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Original Research Article

Assessment of dynamic balance and bone density in premenopausal and postmenopausal middle-age women: a comparative study

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ABSTRACT

Background: Dynamic balance control is required to perform simple and complex mobility task in our day-to-day life. Deficit in balance can results in falls and fractures which can affect health-related quality of life. Menopause is also considered as a risk for fracture due to osteoporosis, which at later life becomes difficult to manage and causes higher morbidity. So, evaluation of balance and bone density is important in middle-age in women, so that we can plan and administer proper treatment strategies at an early stage which can reduce risk of falls and fractures. Therefore, the aim of the study was to assess and compare dynamic balance and bone density in premenopausal and postmenopausal middle-age women.
Methods: Female participants in the age-group of 40-60 years were divided into premenopausal and postmenopausal group based on the criteria of cessation of menstrual cycles for minimum one year. Participants were assessed barefooted for dynamic balance by physical performance mobility tests such as narrow walk test (NWT), Figure-of-8 walk test (F8WT), obstacle walk test (OWT) and normal gait speed (NGS). Bone density was evaluated by using ultrasound bone densitometer at calcaneus in community setting.
Results: The time taken to complete the NWT, F8WT, OWT was reduced significantly ($p<0.05$) in post-menopausal group, showing dynamic balance is significantly affected in postmenopausal women when compared with premenopausal women in middle-age group. Gait speed was also reduced in both the groups but it was significantly reduced ($p<0.05$) in postmenopausal group. Also bone density decreases significantly in post-menopausal group showing osteoporosis, premenopausal group also showed osteopenia when assessed by ultrasound bone densitometer in community setting.
Conclusions: Dynamic balance and bone density significantly decreases in post-menopausal middle-age women as compared with pre-menopausal middle-age women.

Keywords: Dynamic balance, Bone density, F8WT, Gait speed, Narrow walk, Obstacle walk, Physical performance test, Post-menopausal

INTRODUCTION

Dynamic balance control is required to perform all mobility tasks in our day-to-day life. Balance control consists of controlling the body's center of mass over its limits of stability, while at rest or performing movements and requires integration and complex coordination of sensory, musculoskeletal and neural systems to increase the efficiency of upright postures needed for efficient movements.[1] Any deficit in sensory systems such as in vision, vestibular and proprioceptive systems can affect our postural stability. Similarly, impairments in musculoskeletal systems such as decreased strength of muscles, decreased bone strength, reduced flexibility of connective tissues and muscles, also affects dynamic balance and results in decline in physical function which can restrict activities of daily living. Decline in physical function in turn leads to decreased in muscle and bone

strength, which creates fear of movement and can cause falls in the household or community settings.

Fall is one of the commonest problems faced by senior and elderly population globally.[2] According to WHO in April 2021, an estimated 684000 fatal falls occur each year, making it the second leading cause of unintentional injury death, after road traffic injuries. Over 80% of fall related fatalities occur in low-and middle-income countries, with regions of the Western Pacific and South East Asia accounting for 60% of these deaths which are highest among adults over the age of 60 years. According to Pitchai et al in 2019 prevalence of falls in population above the age of 60 years within Mumbai city, Maharashtra was 24.98%.[3] However, in India it ranged from 26% to 37% across various regions and risk of fall is higher among female elderly population.[4]

Advancing age is also a risk factor for fall and can cause fractures, serious injuries, future disabilities and hospitalization affecting their health-related quality of life in older adults.[5,6] Women are more prone to fractures earlier than men, due to changes in their hormonal exposure during and after menopause.[7] Menopause have an adverse effect on overall musculoskeletal health at midlife and beyond.[6,8] Estrogen is an important hormone which helps to maintain female musculoskeletal system in a healthy state. Estrogen deficiency around menopause results in adverse effects on health of bones, muscles, ligaments, tendons, collagen cartilage, synovial membrane and capsule of joints causing sarcopenia and osteoporosis.[9,10]

