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ORIGINAL ARTICLE

Assessment of Short Physical Performance Battery in Postmenopausal Women in Relation to Bone Mineral Density

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Abstract

Background: **Postmenopausal osteoporosis is one of the extreme combined musculoskeletal conditions. It may result from physical inactivity, so encouragement of physical activity is very important to avert osteoporosis.**

Aim: **Assessment of short physical performance battery (SPPB) in postmenopausal women in relation to bone mineral density (BMD) by applying Dual Energy radiography Absorptiometry.**

Patients and methods: **This research contained 90 postmenopausal females between 45 and 70 years (three groups) 30 osteoporotic, 30 osteopenic, and 30 control. The short physical performance battery (SPPB) test was applied to define lower limp performance. Through chair stand test (CST), gait speed test (GST), and balance test (BT). Measurement of BMD at the lumbar and neck of the femur by dual-energy radiography absorptiometry (DXA). The study was conducted in the Rheumatology and Rehabilitation Department of Bab El Sharia University Hospital.**

Results: **There was a favorable association among physical performance with BMD lumbar and femoral neck in postmenopausal women. Among osteopenic postmenopausal women, GST, CST, and whole SPPB scores were positively correlated only for BMD of the neck femur. In addition, among osteopenic females as well as the whole study population, each BT, GST, and whole SPPB scores were negatively correlated for age and duration of menopause. Also, CST was negatively correlated with the duration of menopause.**

Conclusion: **SPPB showed a strong correlation with different degrees of BMD in osteoporotic and osteopenic postmenopausal women and is strongly appreciated to assess lower extremity performance in postmenopausal women.**

Keywords: Bone mineral density, Postmenopausal women, Short physical performance battery

1. Introduction

Physical function assessment in the elderly is important because it provides an index for biological age, health, and quality of life. Early functional decline can be detected through it. This makes it possible to step in and stop further dependency loss and deterioration.[1]

Postmenopausal women are more frequently affected by osteoporosis, a musculoskeletal condition that is described as a reduction in bone mineral thickness and power together with an increased danger of fractures. Osteoporosis is often called as 'the silent robber of the bone' as it progresses asymptomatically.[2]

Osteopenia refers to subnormal bone mineralization; the dual-energy radiography absorptiometry (DXA) scan is the gold criterion for diagnosing osteoporosis and is frequently depends on the T-score which defined as the figure of standard deflections over or beneath bone mineral density (BMD) of a young wholesome from the same gender and ethnicity. T-score is classified into 3 sets: normal (>-1), osteopenia (-2.5 into -1), and osteoporosis (<-2.5).[3]

Postmenopausal women had a greater rate of osteoporosis, up to 47.8%. Considering the significance of having current guidelines for the treatment of osteoporosis,[4] bone health can be improved and maintained by engaging in physical activity.

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Mechanical loading and activity of daily living are required to promote bone intensity; thus, physical activity level and exercise are key lifestyle factors to maintain bone mass during life.[5]

A systematic study found that powerful exercise is an efficient way to enhance and preserving bone bulk in women after menopause. Multi-combined exercises such as power, respiratory, high-effect, and weight-bearing exercises may assist in preventing age-processing bone loss.[6]

Physical performance assessment by Short Physical Performance Battery (SPPB) is applied between society-residence people, nursing home inhabitants, and hospitalized patients. SPPB evaluates balance, strength, and gait to assess physical performance. It consists of three tests: normal gait speed; lower limb force and power demonstrated by standing and sitting in a chair five times; and standing static balance in three postures.[1,7]

2. Patient and methods

This study included 90 postmenopausal women aged from 45 to 70 years, were collected from the clinic of Rheumatology and Rehabilitation of Bab El Sharia Hospital- Al-Azhar University, Cairo. Participants were split into 3 sets: Set (1), 30 osteoporotic women; Set (2), 30 osteopenic women; and Set (3), 30 women with normal BMD.

2.1. Methods

All patients asked for: Full medical history regarding to name, age, duration of menopause, history of fracture and fall, family history of osteoporosis or fragility fracture, current medications-induced osteoporosis. Full general examination including BMI. Assessment of BMD via DXA scan (GE Medical Systems – Lunar Madison, WI USA 41170). Lumbar vertebrae and femoral neck BMD were measured by gram/cm^2±SD per site; T-score was measured for each site which measures BMD plus standard deviation above or below for race and sex.

