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RESEARCH ARTICLE

EFFECTS OF BODY WEIGHT SUPPORTED TREADMILL TRAINING ON BONE MINERAL DENSITY IN STROKE PATIENTS

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ABSTRACT

Objective- To determine the effects of body weight supported treadmill training on bone mineral density in stroke patients. ***Method-*** A scoping review of observational, experimental, randomized control trail, cross sectional studies were performed. SCOPUS, Google Scholar, EBSCO and PubMed were searched using the terms bone mineral density and stroke. Preferred reporting items for scoping review, PRISMA-Scoping review checklist was used to examine the section of each report. ***Result-*** A Total of 47 studies were identified of which 8 were published between 2001-2023 and were included in the study. Two studies were included in our study showed positive effect of body weight supported treadmill training on bone mineral density. Furthermore, few studies which were included showed us BMD of the affected side was not different from normal side. Affected and unaffected side BMD were not significantly different. ***Conclusion-*** This study demonstrates that there is significant effect of body weight supported treadmill training on bone mineral density.

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INTRODUCTION

A stroke is a neurological disorder in which there is insufficient blood and oxygen flow to certain areas of the brain (O'Sullivan, 2019). There are two primary pathophysiology's that could cause this: either a plaque blocks an artery in the skull, or the artery bursts from too much pressure. The immediate result of oxygen starvation is the necrosis of brain matter and tissue (O'Sullivan, 2019).Stroke warning signs include sudden paralysis; weakness or numbness in the face, arm or leg, especially one side; sudden blurred or decreased vision in one or both eyes; sudden confusion, trouble in speaking or understanding; trouble in walking, dizziness, loss of balance and coordination; sudden severe headache. Patients with stroke who are immobilized and restricted in weight- bearing have more risk of osteoporosis and disuse muscle atrophy (O'Sullivan, 2019). Stroke is frequently followed by extensive bone loss, precipitating the increased fracture risk in survivors. Bone loss starts in the days immediately following vascular brain injury and progressively accrues until the 3rd–4th month after stroke (Carda, 2009). Stroke patients are at high risk for fractures because of osteoporosis and falls. Stroke survivors are indeed prone to frequent falls because of reduced strength, balance, visual problems, epilepsy. Osteoporosis after stroke is known to occur more frequently on the paretic side and is more likely to involve the upper rather than lower extremities. Poststroke complications include Altered level of consciousness like coma, decreased level of arousal may occur within extensive brain damage. Disorders of speech and language, characterized by an impairment of language comprehension, formulation, and use. Seizures are common in acute phase; late-onset seizure can also occur several months after stroke; Dysphagia is inability to swallow or difficulty in swallowing, most of the patients presents with multiple problems that include: drooling, difficulty in ingesting food, dehydration. Disturbances in bladder function is most common seen in acute phase. Urinary incontinence occurs due to bladder hyperreflexia or hyporeflexia, loss of sphincter control. Osteoporosis, a bone disease characterized by a loss of bone mass per unit volume (1). Bone mineral density is one of the most important factors to measure bone quality (10). This results from decreased physical activity, changes in protein nutrition, hormonal deficiency, which leads to low BMD. Patients with stroke who are immobilized and restricted in weight- bearing have more risk of osteoporosis and disuse muscle atrophy (O'Sullivan, 2019). Stroke is frequently followed by extensive bone loss, precipitating the increased fracture risk in survivors. Bone loss starts in the days immediately following vascular brain injury and progressively accrues until the 3rd–4th month after stroke (Carda et al., 2009). Stroke patients are at high risk for fractures because of osteoporosis and falls. Stroke survivors are indeed prone to frequent falls because of reduced strength, balance, visual problems, epilepsy. Osteoporosis after stroke is known to occur more frequently on the paretic side and is more likely to involve the upper rather than lower extremities. Osteoporosis may make fragile bones, leading to higher mortality or morbidity rates and a lower quality of life (Zhang et al., 2021). Motor changes including posture, mobility, and balance post-stroke contribute to bone loss and therefore lead to increase risk of bone fracture. Bone mineral density is a useful indicator for bone resorption and is useful to identify patients at risk of post-stroke bone fracture (Huo, 2016). The clinical significance of osteoporosis after stroke is that it results in skeletal fragility and in an increased risk of fractures. Fractures are usually the triggering event that focuses attention on bone health of stroke survivors (Carda et al., 2009). Bone resorption occurs rapidly after stroke, with a later and slower loss of bone in subsequent years. "Regional" osteoporosis of a

