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Parathormone and Serum Calcium Response to Moderate Intensity Treadmill Exercise in Elderly: A Randomized Controlled Trial

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Abstract:

Purpose: The study aimed to investigate the impact of moderate intensity treadmill exercise parathyroid hormone and serum calcium levels to in elderly women.

Methods: Fifty three elderly women with mean age of 64.45±3.06 were allocated into experimental and control groups at random. In the experimental group, participants received moderate intensity treadmill exercise calculated at 60% to 70% of their predetermined maximum heart rate, 3 sessions per week for 12 weeks, while control group received no treatment. Biochemistry analysis was used to measure parathyroid hormone and calcium levels prior and after the intervention.

Results: The results of statistical analysis revealed a considerable decrease in parathyroid hormone with a substantial increase in serum calcium in the experimental group (p value < 0.05) with non-significant difference in control group after intervention.

Conclusion: Moderate aerobic training reduces parathyroid hormone level while increasing serum calcium concentration in the elderly that lower risk of post-menopausal osteoporosis

Keywords: Calcium, Elderly, Osteoporosis, Parathyroid hormone, Aerobic Exercise.

1. Introduction

Aging is a biologic phenomenon marked by functional decreases over time**.** Bone weakening is one of these aging effects; the ratio of old bone lost to new bone created during the remodeling process gets negative (1).Furthermore, bone strength diminishes disproportionally to bone mass loss resulting in osteoporosis which is a bone fragility disease. Also ovarian function declines in menopausal women, the so-called postmenopausal type of the disease (2).

Calcium is the most important factor in bone mineralization, Serum calcium has been demonstrated to contribute significantly as a biomarker to monitor bone metabolism because it is responsible for many of the material characteristics of bone (3)**.** Calcium homeostasis is regulated by controlling the entry (intestines), exit (kidneys), and storage gates (the skeleton). The parathyroid hormone (PTH) and other hormones create the signal for regulation (4).

Parathyroid hormone plays a major role in bone mineralization, ensuring that the calcium ion concentration in extracellular fluids stays within physiological norms. As an outcome, it is an essential element in maintaining intracellular calcium homeostasis (5). A low degree of mineralization is related with increased bone turnover caused by elevated PTH levels (6).

Exercise alters circulatory calcium and phosphate levels, which influences PTH expression and secretion. PTH, in turn, responds to activity and myokines that are produced during exercise (7). Physical activity has been proposed as a method for increasing bone mass, density, and structural competence. Exercise causes homeostasis to be interrupted. The more intense and extended the exercise activity as a stressor, the higher the disturbance (8). Jumping or resistance exercise at a high intensity has favorable osteogenic effects on bone resorption and formation (9).

Exercise's effects on the bones have generally been studied in pre- and postmenopausal women (10), because women have a higher rate of osteoporosis than males. According to the results of these exercise trials, the combination of high-impact loading exercises and moderate to high intensity resistance training is effective in preventing age-related bone loss in women (11). While the effects of aerobic weight bearing on balance and muscle strength have been reported in the literature, osteoporotic hormonal indices in response to aerobic training has been far less studied in exercise physiology (7). Therefore, this study was conducted to investigate the influence of moderately intense treadmill exercise on parathormone and blood calcium concentrations in the elderly.

2. Materials and Methods

Participants:

Fifty three elderly women were participated in this study; they were recruited from out-patient clinic in Um El-Masryeen General Hospital/Giza /Egypt where the study was conducted. The inclusion criteria were as follows: age range from 60-70 years, post menopause stage with normal calcium blood level and BMI < 30 kg/m^2. Subjects with severe musculoskeletal disease or surgeries affecting the lumbar region and lower limbs, a history of cardiovascular or psychological illnesses, renal disease or hormonal replacement medication were excluded.

This study adopted randomized controlled design with a single blinding. It was blinded to the assessor of the outcomes. The subjects were randomly allocated into two groups: an experimental group that received moderate intensity treadmill exercise and a control group that received no treatment. Sequentially numbered, opaque and sealed envelopes was used for concealing the allocation in which the envelopes receive numbers in advance, and are opened sequentially, only after the participant's name is written on the appropriate envelope by an outside independent person. To avoid a type II error, a preliminary power analysis (power [1-β error probability] =0.8, α=0.05, effect size =0.5) indicated a sample size of 53 for this study, as it generated a reasonable sampling size (12). The progression of participants through the successive stages of the study is described in Figure 1.