2.2. Assessment of short physical performance battery (SPPB)

SPPB was evaluated utilizing standardized techniques for instructions, placement, and scoring. It involves the following tests: chair stand (CST), gait speed (GST), and balance (BT). Standing balance tests (BT) formed of full tandem, semi-tandem, and stand side-by-side, while the time was recorded till the patient moved or 10 s had passed. Patients were asked to gait 4 m at their ordinary step twice to test GST. A pretest was administered before the chair stand test (CST), where patients had to flex their arms over their chest (without using the armrests) and standing from the seat. If the previous test was successful, the patients were instructed to complete 5 times of standing on the chair as rapidly as possible. The time was recorded (in seconds) from the first sit to the fifth attitude.[1]

Every test is graded from 0 (unable for completion of the test) to 4° (the best performance), and the full SPPB score is scaled from 0 (the least effective performance) to 12° (performance is excellent). The level of test performance is classified into three classes or four categories of outcomes; three categories: 0–6° (performance is poor), 7–9° (performance is moderate), and 10–12° (performance is good); while 4 categories: 0–3° (performance is extremely low), 4–6° (performance is low), 7–9° (performance is average), and 10–12° (performance is ideal).[8,9]

2.3. Inclusion criteria

Postmenopausal Egyptian women with ages ranged from 45 to 70 years.

2.4. Exclusion criteria

Patients older than 70 years., smoking, patients on drugs affecting BMD, endocrinal diseases, autoimmune diseases, malignancy, CKD, congenital skeletal deformity, inherited neuromuscular disease.

2.5. Patient approval and morality

Each step has been approved with the participants' informed written approval. And every step was taken in accordance with the regulations of the Al-Azhar University Morality Council.

2.6. Interpretation of statistics

Data collected were examined by SPSS Inc.'s statistical program for social sciences, copy 23.0, Chicago, Illinois, USA. When the distribution of the quantitative data was normative, the average ± SD, and spans were reported. Conversely, non-parameterized data have been presented as the average and the interquartile range (IQR). Qualitative factors can also be seen as % and numbers. By the Shapiro-Wilk Test and Kolmogorov-Smirnov tests, data were checked for normality and if a single or both groups of parameters were sidetracked, the level of relationship across the two was evaluated via Spearman's rank correlation coefficient (Rs).

Table 1. Comparison of the three sets regarding BMD and T-score of femoral neck and lumbar vertebrae.

T-score & BMD	Osteoporotic set ($N = 30$)	Osteopenic set ($N = 30$)	Control Set ($N = 30$)	F-test	*P*-value	Tukey's test		
						*P*1	*P*2	*P*3
T-score femoral neck								
Mean ± SD	−2.05 ± 1.02	−1.33 ± 0.72	−0.25 ± 0.68	36.799	<0.001**	<0.001**	<0.001**	<0.001**
Range	−3.7 : 1.1	−2.4 : 0.4	−1 : 1					
BMD femoral neck g/cm^2								
Mean ± SD	0.72 ± 0.08	0.82 ± 0.09	0.95 ± 0.08	56.912	<0.001**	<0.001**	<0.001**	<0.001**
Range	0.532–0.874	0.695–1.025	0.848–1.098					
BMD lumbar spine g/cm^2								
Mean ± SD	0.83 ± 0.07	1.03 ± 0.11	1.19 ± 0.09	109.279	<0.001**	<0.001**	<0.001**	<0.001**
Range	0.727–1.08	0.892–1.29	1.069–1.397					
T-score lumbar spine								
Mean ± SD	−2.99 ± 0.62	−1.25 ± 0.93	0.06 ± 0.78	113.194	<0.001**	<0.001**	<0.001**	<0.001**
Range	−3.8: −1	−2.4 : 0.9	−1 : 1.8					

*P*1: Comparison between Osteoporotic set and Osteopenic set.
*P*2: Comparison among Osteoporotic set and control set.
*P*3: Comparison among Osteopenic set and control set.

3. Results

Table 1 showed that the T-score at the femoral neck has a great statistically considerable variation among sets (*P* value < 0.001). The control set has the highest value (−0.25 ± 0.68) followed by osteopenic group (−1.33 ± 0.72) while the least value was found in osteoporotic group (−2.05 ± 1.02).

In addition BMD of femoral neck showed a highly statistically considerable variation between sets (*P* < 0.001). The control set has the highest value (0.95 ± 0.08) followed by osteopenic set (0.82 ± 0.09). Whilst the osteoporotic set has the least value (0.72 ± 0.08).

While T-score of lumbar vertebrae showed a highly statistically noteworthy variance among sets (*P*-value <0.001). The control set has the highest value (0.06 ± 0.78) followed by osteopenic group (−1.25 ± 0.93) while osteoporotic group has the lowest value (−2.99 ± 0.62).

