact that we considered active range at the ankle joint, studies have reported that decreased passive elastic stiffness is seen within the last half of the available passive dorsiflexion ROM. Although, decreased calf extensibility has been reported to limit the ability to respond to anterior postural perturbations and to generate forces needed to control center of mass [26].

Also, low to moderate correlation exists between individual ankle ROM as compared to moderate to high correlation in planer and total ankle ROM.Therefore, planer movements i.e. sagittal and frontal are more important when considering balance as compared to individual joint ROM. Also, goniometric measurements for planer movements are more reliable than individual ROM owing to the variations that might exist in measurements of individual ROM.

Frontal plane

Comparing figures 3-4, it is clear that as compared to sagittal plane ROM, frontal plane ROM correlates more with balance measures during ambulation and where there is a change in the base of support (BOS) i.e. DGI, POMA as compared to balance measures where the BOS is fixed (MDRT).

This may indicate the importance of frontal plane motions in ADL’s which primarily requires a change in BOS and a shift of centre of mass (e.g. gait). This is consistent with the findings of other researchers who have demonstrated that ankle inversion and eversion has a higher correlation with balance measures as compared to dorsiflexion and plantar flexion ranges [3,27]. Also, the vertical and horizontal displacement of COG during walking describes a figure of eight, a 5-cm (2 inch) displacement, also owing to the small base of support of the foot may attribute to the importance of frontal plane ankle motion and its strong association with balance during gait.

Sagittal plane

Also, sagittal plane ROM when compared to frontal plane ROM is more correlated with balance measures i.e. MDRT and that too for voluntary control in AP direction as compared to other balance scales. This is consistent with the finding of other authors [3]. Limited ankle dorsiflexion range may decrease ankle’s dorsiflexion excursion, decrease the time to heel off &/or change the maximum amount of knee excursion before heel off during gait. Also, the ROM required at the ankle required for negotiating stairs is more as compared to level surface walking (15° of DF) [7]. The total ROM of the ankle joint in sagittal plane is approximately 45°. Fallers have been reported to have less ankle excursion (DF ROM) during single support phase of walking [24,28]. Movement of ankle during gait is a precisely controlled motor task and inadequate foot clearance (due to reduced DF ROM) would predispose an individual to an accidental stumble and a fall [22]. Although, sideway falls are more associated with hip fractures, backward falls are also a cause of significant morbidity. Since, there is a strong correlation between sagittal plane ROM and BR, this may indicate the important role that improving ankle ROM can play in reducing the incidence of backward falls [29].

Total ROM

All ankles ROM, the strongest correlation exists between total ROM and DGI and FR. Also, correlation for BR and POMA_T were strong, with POMA_G subtest showing moderate correlation but higher in magnitude compared to POMA_B and moderate correlation with RR. Inversion and eversion occurs at the ankle joint along with DF & PF owing to the orientation of the joint axis and also at subtalar joint especially during weight bearing activities [30,31].

Therefore, sagittal and frontal plane motion, both are important. This is consistent with our finding that total ankle ROM shows a higher correlation with balance measures indicating that a composite ankle ROM may be more important for maintaining balance as compared to separate planer motions.

Studies have proved that many older adults generally used a strategy involving hip movements rather than ankle movements. This may be a way of adapting to certain constraints associated with aging, such as muscle weakness, joint stiffness or reduced ankle joint sensation.Therefore, maintenance of strength of dorsiflexing and planter flexing muscles as well as adequate ankle ROM is necessary to allow efficient force generation and balance strategy execution to prevent a fall[8].Studies have stated that gait changes that are thought to represent the adoption of a more stable walking pattern have also shown to be risk factors for falls in prospective studies [22]. As also seen in patients with Parkinson's who have reduced walking speed and a stiff gait thought to be for improving stability but they are reported to be at more risk for falls. Also, the overall stiffness of musculoskeletal system leading to a stiffer gait pattern, which could be because of increased co-contraction in older subjects. E.g. soleus was not completely inhibited during gait initiation [33].The presence of this co-contraction would cause a decrease in articular ROM, moments of force and powers during gait [34].

Groups on basis of scores on POMA and DGI

On comparison between high, moderate and low risk groups based on their scores on POMA, there was found to be a significant difference in the mean ankle ROM between the high and low risk group in both sagittal and frontal plane. Those who were at high risk had a significantly less ankle ROM as compared to high ankle ROM found in subjects in low risk group. Whereas, there was no significant difference between the high and moderate, moderate and low risk groups.

For total ROM, there was significant difference between high and moderate, high and low risk groups.

Also, for groups as per scores on DGI, there was significant difference in the mean ankle ROM between the subjects those who were safe ambulators and those at risk for falls in sagittal, frontal and total ROM.Therefore, this may suggest that a significant reduction in ankle ROM may be useful to categorize those at high risk for falls on POMA, or those at risks of falls according to scores on DGI.

Conclusion

The results of our study suggest that age related decline in ankle ROM may result in decline in function and balance control. This is an important finding as therapy directed at improving ankle ROM along with training balance strategies in the elderly may help improve balance, postural stability and function and thus reduce the risk of falls in the elderly population.

Total ankle ROM is imperative for maintaining balance but frontal plane ROM is considerably important in balance during dynamic activities like walking as compared to sagittal plane ROM which may be more important for balance with voluntary control in AP direction.

Also though maintaining adequate length of the gastro-soleus is important to improve balance but the other non-contractile structures should not be overlooked during treatment, especially when there have been reported improvements in the ankle ROM and balance control in the elderly by using joint articular techniques.[9]The results also reflect that subjects who were at high risk for falls, had considerable reduction in ankle ROM in comparison to subjects who were at low risk for falls or were safe ambulators.Thus, ankle exercises directed at increasing ankle ROM may increase the effectiveness of clinical and community interventions designed for improving balance and function and reducing falls in the elderly.

Limitations

The sample size selected was small. Lifestyle and foot wear differences were not considered in the population selected. Only ankle complex (talocrural and subtalar) ROM was taken into consideration and rest of the foot complex was not considered. Only ROM was considered whereas, other foot and ankle characteristics, i.e. foot posture, strength and deformity were not considered.

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