limb occurs rapidly after it is immobilized. More widespread skeletal osteoporosis can occur with prolonged immobilization, but after a stroke the paretic side is markedly affected (Poole et al., 2002). Osteoporosis is defined by a T-score of no more than −2.5 (Haseltine et al., 2021). According to recent articles treadmill exercise improves gait velocity secondary to increased stride length, and to a lesser extent, cadence. Treadmill exercise improves the dynamic stability (Patterson et al., 2008). Treadmill walking training performed with increased speed may be more beneficial than increasing the incline in patients with stroke (13).

METHODOLOGY

Literature search strategy: A comprehensive literature search was conducted to identify relevant studies on the effects of treadmill training on the bone mineral density in stroke. Multiple databases, including Pubmed, Scopus, Web of Science, and CINHAL were systematically queried. The search was conducted with a combination of keywords and medical subjects headings (MeSH) terms, such as "bone mineral density", "bone mineral density in stroke", "treadmill training in bone mineral density ". Boolean operators (AND, OR) were used to refine the search results.

Screening and Data Extraction: The selection criteria were set to identify the studies with the effects of body weight supported treadmill training on bone mineral density in stroke, including the following:

Patients with stroke: Outcome variables were parameters of bone mineral density (Bone mineral densitometer).

- Tinette Poma Scale.
- Modified Ashworth Scale.

In a total of forty-seven studies, ten duplicate studies were removed and the remaining thirty-seven studies were then entered into the screening process. All the studies selection was performed by the author. Finally, we identified eight studies that met our review objectives and all inclusion criteria has been shown in (Fig. 1)

RESULTS

Ethical Consideration: This scoping review included only summary or statistics from previously published studies therefore this study did not require a review or approval by institutional review board.

Limitations: Number of relevant studies were less; we recommend that more studies which focus on interventional treadmill training to be analyzed in future.

Conclusion: Our study mapped the effect of treadmill training on bone mineral density. we also found that treadmill training improves the gait pattern and the bone mineral density.

DISCUSSION

The aim of this review was to evaluate the effect of treadmill training and body weight support, individually or in combination, for walking after stroke. We included 50 participants in this intervention. Overall, in recent studies we found that female, but not male, stroke patients have lower BMD than population controls. Our results confirm the findings of previous studies about women and provide for the first-time information about the relationship in men (Jørgensen, 2001). Shoko merit Yamada's article suggests that Our results strongly imply