Osteoporosis is the condition characterized by decrease bone density. It is largely prevalent in India and have multiple causative factors including nutrition, sedentary lifestyle, geographic area, decreased exposure to sunlight calcium and vitamin D deficiency and hormonal imbalances but menopause is the most important risk factor for developing osteoporosis in women.[8,11] Osteoporosis is largely, a preventable condition, but diagnosis is seldom done till osteoporotic fracture occurs. Decrease in bone density, reduce bone strength and muscle weakness increases the risk of falls by impairing balance and mobility, thus increasing the incidence of osteoporotic fractures in postmenopausal women and can lead to high morbidity, mortality and financial burden impairing health-related quality of life.[12-16] Therefore, preventing falls and fracture risk should always be a fundamental physical therapy goal in such individuals. Reduction in fall and fracture risk should focus on screening of bone density and related balance impairments at regular intervals and incorporating exercises aiming to improve balance and bone strength in earlier middle age of life, rather than in later years of life where it becomes difficult to manage.

In order to prevent disabilities arising from falls and fractures, simple screening tools for assessing balance and bone density which are cost-effective and easy to administer for larger community population are needed to identify people with impairments at an earlier and possibly more treatable phase. Fracture risk can be assessed by DEXA, quantitative ultrasonography, computed tomography. DEXA is a known to be a gold standard for assessing bone mineral density, however it exposes patients to harmful ionizing radiations and is costly for patients in community settings.[17] So alternatively quantitative ultrasound can be used to assess bone strength for larger community population for screening purposes as it is reliable, easy to administer and is cost-effective and portable.[17]

Challenging the balance conditions may stress the ability to adapt walking or physical performance in the presence of subclinical abnormalities in the balance ability of the individual. Thus, it may provide the means to detect early alterations in balance and mobility, and can assess the risk of falls.[18] Various clinical screening tools includes challenges in walking to assess dynamic balance and mobility as most of the fall occurs during walking. This physical performance tests can provide early indication of impaired dynamic balance and predicts risk of falls in postmenopausal women.[18,19]

The use of challenging balance conditions to detect subclinical risk of balance impairment has been reported in aging population.[6,18,19] In a systematic review done by Muir-Hunter, gait performance under challenging conditions was predictive of falls.[20] Brach et al assessed gait in older adults during the challenging conditions using narrow walk and obstacle walk to uncover mobility difficulty, that is not identified by usual gait testing.[21] Nolan et al evaluated age-related changes in musculoskeletal function, balance and mobility measures assessed by performance tests in men in the age group of 30-80 years of age.[22]

Much of the available literature focuses on evaluation of balance in older adults and postmenopausal women above the age of 60 years, where aging changes are more readily evident when assessing for balance.[14-16] However, there is paucity of literature for assessment of balance in middle aged females in their perimenopausal and early postmenopausal period. It gets difficult to treat the morbidity related with serious injuries and osteoporotic fractures due to falls in older female adults. So, timed physical performance tests which are sufficiently challenging to assess dynamic balance in middle age women are needed, since an early detection of loss of balance and low bone density is important to prevent the risk of falls and assess fracture risk in later life.[23] Patel et al suggested that the older adults who reported higher levels of physical activity in midlife had better mobility in old age than less physically active ones.[24] If impairments of dynamic balance are known in this middle-age female population, treatment strategies to improve dynamic balance and bone strength can be routinely instituted in early middle age to prevent fall and future disabilities associated with it in later life.

Therefore, there was a need to assess dynamic balance and bone density in middle early age, so as to prevent the risk of falls and fall related osteoporotic fractures which can be done by planning proper treatment strategies.

METHODS

The study design was observational and was conducted through a period of 2016-2019 in accordance with the declaration of Helsinki and was approved by institutional ethical review board of Government medical college and hospital, Nagpur. The study was conducted at Government medical hospital, Nagpur, India. All participants who agreed to participate in the study provided written informed consent and parts and procedure were explained in the language they understood. Female participants in the age group of 40-60 years were included. They were categorized into two groups based on their menopausal status. Participants who were having regular periods and participants who were having missed and irregular periods, hot flushes, mood swings, hormonal imbalances were also included and were categorized into pre-menopausal group. Post-menopausal group was categorized by the criteria of participants having cessation of periods or menstruation for 1 year.