Demographic data including age, sex, height, weight, and body mass index (BMI) are shown in table 1. Each participant signed a written informed consent form for participation in the study and for publication of the results. The research protocol was approved by Ethical Committee for scientific research, Faculty of Physical Therapy, Cairo University [No: P.T.REC/012/001572]. The study was conducted following the principles of the Declaration of Helsinki.

Assessment procedure

Snibe device (Maglumi 1000, made in China) for analysis of the Parathyroid hormone (intact PTH); and Biochemistry Analyzer (ROBONIK prietest, made in India) device for analysis of total blood Ca+. Venous blood sample was collected from all women after overnight fasting, before starting the treatment plan and two days after finishing the training program sessions to measure parathyroid hormone and total calcium level.

Pulsometer: (Tunturt TPM-400, made in Japan) was used to detect the pulse rate and arterial oxygen saturation (SPO2) prior and after exercise, and to control exercise intensity within the pre-calculated training heart rate during every exercise session. Digital sphygmomanometer: (Omron, made in Germany) to measure the blood pressure before, and after each exercise training session as a monitoring.

Training procedures:

Experimental group received 3 sessions per week for 12 weeks aerobic training in the form of walking on electronic treadmill with moderate intensity training program. Max. Heart rate was calculated for each subject using age predicted max heart rate equation = 206 - 0.88(age) (13).