As well BMD at lumbar spine showed a highly statistically considerable difference among sets (*P* -value <0.001). The control set got the highest value (1.19 ± 0.09) followed by osteopenic group (1.03 ± 0.11) however the least value was found in osteoporotic group (0.83 ± 0.07) (Figs. 1 and 2).

Table 2 displays a statistically significant variation among groups according to SPPB in BT score, GST score and CST score (*P* < 0.05). The control set got the highest value (2.77 ± 1.14), followed by osteopenic set (2.50 ± 1.31), however osteoporotic group has the least value (2.00 ± 1.49) among three measurements.

While BT score has a statistically considerable variation midst osteoporotic and control sets (*P* value = 0.027).

In addition GST score has a highly statistically significant difference among osteoporotic and control groups (*P* value < 0.001).

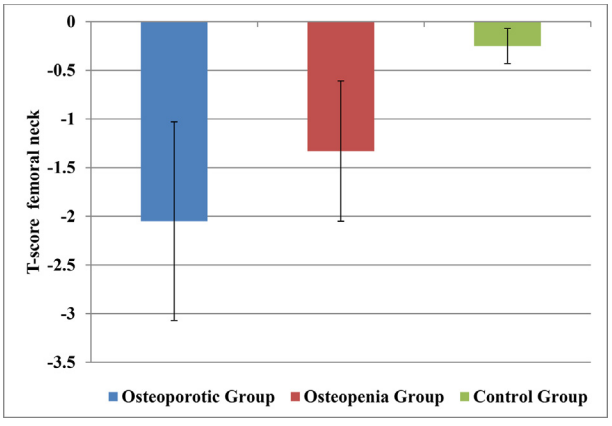

Fig. 1. Comparison between three groups according to T-score femoral neck.

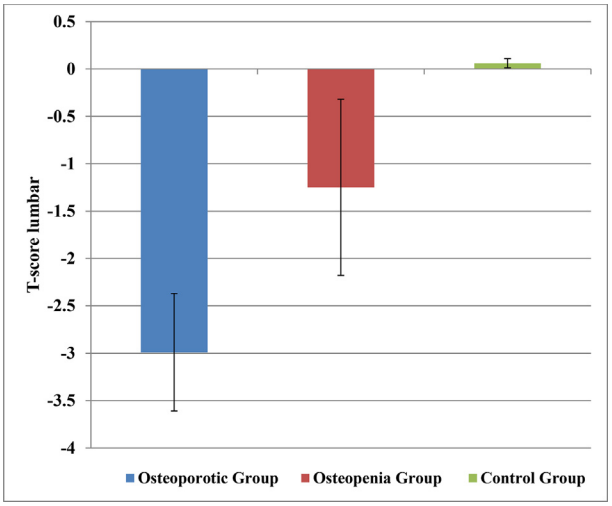

Fig. 2. Comparison of the three sets according to T-score lumbar.

Table 2. Comparison among three sets based on short physical performance battery.

Short physical performance battery	Osteoporotic set ($N = 30$)	Osteopenic set ($N = 30$)	Control set ($N = 30$)	H-test	*P*-value	Mann-Whitney		
						*P*1	*P*2	*P*3
Balance score								
Mean ± SD	2.00 ± 1.49	2.50 ± 1.31	2.77 ± 1.14	2.621	0.048*	0.145	0.027*	0.435
Median (IQR)	2 (1–4)	3 (1–4)	3 (2–4)					
Range	0–4	0–4	1–4					
Gait speed score								
Mean ± SD	1.70 ± 0.84	1.97 ± 0.81	2.37 ± 0.61	5.850	0.004*	0.178	<0.001**	0.045*
Median (IQR)	2 (1–2)	2 (2–2)	2 (2–3)					
Range	0–3	0–3	1–3					
Chair stand score								
Mean ± SD	0.80 ± 0.71	1.00 ± 0.53	1.20 ± 0.76	2.936	0.047*	0.254	0.024*	0.254
Median (IQR)	1 (0–1)	1 (1–1)	1 (1–2)					
Range	0–2	0–2	0–3					

Table 3. Comparison among the three sets based on the total score of the short physical performance battery.