Participants with severe osteoarthritis of hip, knee and ankle, rheumatoid arthritis, neuromuscular disorders, major surgery in previous six months, pregnancy, hysterectomy, hormone replacement therapy, thyroid surgeries, malignancy, vestibular disorders, structural scoliosis, peripheral neuropathy or any musculoskeletal condition, which would affect mobility of the individual and athletes were excluded from the study. The 148 participants were screened and enrolled for the study. After explaining the parts and procedure of the study, participants were assessed by primary investigator for a demographic and clinical assessment. Two participants having rheumatoid arthritis, and one participant having severe osteoarthritis of knee were excluded from the study. Total 145 female participants were included and provided written informed consent prior the study in the language they understand. The 76 female participants were included in premenopausal group (n=76) and 69 female participants were included into post-menopausal group (n=69).

Procedure

Demographic and clinical assessments were done for each participant at physiotherapy department, government medical college according to the case record form and took approximately 15 mins time for each participant. The materials used for assessments were stature meter, stopwatch, measuring tape and colored floor markers, two different sizes obstacle blocks, ultrasound bone densitometer Furuno CM-200, Tanita-364 bioelectrical Impedance machine. Height was measured by stature meter. The participants were asked to stand straight barefooted and nearest 0.5 cm was taken as round off for height measurement. Weight and BMI were measured by Tanita-364 bioelectrical impedance machine.[25] Participant were asked to stand on the machine barefooted and hand piece was held in both hands, keeping the elbows straight with shoulder at 90 degrees of flexion and readings were recorded from display panel. Daily physical activity was assessed by self-reported walking. Approximate walking time was noted by participant as the average walking she does in a day excluding her activities in her household work and activities of daily living. Bone density was assessed by ultrasound bone densitometer Furuno CM-200. The participant was asked to keep her right heel with adequate aquasonic gel applied, on the foot piece of machine. Bone density was measured at calcaneus bone and score was given as T-score by the machine and was noted into the case record form.[26] Participant was further taken for physical performance assessment tests to evaluate dynamic balance.

Physical performance tests for dynamic balance

Participants were asked to perform timed physical performance tests, that was, NWT, F8WT, OWT and NGS for dynamic balance.[16,27,28] The procedure to perform the tests was explained to the participants individually and trail was shown by investigator before performing the test. The participants performed the tests barefooted and the time to complete the test was noted in seconds for the single attempt. The persons who were not able to complete the test in first attempt or had deviations from the colored path were asked to rest for 5 mins and again perform the test.

NWT

For narrow walk, participant was asked to walk a 4-meter distance walkway at their usual pace within a 15-cm-wide path marked on floor with black colored tape and time taken to complete the distance was recorded by the stopwatch. Participants were instructed to walk keeping their feet within the taped lines.

Figure-of-8 walk test (F8WT)

Participant were instructed to walk at their usual pace on a figure-of-8 pattern drawn (5 ft) apart drawn with black tape on the floor. The participant started the walk with their normal walking speed from the centre of figure-of-8 and completed the walk at centre of figure-of-8 pattern. Time taken to complete the figure-of-8 colored pattern was recorded by the stopwatch.

OWT

Participant were asked to walk a 7-m course at her usual walking pace and stepping over 2 obstacles of different height. One obstacle was 6 cm tall and 2 cm wide rectangular (6×2 cm) and was positioned 2 meters from

the starting line, and the other obstacle was 30 cm tall and 2 cm wide rectangular (30×2 cm) and was positioned 4 meters from the starting line. Participants were instructed to get past obstacles without touching them and time taken to complete this task was recorded.

NGS

The participants were asked to walk at their comfortable walking speed on a 10-m walkway. Initial and last meter of walkway was not included in calculating gait speed to minimize the acceleration and deceleration effect of gait. Time taken to complete central effective 8-m walkway was noted and gait speed was calculated.