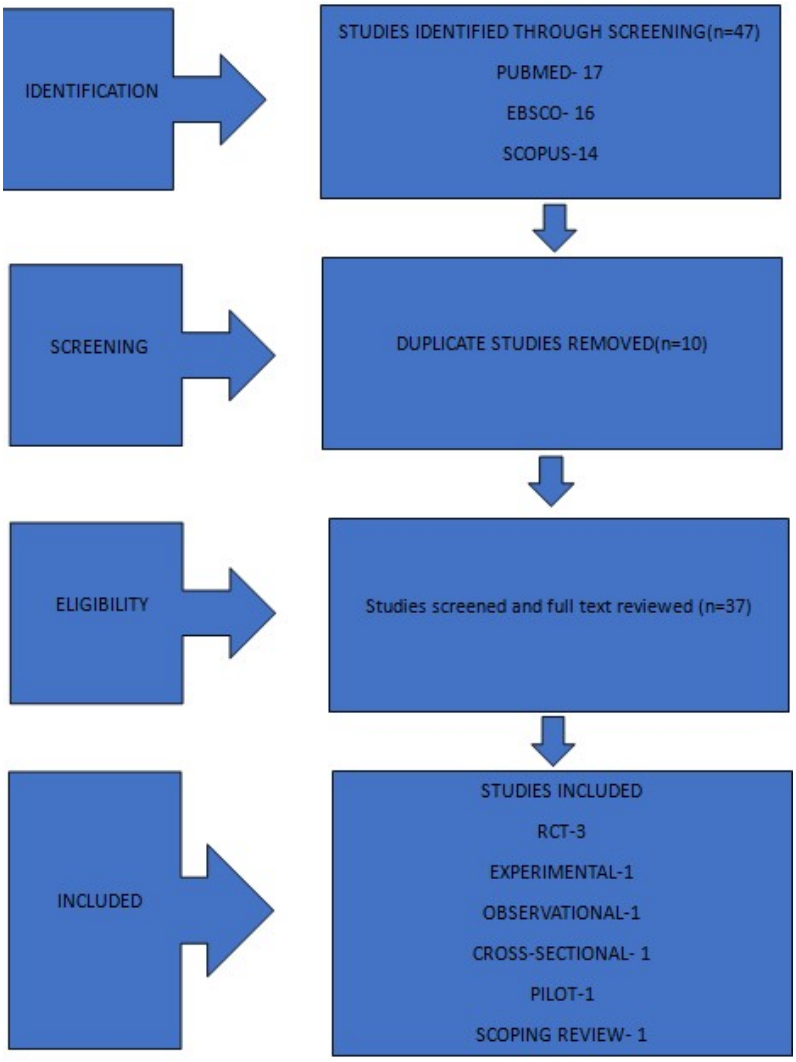

Figure 1. Selection process for inclusion of studies in the scoping review

Table 1.

AUTHOR	TITLE OF STUDY	POPULATION	RESULT	CONCLUSION
Lone Jorgensen et al, 2000	Bone mineral density in acute stroke patient	Sixty-three stroke participants and 188 control subjects from general population were included.	the bmd at femoral neck in the female stroke patientswas 8% lower than in the control subjects (p= 0.007). in men, no difference in BMD between the stroke patients and their controls was found. Women with BMD values in the lowest quartile had a higher risk of stroke than women with BMD values in the highest quartile (OR 4.8), and the probability value for linear trend over the quartiles was statistically significant (P= 0.003). the OR for stroke increased 1.9 per SD (0.13g/cm^2) reduction in BMD, and association between low BMD and stroke in women remained significant when the analysis was adjusted for potential confounders.	Female, but not male, stroke patients have lower BMD than population controls. Low BMD may predict stroke in women.
Michael E. Mussolino et al, 2002	Bone mineral density and stroke	Total 3402 black and white subjects were included.	Results were evaluated to determine the relative risk (RR) for stroke per 1- SD decrease in BMD, after controlling for age at baseline, smoking status, alcohol consumption, history of diabetes, history of heart disease, education, body mass index, recreational physicalactivity and blood pressure medication. InCox proportional-hazards analysis, incidence of stroke was not associated with thedecrease in BMD in any of 3 race-sex groups: white men(RR, 1.01;95% CI, 0.86 to 1.19; P=0.88), white women(RR, 1.13; 95% CI, 0.93 to 1.38; P=0.21), or blacks(RR, 0.93; 95% CI, 0.72 to 1.21; P=0.60). No associationbetween BMD and stroke mortality was found (RR, 1.03; 95% CI, 0.86 to 1.23;P= 0.77).	In a large national study, no significant associations of BMD and stroke mortality were found for whites or blacks.
Shawanna L. Patterson et al,	Effect of treadmill exercise training on spatial and temporal gait parameters in subjects with chronic stroke: A preliminary report	Thirty- nine hemiparetic subjects were included.	T-EX improves gait velocity secondary to increased stride length, and to a lesser extent, cadence. This increased velocity is carried over to multiple functionally relevant conditions. Additionally, T-EX improves indexes of dynamic stability without changing symmetry. Further studies are needed to optimize the translation of treadmill gait training to overground walking. Additionally, specific training for symmetry may have a stronger effect on improvements in spatiotemporal gait parameters, such as cadence or step length, thereby creating more efficient gait.	Limitations of this study include the large range of the subjects' timed and distance walks, the absence of a control group, and limited details about gait biomechanics. Further studies with a control group are needed to evaluate the specificity of the effect of T-EX and the effects of T-EX on angular kinematics and torques of the lower-limb joints. These evaluations will help us determine whether the increased velocity is secondary to changes across the different joints in each limb and evaluate the emergence of other compensatory strategies.
Li Zhang et al, 2020	Stroke and osteoporosis: a Taiwan cohort study	A total of 7550 newly diagnosed patientswho had a stroke were enrolled during 1996–2010	During the follow-up period, osteoporosis developed in 1537 patients who had a stroke and in 5830 patients who had not had a stroke. The incidence of osteoporosis for cohorts with and without stroke was 32.97 and 14.28 per 1000 person-years, respectively. After controlling for covariates, the overall risk of osteoporosis was 1.82-fold higher in the stroke group than in the non-stroke group. The relative osteoporosis risk contributed by stroke had apparently greater impact among male gender and younger age groups	History of stroke is a risk factor for osteoporosis in Taiwan. Much attention to stroke-targeted treatment modalities might minimise adverse outcomes of osteoporosis.
Phyo Kyaw Myint et al, 2013	Bone mineral density and incidence of stroke	A total of 14 290 men and women 42 to 82 years old were included.	In 14 290 participants (mean follow-up of 9.3 years; total person-years 132 574), there were 599 incident strokes. Participants in the lowest 10% of the calcaneum broadband ultrasound attenuation distribution had an increased stroke risk (hazard ratio 1.41; 95% confidence intervals, 1.02–1.94) compared with those in the top 30% of the distribution after adjustments. A decrease of ~1 standard deviation in broadband ultrasound attenuation (20 db/MHz) was associated with a 17% increase in relative risk of stroke (95% confidence intervals, 5%–30%).Meta-analysis of 4 studies (25 760 participants, 1237 cases of stroke) found that for every decrease in 1 standard deviation in bone mineral density, there was an increased risk of incident stroke among women (pooled relative risk 1.22; 95% confidence intervals, 1.09–1.37; I^2=0%, 3 studies) but not in men (pooled relative risk 1.05; 95% confidence intervals, 0.94–1.17; I^2=0%, 2 studies).	Bone mineral density predicts total stroke risk. The evidence is stronger in women with regard to the continuous relationship
P. Potin et al, 2022	Loss of bone mineral density in hemiplegic patients after stroke: Prospective single-center study	18 patients were hemiplegic patients were included.		The occurrence of hemiplegia following a stroke is accompanied by a significant decrease in BMD, from the first year, measurable by DXA, and predominantly in the hip on the affected side.