Total score of short physical performance battery	Osteoporotic group ($n = 30$)	Osteopenic group ($n = 30$)	Control group ($n = 30$)	H-test	*P*-value	Mann-Whitney		
						*P*1	*P*2	*P*3
SPPB score								
Mean ± SD	4.50 ± 2.03	5.47 ± 1.93	6.33 ± 2.09	6.208	0.003*	0.067	<0.001**	0.100
Median (IQR)	5 (2–6)	6 (4–7)	6 (5–8)					
Range	0–7	1–9	3–9					

Furthermore GST score has a statistically noteworthy difference midst the osteopenic and control groups (*P* value = 0.045).

As well CST score has a statistically considerable variation among osteoporotic and control sets (*P* value = 0.024).

Table 3 showed that SPPB total score has a statistically considerable variation among sets (*P* value = 0.003). The control group got the highest value (6.33 ± 2.09) followed by osteopenic group (5.47 ± 1.93) whereas the least value was found in osteoporotic group (4.50 ± 2.03).

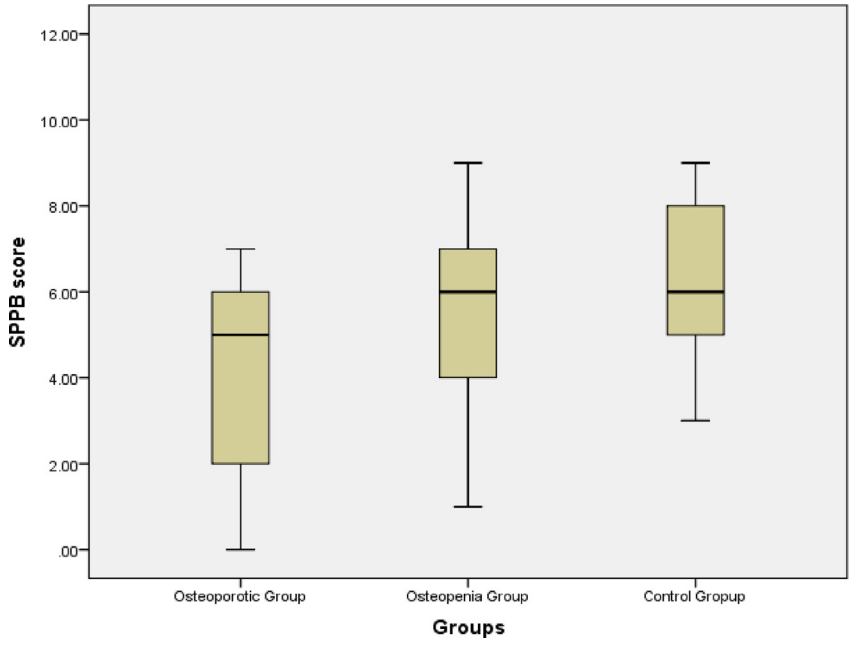

Fig. 3. Box plot between three groups according to SPPB score.

Table 4. Comparison among the three sets regarding level of performance of short physical performance battery.

Level of SPPB score	Osteoporotic set No. (%)	Osteopenic set No. (%)	Control set No. (%)	Chi-square test		
				*P*1	*P*2	*P*3
0-3 Disability	10 (33.3%)	6 (20.0%)	3 (10.0%)	$\chi^2 = 3.393$; $P = 0.183$	$\chi^2 = 7.359$; $P = 0.025$*	$\chi^2 2 = 1.204$; $P = 0.548$
4-6 Poor performance	15 (50.0%)	13 (43.3%)	14 (46.7%)			
7-9 Moderate performance	5 (16.7%)	11 (36.7%)	13 (43.3%)			
Total	30 (100.0%)	30 (100.0%)	30 (100.0%)			

Also SPPB total score showed a highly statistically considerable difference among osteoporotic and control sets (*P* value < 0.001) (Fig. 3).

Table 4 displays that the level of SPPB score has a statistically considerable variation among sets ($P < 0.05$). The moderate performance was increased in control set (43.3%) then comes osteopenic set (36.7%) whereas the least value was found in osteoporotic group (16.7%) (Fig. 4).

Table 5 showed that BT score has a great statistically considerable (*P* value < 0.001) passive association (Rs = −0.454) with age (in years), statistically noteworthy (*P* value = 0.002) passive association (Rs = −0.329) with duration of menopause (in years), statistically significant positive correlation with BMD lumbar, T-score lumbar, BMD neck of femur, and T-score neck of femur (*P* value = 0.019, Rs = 0.248) (*P* value = 0.016, Rs = 0.253) (*P* value = 0.024, Rs = 0.238) (*P* value = 0.239, Rs = 0.023), respectively.