Statistical analysis

The data analysis is done by GraphpadInstat 3.1 software. Descriptive statistics are stated as mean and standard deviations. Students t test was used to compare baseline characteristics between pre-menopausal and post-menopausal groups. Statistical significance level is set at $p<0.05$.

RESULTS

Table 1 shows descriptive characteristics of premenopausal and postmenopausal women in the age group of 40-60 years. Participants were assessed in premenopausal group (n=76) and postmenopausal group (n=69) for age, BMI, self-reported walking, BMI and physical performance tests for dynamic balance.

Age

The mean age in premenopausal group was 42.85±3.66 years with 50th median percentile of 41 years, whereas in postmenopausal group mean age was 51.30±4.24 with 50th median percentile of 50.

Body mass index (BMI)

Mean body mass index of premenopausal group shows women with normal BMI, whereas postmenopausal group shows overweight range. This showed that BMI tends to increase in postmenopausal women.

Table 1: Descriptive statistical data for premenopausal and postmenopausal women.

Variables	Premenopausal, (n=76)			Postmenopausal, (n=69)		
	Mean±SD	SEM	Median (50th%)	Mean±SD	SEM	Median (50th%)
Age (years)	42.85±3.66	0.42	41.00	51.30±4.24	0.51	50.00
Height (cm)	155.61±6.47	0.74	155.00	150.65±6.17	0.74	151.00
Weight (kg)	61.59±10.55	1.21	61.65	61.97±9.89	1.19	60.60
BMI (kg/m^2)	24.54±4.50	0.51	25.20	27.42±3.81	0.45	27.10
Self-reported walking (mins)	24.53±13.71	1.57	20.00	24.27±12.07	1.54	20.00

Table 2: Comparison of measures of dynamic balance between premenopausal and postmenopausal group.

Measures of dynamic balance	Premenopausal women, (n=76)			Postmenopausal women, (n=69)			T value	P value
	Mean±SD	SEM	Median (50th%)	Mean±SD	SEM	Median (50th%)		
NWT (sec)	5.73±1.62	0.18	5.50	6.69±2.25	0.27	6.12	2.917	0.0042**
OWT (sec)	7.64±1.20	0.13	7.49	9.02±1.19	0.23	8.77	5.129	<0.0001***
F8WT (sec)	11.04±3.64	0.41	9.19	13.13±4.71	0.56	11.95	2.962	0.0036**
GS (m/s)	1.09±0.15	0.017	1.085	1.01±0.17	0.02	0.98	2.898	0.0044**
Bone density	-1.78±0.65	0.07	-1.70	-2.12±0.60	0.07	-2.20	3.190	0.0018**

P values significance level set at $p<0.05$, *Significant, **Highly significant, ***Extremely significant, ¶ footnotes, NWT-Narrow walk test, F8WT-Figure of 8 walk test, OWT-Obstacle walk test, GS-Gait speed.

Self-reported walking

Self-reported walking in premenopausal and postmenopausal group is showed approximately 25 mins of walking other than their household and ADLs in both the groups.

NWT

Time taken to complete the NWT measured in second was significantly increased ($p=0.0042$) in postmenopausal women as compared to premenopausal women.

OWT

The mean time taken for completing the OWT in secs was increased in postmenopausal women when compared with premenopausal women, showing significance level of $p<0.0001$ which is extremely significant when compared between the groups. This showed that the, walking speed decreases in post-menopausal women when they were challenged with different obstacles.

F8WT

Mean time taken for completing F8WT test in sec also significantly increased (p=0.0036) in post-menopausal group when compared with pre-menopausal group.

NGS

NGS was significantly decreased with p=0.0044 in postmenopausal group when compared to premenopausal group.

Bone density

The mean values of bone density measured at calcaneus showed osteopenia in premenopausal group and osteoporosis in post-menopausal women showing that bone density in women significantly decreases (p=0.0018) with menopause status.