that immobilization affects the progression of BMD loss in bedridden patients, and that weight loading and physical stimulation to the bone must be an essential factor. In both males and females, the lumbar BMD was increased at 2 months after patients became immobile, while the femoral BMD was decreased at 2 months (Yamada, 2022). P. Potin's study demonstrated that the occurrence of hemiplegia following a stroke is accompanied by a significant decrease in BMD, from the first year, measurable by DXA, and predominantly in the hip on the affected side (Potin, 2022). Olga Lazoura article suggest that Hemiplegia leads to reduction of BMD in the paretic extremities, especially during the first months of immobilization. Stroke mainly occurs in the elderly population, where osteoporosis often is already present, and an accelerated bone loss in the paretic limb may be an important factor for the increased prevalence of osteoporotic fractures in these patients (Bae et al., 2024). Bae, Yeong Kyun MD[a]study suggests that Older adult patients with stroke diagnosed with osteopenia had significantly decreased BMD in both paretic and non-paretic femoral necks, even if they were able to walk independently. Therefore, although elderly stroke patients with osteopenia can walk independently, more active osteoporosis treatment is needed to prevent bone loss and fractures, including improvement in daily living function and bilateral lower extremity strength training (Bae, 2024). Recent long-term, prospective studies have illustrated a highly nonuniform pattern of bone changes after stroke. In general, there is significant bone loss on the paretic side, which is greatest in those patients with the most severe functional deficits. In some patients, bone loss in the paretic arm during the first year after stroke is the equivalent of >20 yrs of bone loss in healthy individuals of comparable age. Bone density in the nonparetic upper limb can increase after stroke, consistent with an increase in habitual use of the nonparetic hand. Bone density in the paretic lower limb can decrease by >10% in <1 yr, with smaller decreases being typical for the nonparetic lower limb. L. Jorgensen'sstudy provides clear evidence that lack of mobility and weight-bearing early after stroke is an important factor for the greater bone loss in the paretic leg, but that relearning to walk within the first 2 months after stroke, even with the support of another person, may reduce the bone loss after immobilization.

CONCLUSION

As a conclusion, we have found that there is a significant change in bone mineral density in stroke patients.

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