Regarding GST it has a statistically noteworthy (*P* value = 0.002) passive association (Rs = −0.326) with age (years), major statistically considerable (*P* value < 0.001) passive association (Rs = −0.340) with duration of menopause (years), statistically significant positive association with BMD and T-score of lumbar (*P* value = 0.045, Rs = 0.212) (*P* value = 0.048, Rs = 0.209), respectively, while it has a major statistically considerable positive association with BMD neck and T-score neck (*P* value < 0.001, Rs = 0.429) (*P* value < 0.001, Rs = 0.391), respectively.

In regards CST it has a statistically noteworthy (*P* value = 0.040) passive association (Rs = −0.216) with duration of menopause (years), statistically significant positive association with BMD and T-score of neck (*P* value = 0.002, Rs = 0.327) (*P* value = 0.004, Rs = 0.304), respectively.

While SPPB total score it has a great statistically considerable (*P* value < 0.001) passive association

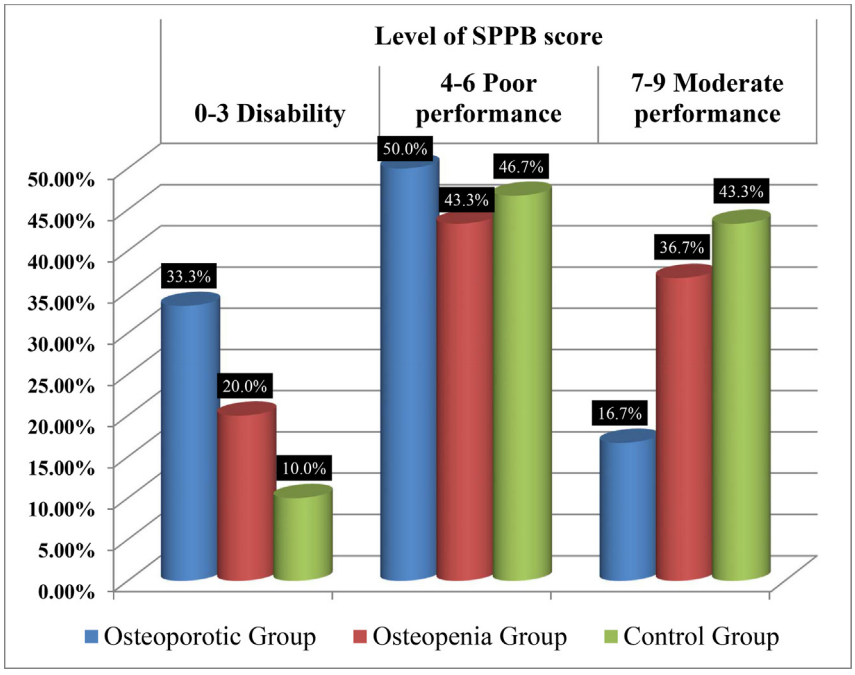

Fig. 4. Comparison between three groups according to level of SPPB score.

Table 5. Relationship of short physical performance battery with different parameters in all participants through Spearman's rank correlation coefficient (Rs).

Parameters	Short physical performance battery			
	Balance score	Gait speed score	Chair stand score	SPPB score
Age (years)				
Rs	−0.454	−0.326	−0.163	−0.475
P value	<0.001**	0.002*	0.124	<0.001**
Duration of menopause (years)				
Rs	−0.329	−0.340	−0.216	−0.413
P value	0.002*	<0.001**	0.040*	<0.001**
BMI (kg/m^2)				
Rs	−0.110	0.006	−0.020	−0.086
P-value	0.303	0.955	0.854	0.418
BMD lumbar (g/cm^2)				
Rs	0.248	0.212	0.189	0.266
P-value	0.019*	0.045*	0.075	0.011*
T-score lumbar				
Rs	0.253	0.209	0.189	0.268
P value	0.016*	0.048*	0.074	0.011*
BMD neck (g/cm^2)				
Rs	0.238	0.429	0.327	0.387
P value	0.024*	<0.001**	0.002*	<0.001**
T-score neck				
Rs	0.239	0.391	0.304	0.362
P value	0.023*	<0.001**	0.004*	<0.001**

(Rs = −0.475) with age (years) and duration of menopause (years) (*P* value < 0.001, Rs = −0.475) (*P* value < 0.001, Rs = −0.413), respectively. Also it had a statistically considerable positive association with BMD and T-score of lumbar (*P* value = 0.011, Rs = 0.266) (*P* value = 0.011, Rs = 0.268), respectively. Additionally, it has a major statistically considerable favorable association with BMD neck and T-score neck (*P* value < 0.001, Rs = 0.387) (*P* value < 0.001, Rs = 0.362), respectively (Figs. 5–8).