DISCUSSION

The present study was aimed to assess and compare dynamic balance and bone density in premenopausal and postmenopausal females in the age-group of 40-60 years of age. The result of the present study suggested that performance based dynamic balance and bone density were significantly decreased in postmenopausal women when compared to premenopausal women. In this study, challenging dynamic balance performance test were used such as NWT, which required a greater medio-lateral stability to walk in tandem pattern on a line, OWT which measured the ability to walk into our environment with obstacles around and participant required to adopt different strategies to overcome obstacles and figure-of-8 pattern gave an insight of straight and curved walking which is more apt measure of dynamic balance and mobility in community setting.[37] GS was also assessed as this was a requirement of daily activities.[6,28]

The results of the present study are in accordance with the study done by Cheng et al and Sowers et al where they found that the balance performance was decreased in postmenopausal women when compared to premenopausal women. This study evaluated static balance performance in the middle-age women (43-57 years) using one-legged standing with eyes open and closed.[29] Sowers et al also longitudinally studied physical function and walking ability of pre-and peri-menopause females and menopause over a period of 5 year of the same participants using performance-based measures like gait speed, stair climbing, forward reach test and sit-to-stand.[30] He found that gait speed was decreased over a period of 5 years, suggesting women with menopause were more vulnerable for decline in physical performance. There are very few comparative studies reported in literature with respect to pre- and postmenopausal status.[15,31] Also, most of the studies focused more on evaluation of balance in older adults.[21,22,32]

Nolan et al studied age-related changes in balance and mobility measures with the timed-up-and-go test, step test, forward and lateral reach test in men aged 30-80 years and found that the significant decline in balance and mobility started around the 60 years of age in men.[22] In the present study, significant decline in balance ability was seen in postmenopausal group which had a mean age of 52 years, this may suggested that decline in balance performance started early in females and this decline can be attributable to the musculoskeletal and bone changes related with menopause in women as compared to men of the same age group.

A significant increase in time to complete the 15 cm wide narrow walk way at their preferred speed was noted in the postmenopausal group when compared with premenopausal group. Bandinelli et al evaluated fast narrow corridor walking (15 cm wide) in individuals of 65-74 years of age and recorded mean values of 3.63±1.4 for females and 2.54±1.2 sec for males.[27] Cook et al assessed fast narrow corridor walking test and fast 7-meter obstacle walking and found mean speed of 1.39 m/s and 0.47 m/s respectively in adults less than 65 years of age and found greatest percentage of walking velocity decrease in narrow corridor walk test.[18] In present study, middle-age females were asked to walk at their preferred speed for the mobility tests and found significant decrease in walking speed in NWT (0.59 m/s) in post-menopausal group as compared to premenopausal group (0.69 m/s) and, also in OWT (0.77 m/s) in postmenopausal group when compared to premenopausal group (0.91 m/s). According to Bandinelli, time taken to complete 10m obstacle walk pathway in OWT at normal preferred speed was 6.89±0.41, the speed was 1.45 m/s. When compared with the normal obstacle walk speed, in present study we used 7 m walkway two obstacles in between the pathway and found that both premenopausal and postmenopausal group have decreased speed.

Our results were also similar to the study conducted by Isles et al where they evaluated dynamic balance control in 20-80 years of age in women in age. They evaluated timed up and go test, step test, functional reach test and lateral reach test and found that decrease in balance performance starts from the fourth decade of women's life. They suggested that clinical balance tests can be used to screen women aged 40-60 years to detect impaired balance risk if they fall outside the normal values for age and to decrease falls risk in later life.[5] Similarly in the present study also, it was found that walking speed starts to decrease from fourth decade.

Figure-of-8 walking speed was also found to be affected in postmenopausal women when compared to premenopausal. Brach et al stated that if F8WT times exceeds 8 seconds then it accounts for impaired balance skills for adults greater than 65 years of age.[21] In the present study the time taken to complete the F8WT was 11 sec in premenopausal group and 13 secs in postmenopausal group, which may suggest impaired

balance, but the age group was between 40-60 years. Figure-of-8 walking is a perfect community walking trials to evaluate dynamic balance and mobility, which requires straight and curved walking along a narrow path.[6] Shkuratova evaluated healthy young subjects aged 20 years for figure-of-8 walking at preferred speed and found the normative value to be 0.91±8.82 m/s and for gait speed to be 1.23±0.21 m/s.[28] In our study, both premenopausal and post-menopausal group showed decrease in walking speed for these tasks, however walking speeds were significantly less in postmenopausal group. Liu-Ambrose et al also studied post-menopausal women above the age of 64 years and used F8WT as a tool for dynamic balance and found decrease speed in postmenopausal women.[15] As aging affects balance ability, in our study we evaluated middle-aged women to see whether balance is affected where aging effects are not so prominent.

The studies done by Olchowik et al, Cangussu et al, Liaw et al, Choy et al also supports our study, but they studied post-urography to assess the dynamic balance control in women and concluded that postural stability is decreased in postmenopausal group.[7,33,34,35] Cunha-Henriques and Nitz et al suggested that there is a significant decline in medio-lateral postural stability in women that occurs in between their forties and sixties years and more in postmenopausal women which can be the main cause of imbalance, so screening of postural instability should be performed routinely in this age-group.[31,35,36]

GS was reduced in both the groups in present study, but there more significant decrease in GS in postmenopausal group when compare to premenopausal group. However, in a study done by Saionara et al and Cheng et al found that there was no significant difference between premenopausal and postmenopausal women for GS.[35]

Bone density evaluation showed premenopausal group had osteopenia (T-score-1.78) as compared to postmenopausal group which showed osteoporosis (Tscore-2.12), when assessed by the quantitative ultrasound machine. Neelam et al suggested that bone loss starts to occur more early in women and noted high prevalence of osteoporosis in peri- and postmenopausal women after measuring bone density at postero-anterior lumbar spine and femur by densitometer.[11] Mittal et al also studied bone studied measure done density with DEXA scan and their results are similar to our study.[37]

Khadilkar have reported one of the factors responsible for decrease in balance performance in postmenopausal women could be decrease in bone strength and associated decrease in muscle strength and flexibility in postmenopausal women. Also, estrogens have an effect on multiple musculoskeletal sites along with the neuromuscular system, so menopause estrogen deficiency can affect postural instability.[8,10] Therefore, balance and bone density assessment in the early and late middle age can give insight of these impairments. Treatment strategies such as dynamic balance retraining which includes complex challenging walking tasks and bone strengthening exercises which are easy to administer in community settings should be integrated into the management of early post-menopausal women treatment.

Obesity is also known to affect the balance ability. The subject participated in our study in postmenopausal group were in overweight category and pre-menopausal were in the normal category. However, we didn't come across any obese participant with BMI greater than thirty. Aging also strongly affects balance ability, as age increases our balance ability tends to decrease because of many reasons. We tried to minimize the effect of age by selecting a shorter range of middle age-group. In our study we included women with irregular periods, hot flushes, mood swings which are characteristics of perimenopausal period, into premenopausal group. As such, premenopausal and peri-menopausal period overlaps each other in the age-group of 40-60 years. So perimenopausal were categorized into pre-menopausal group and those have normal cessation of period for one year were categorized into postmenopausal group.

Limitations

Premenopausal and perimenopausal status of the women in the age-group of 40-60 years usually overlaps so women who experienced various peri-menopausal symptoms were also included in pre-menopausal group. Daily physical activity in the present study was assessed by approximate self-reported walking time, which the participant doing on a single day excluding her household and ADLs, but different physical activities other than walking which women were performing at their daily household/recreational work not taken into consideration, which may affect balance abilities. Participants were not categorized separately as per their BMI status whether normal weight or overweight within the group.

CONCLUSION

The present study suggests that dynamic balance is significantly reduced in postmenopausal women when compared to pre-menopausal women in middle-age group. Also, bone density is significantly decreased in postmenopausal women when screened and measured by ultrasound bone densitometer at calcaneus, suggesting bone loss occurs at more rapid rate after menopause as compared to premenopausal period. Therefore, assessment of balance and treatment strategies to improve dynamic balance and bone strength which would decrease future fall risk should be incorporated from the start of fourth decade of age in women.