4. Discussion

Evaluation of SPPB in senior subjects to detect lower-extremity muscular function and level of balance has been extensively used as a sign of disability and hospitalization and as a tool for interventions in frail elderly Perracini and colleagues.[10]

In our study we assessed SPPB in postmenopausal women in relation to BMD of lumbar and femoral neck.

Previous research has revealed that in postmenopausal women, BMD, and muscular performance both declined with age Kim and colleagues.[11]

In our study, females in osteoporotic group (4.50 ± 2.03) had significantly lower total score of SPPB when compared with control group (*P* < 0.001). Similarly, Dai and colleagues[12] have applied the SPPB test to assess muscular performance in 247 postmenopausal females and reported that muscular performance of lower-extremity was reduced in osteoporotic postmenopausal women when compared with normal postmenopausal females.[12]

Regarding balance test (BT), our study demonstrated a considerable difference among sets (*P* value = 048). The control group got the highest value, then comes osteopenic group, and the

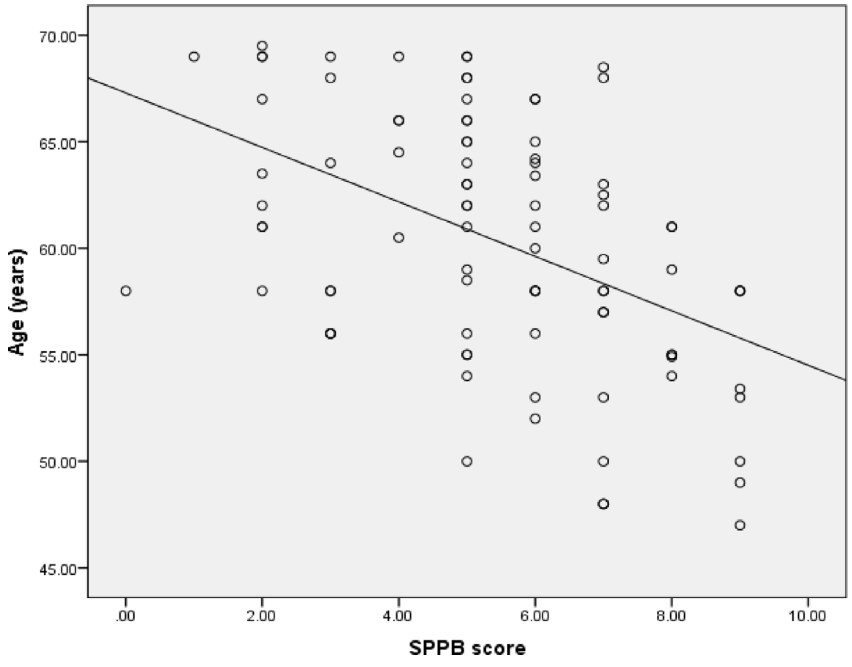

Fig. 5. Scatter plot between SPPB score and age (years).

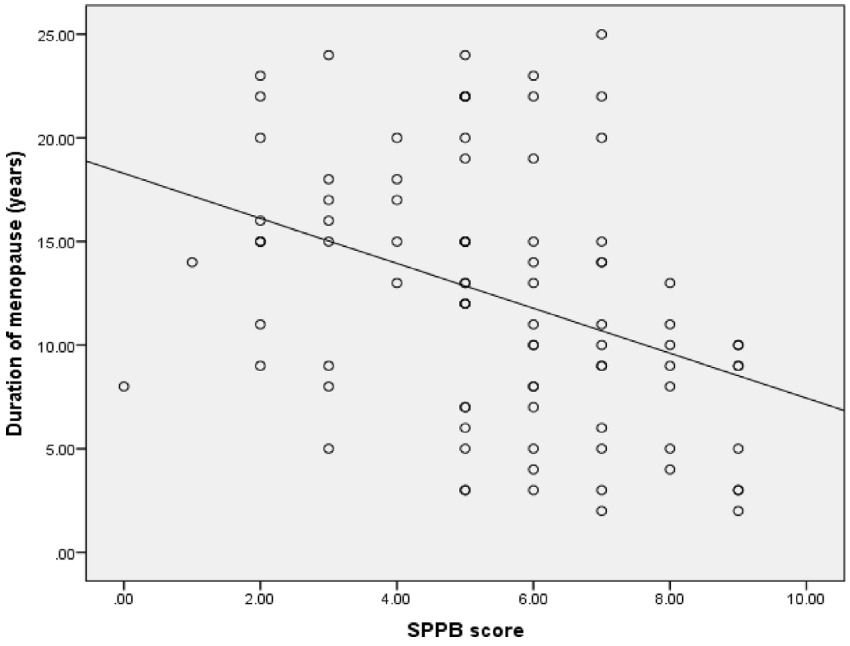

Fig. 6. Scatter plot between SPPB score and duration of menopause (years).