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REFERENCES

1. Shumway Cook A, Woollacott, M. Control of posture and balance. In Motor Control: Theory and Practical Applications. 2nd Edition. Baltimore: Lippincott Williams and Wilkins. 2006.
2. Available at: https://www.who.int/news-room/fact-sheets/detail/falls. Accessed on 10 January 2021.
3. Pitchai P, Dedhia HB, Bhandari N, Krishnan D, John D'Souza NR, Bellara JM. Prevalence, risk factors, circumstances for falls and level of functional independence among geriatric population-A descriptive study. Indian J Public Health. 2019;63(1):21-2.
4. Joseph A, Kumar D, Bagavandas M. A review of epidemiology of fall among elderly in India. Indian J Community Med. 2019;44(2):166-8.
5. Isles RC, Choy NLL, Steer M, Nitz JC. Normal values of balance tests in women aged 20-80. J Am Geraitr Society. 2004;52(8):1367-72.
6. Hess R, Brach J. Walking skill can be assessed in older adults: Validity of Figure 0f 8 walk test. Physical Therapy. 2010;90(1):89-99.
7. Olchowik G, Czwalik A, Kowalczyk B. The changes in postural stability of women in early old age. J Nutr Health Aging. 2020;24(7):739-44.
8. Suvarna Khadilkar. Musculoskeletal disorders and Menopause. J Obstret Gynaecol India. 2019;69:94-103.
9. Saionara MA da Camara. Menopausal status and Physical Performance in middle-age women: A cross-sectional Community Based study in North-east Brazil. Plos One. 2015;e-0119480.
10. Dmitriy B, Eija L, Taija F, Katja K, Urho K, Pauliina A et al. Physical Performance in relation to menopause status and physical activity. J N Am Menopause Society. 2011;25(12):1432-41.
11. Aggarwal N, Raveendran A, Khandelwal N, Sen RK, Thakur JS, Dhaliwal LK et al. Prevalence and related risk factors of osteoporosis in peri- and postmenopausal Indian Women. J Mid-Life Health. 2011;2(2):81-5.
12. Ibeneme SC, Ekanem C, Ezuma A, Iloanusi N, Lasebikan NN, Lasebikan OA, Oboh OE. Walking balance is mediated by muscle strength and bone mineral density in postmenopausal women: An Observational study. BMC Musculoskeletal Disorders. 2018;19(84).
13. Frost ML, Balake GM, Fogelman I. Quantitative Ultrasound and Bone Mineral Density are equally strongly associated with risk factors for Osteoporosis. J Bone Mineral Res. 2017;16:2.
14. Khazzani H, Allali F, Bennani L, Ichchou L, EI Mansouri L, Abourazzak FE et al. The relationship between physical performance measures, bone mineral density, falls, and the risk of peripheral fracture: a cross-sectional analysis. BMC Public Health. 2009;9(297).
15. Liu- Ambrose T, Eng JJ, Khan KM, Carter ND, McKay HA. Older women with osteoporosis have increased postural sway and weaker quadriceps strength than counterparts with normal bone mass: Overlooked determinant of fracture risk ? J Gerontol Biol Sci Med Sci. 2003;58(9):M862-66.
16. Polambaro K, Hack L, Mangione K, Barr AE, Newton RA, Magri F et al. Gait Variability detects Women in Early Post menopause With Low Bone Mineral Density. Physical Therapy. 2009;89(12):1315-26.
17. Schraders K, Zatta G, Kruger M, Coad J, Weber J, Brough L, Thomson J. Quantitative Ultrasound and Dual X-Ray Absorptimetry as Indicators of Bone Mineral Density in Young Women and Nutritional Factors affecting it. Nutrients. 2019;12(1):30.
18. Shumway Cook Guralnik JM, Phillips CL, Coppin AK, Ciol MA, Bandinelli S, Ferrucci L. Age-associated decline in complex walking task performance: the walking InCHIANTI toolkit. J Am Geriatr Society. 2007;55(1):58-65.
19. Means K. The Obstacle course: A tool for the Assessment of Functional Balance and Mobility in the elderly. J Rehabil Res Dev. 1996;33(4):413-28.
20. Muir-Hunter SW, Wittwer JE. Dual task testing to predict falls in community-dwelling older adults: A systematic review. Physiotherapy. 2016;102(1):29-40.
21. Brach J, Lowry K, Perera S, Honyak V, Wert D, Studenski SA et al. Improving motor control in walking: a randomized clinical trail in older adults with subclinical walking difficulty. Arch Physcial Med Rehabil. 2015;96(3):388-94.
22. Nolan M, Nitz J, Choy NL, Illing S. Age-related changes in musculoskeletal function, balance and mobility measures in men aged 30-80 years. Aging Male. 2010;13(3):194-201.
23. Fujita K, Kaburagi H, Nimura A, Miyamoto T, Wakabayashi Y, Seki Y et al. Lower grip strength and dynamic body balance in women with distal radial fractures. Osteoporosis Int. 2019;30(5):949-56.
24. Patel K, Coppin A, Manini T, Bandinelli S, Ferrucci L, Guralnik JM. Midlife Physical Activity and Mobility in Older Age: The InCHANTI Study. Am J Preventive Med. 2006;31(3):217-24.
25. Vasold KL, Parks AC, Phelan DML, Pontiflex MB, Pivarnik JM. Reliability and Validity of Commercially Available Low-Cost Bioelectrical Impredance Analysis. Int J Sport Nutrit Exercise Met. 2019;29:406-10.
26. Wang O, Nicholson PHF, Timonen J, Alen M, Moilanen P, Suominen H et al. Monitoring Bone growth using Quantitative Ultrasound in comparison with DXA and pQCT. J Clin Densitometry. 2008;11(2):295-301.
27. Bandinelli S, Pozzi M, Lauretani F, Phillips C, Shumway-Cook A, Guralnik JM et al. Adding challenge to performance-based tests of walking: the Walking InCHIANTI Toolkit (WIT). Am J Phys Med Rehabil. 2006;85:986-91 .