osteoporotic group got the least value. Also, no significant difference among osteopenic group and other groups. This is conforms to Dai and colleagues,[12] who stated that BT was reduced in osteoporotic set in comparison to osteopenic and control groups. While no considerable variation among osteopenic and control groups. However, they reported a significantly lower BT in osteoporosis set in comparison to osteopenia set Dai and colleagues.[12] The difference can be attributed to difference in female characteristics when compared with osteopenic group in Dai and colleagues study.

As regard chair sit-to-stand test (CST), our study reported a significant difference among groups (*P*

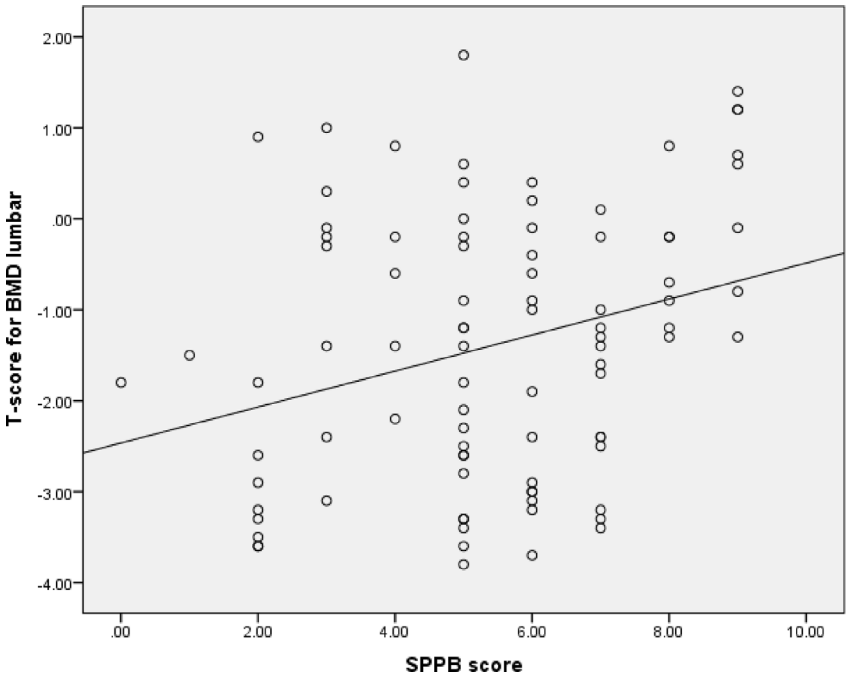

Fig. 7. Scatter plot between SPPB score and T-score lumbar.

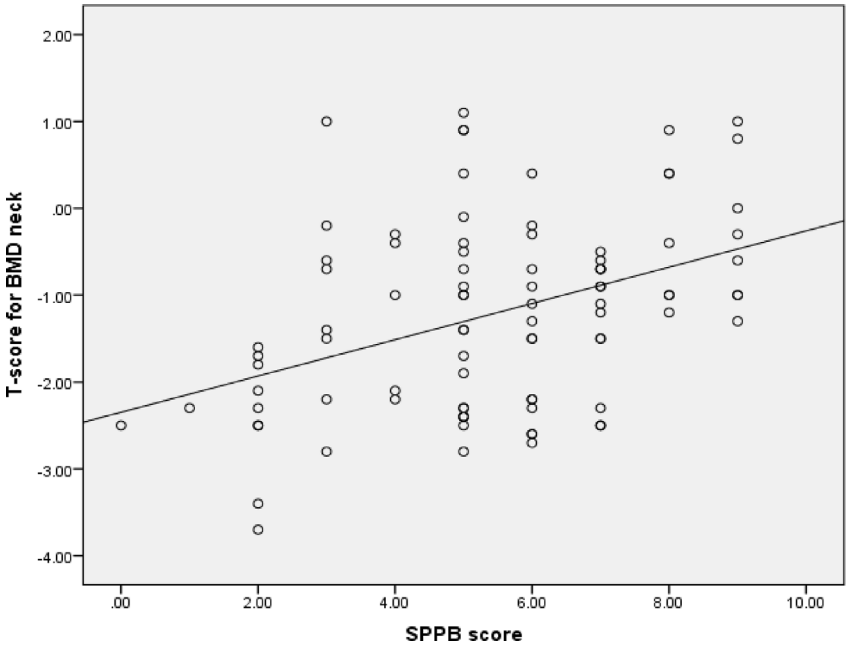

Fig. 8. Scatter plot between SPPB score and T-score neck.

value = 0.047). The normal set got the perfect value, followed by osteopenic group, and the lowest value was found in osteoporotic group. Also, no statistically considerable difference among the osteopenic group with another group. Like our finding, Dai and colleagues[12] reported that CST was reduced in osteoporotic set in comparison to osteopenic and control set. While no considerable variation among osteopenic and control sets. However, Dai and colleagues[12] noted a significantly lower CST in osteoporosis set in comparison to osteopenia set.

As for gait speed test (GST), in our study a noteworthy variation among sets was present (*P* value = 0.004). The control set got the highest value, then comes the osteopenic set, but the osteoporotic set got the least value. Moreover, there was a significantly lower GST in osteopenic group when compared with control group. Whilst no considerable change in GST was reported among osteoporotic and osteopenic sets. In line with our study, Dai and colleagues[12] reported that GST was reduced in osteoporosis set in comparison to osteopenia and control groups, but there was no considerable variation among osteopenic and normal sets. However, Dai and colleagues[12] stated that GST was significantly lower in the osteoporotic group when compared with osteopenia group.[12]

According to the total score of SPPB, a significant difference was reported in our study among groups (*P* value = 0.003). The normal set got the perfect value (6.33 ± 2.09) followed by osteopenic group (5.47 ± 1.93), while the osteoporotic group got the least value (4.50 ± 2.03). Also no statistically considerable change among osteopenic and another sets. Regarding level of SPPB score a considerable variation among sets was noted. The increased frequency of moderate performance was reported in control group (43.3%) followed by osteopenic group (36.7%) while osteoporotic group has the lowest value (16.7%). Supporting our finding, Sadeghi and colleagues[13] have studied if balance and active mobility alone anticipate BMD for women after menopause. Measurement of femoral and lumbar BMD has been done by (DXA). Subjects were divided in 3 sets (osteoporotic: $N = 20$; osteopenic: $N = 20$; healthy BMD: $N = 20$) based on DXA T-scores. Patients completed the rising-and-moving test, walking at normal gait for the 6-m test and standing on one leg all recorded by stopwatch. They reported that shorter time to hold one leg on standing and longer rising-and-moving time predicted low BMD Sadeghi and colleagues.[13]

In our study, the association between BMD (lumbar and neck of femur along with their T scores) and muscle performance were analyzed among the whole study population. Our outcomes stated that the BT, GST, and SPPB whole scores were favorably correlated with BMD. (lumbar and neck of femur BMD) and their T scores. While CST was favorably correlated only with BMD of the neck femur. This agrees with Dai and colleagues[12] who reported association between BMD lumbar and

neck of femur, and muscular performance of lower-extremity, also found that the BT, GST, and whole scores of SPPB were favorably associated with lumbar and femoral neck BMD. However, CST was favorably correlated with all BMD lumbar, neck of femur, and whole hip BMD score Dai and colleagues.[12]

On the contrary, El Hakeem and colleagues[14] reported no correlation among CST, GST and BMD of the neck femur and total hip in old females. The cause for this conflict among our results and the findings recorded by El Hakeem and colleagues[14] can be attributed to the older age of their study population.

Furthermore, Shin and colleagues[15] found that the rising-and-moving test, walking at normal gait for the 8-m test, standing on one leg test and CST no longer linked to lumbar BMD in women after menopause. Compared with patients from our research, The subjects in Shin's research appeared younger (age range: 46.6–66 years in Shin study vs. 47–69.5 in our study), suggesting that patients from Shin's study performed physically better than our patients did.

4.1. Conclusion

SPPB showed a strong correlation with different degrees of BMD in osteoporotic and osteopenic postmenopausal women and is strongly appreciated to assess lower limb performance in women after menopause. Our study reported a favorable correlation among physical performance with BMD lumbar and neck of femur in women after menopause. While among osteopenic postmenopausal women, GST, CST, and whole scores of SPPB were favorably correlated only with BMD of femoral neck.

Authorship

Each author added something to the article in conceptualization, methodology, data organizing, validation, writing -review and editing, resources as well as visualization, and investigation.

Conflicts of interest

Statement disclosing a conflict of interest: The writers affirm that they have no documented interpersonal or financial disputes that might have seemed to have an impact on the research presented in this study.

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