28. Shkuratova N, Morris M, Huxham F. Effects of age on balance control during walking. Archieves of Phys Med Rehabil. 2004;85(4):582-8.
29. Cheng MH, Wang SJ, Yang FY, Wang PH, Fuh JL. Menopause and physical performance – a community based cross-sectional study. Menopause. 2009;16(5):892-6.
30. Mary Fran A, Kristin T, Mary J, Aimee E, Bin N, John R. Physical Functioning and Menopause states. Obstetr Gynecol. 2007:110(6):1290-6.
31. Cunha-Henriques S, Costa-Paiva L, Pinto-Neto AM, Fonsechi-Carvesan G, Nanni L, Morais SS. Postmenopausal women with Osteoporosis and Musculoskeletal status: A Comparative Cross-sectional study. J Clin Med Res. 2011;3(4):168-76.
32. Bragin I, Nair V, Verghese J. Epidemiology of Tandem Gait Abnormalities in Aging. Neurology. 2014;82(10).
33. Cangussu LM, Neto JN, Nahas EAP, Rodriques Barral ABC, de Araujo Buttros D, Uemura G. Evaluation of postural balance in postmenopausal women and its relationship with bone miberal density- a cross sectional study. BMC Musculoskeletal Disorders. 2012;13(2).
34. Liaw MY, Chen CL, Pei YC, Leong CP, Lau YC. Comparison of the static balance and dynamic balance performance in young, middle-aged and elderly healthy people. Chang Gung Med J. 2009;32(3):297-304.
35. Choy NL, Brauer S, Nitz J. Changes in postural stability in women aged 20-80 years. J Gerontol: Series A. 2003;58(6):M525-30.
36. Nitz JC, Low Choy NL, Isles RC. Medial-lateral postural stability in community-dwelling women over 40 years of age. Clin Rehabil. 2003;17(7):765-7.
37. Mittal S, Kumar A, Gupta RK, Kapoor S, Gulati P, Shukla DK. Compariosn of Bone Mineral Density and its variables between premenopausal and postmenopausal women. J Obstet Gynaecol Inida. 2011;61(2):200-4.

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