Flow Diagram

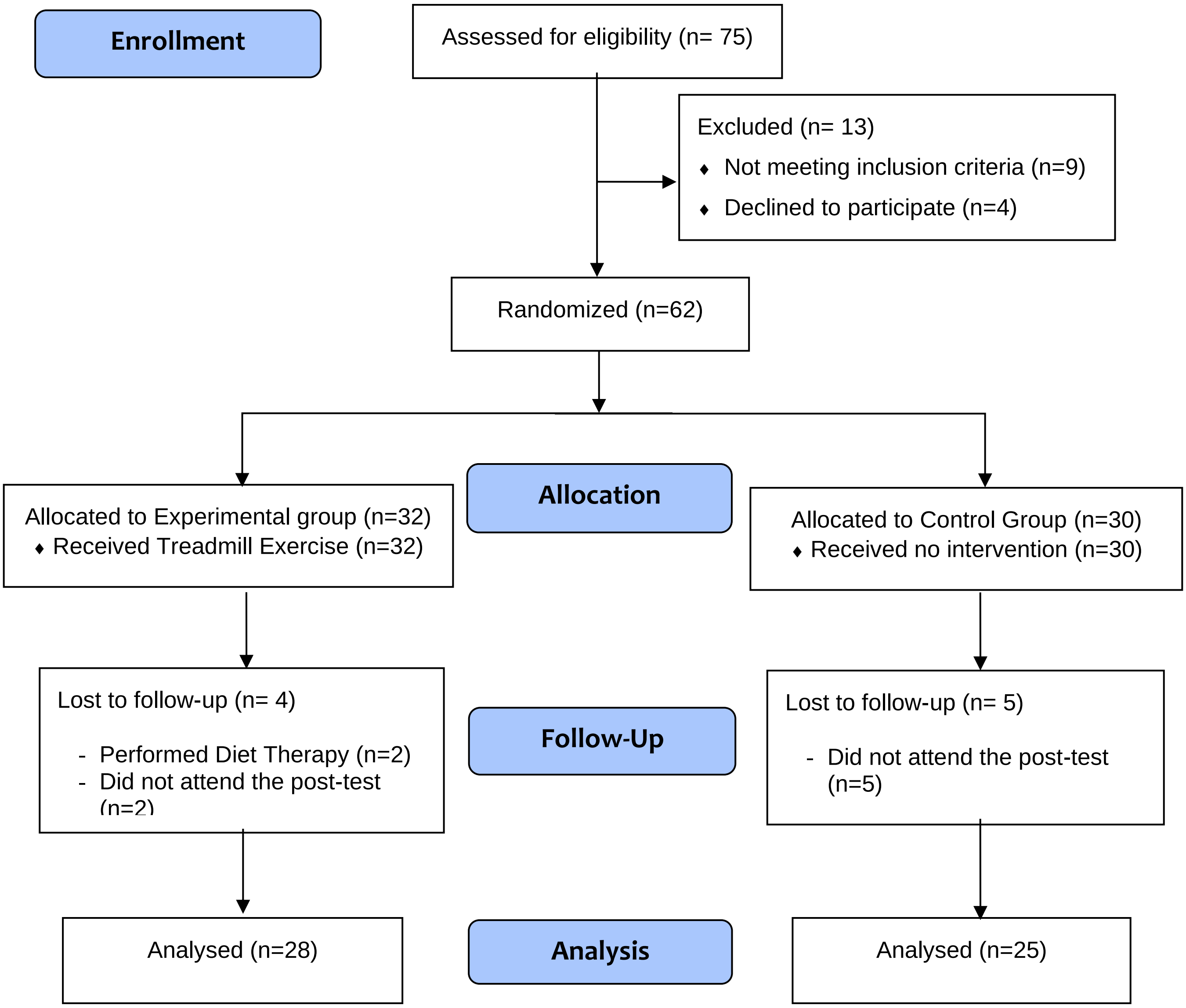

Figure1. Flowchart of the study processes

The exercise intensity had been prescribed as a training heart rate (THR) and calculated according to Karvonen formula as follow:
THR=HR rest + (HR max –HR rest) TF {60-70% (moderate aerobic training)}.
The exercise session was started with warming up at 10% to 20% of their heart rate reserve (HR max –HR rest) for 5 mins; then the speed is gradually increased every 2 mins (14); active phase at which continuous running was performed for 20-25 min , ended by cooling down phase; 5 to 10 minutes of very slow walking to avoid postural hypotension and venous pooling of blood(15).

Data analysis

In this study, un-paired t-test was used to investigate the significant difference between the experimental and control groups regarding age, BMI, THR, PTH and Ca+. The pre- and post-intervention mean values of PTH and Ca+ in each group were compared using a paired t-test. For all statistical measures, the significance level was established at $p < 0.05$. The statistical package for social studies (SPSS) version 20 for Windows was used to run all statistical tests (SPSS, Armonk, NY, IBM Corp.).

3. Results

Regarding age, body mass index, training heart rate; there were non-significant differences between both groups (p> 0.05), as shown in Table 1. The pre experimental mean values of the PTH and Ca+ of both groups were not significantly different (p> 0.05).

Table 1. Demographic and clinical characteristics of subjects in both groups

Variables	Experimental group, n=28 Mean ± SD	Control group, n=25 Mean ± SD	p-value
Age (year)	64.45 ± 3.38	65.01 ± 2.74	0.25
BMI (kg/m^2)	28.98 ± 0.97	28.56 ± 1.02	0.11
THR (beat/min)	120.02 ± 2.09	119.02 ± 2.49	0.09

NS P > 0.05 = non-significant, P = Probability.

On comparing pre and after intervention mean values, the study group's PTH decreased significantly after treatment (p = 0.02) with a percent of change 5.98%; along with a significant increase in the Ca+ (p = 0.02) with percent of change was 0.44%; with non-significant difference in the control group (As shown in Table 2).

Table 2. Statistical Data of the PTH and Ca+ before and after intervention in both groups.

Variables		Experimental group, n=28 Mean ± SD	Control group, n=25 Mean ± SD	p-value
PTH (ng/L)	Pre	31.57 ± 7.68	32.34 ± 7.79	0.59
	Post	29.68 ± 8.22	32.39 ± 7.81	0.001*
	% of change	↓5.98%	↑0.46%	
	p-value	0.02*	0.25	
Ca+ (mg/dl)	Pre	8.92 ± 0.23	8.94 ± 0.23	0.65
	Post	8.96 ± 0.26	8.93 ± 0.24	0.03*
	% of change	↑0.44%	↓0.11%	
	p-value	0.02*	0.45	

4. Discussion

Studies on exercise-induced variations in PTH are inconclusive and the significance of PTH role in the health benefits associated with physical activity has yet to be identified (7). The present study aimed to investigate the effect of moderate aerobic exercise on PTH and serum calcium in elderly women. The result of the current study revealed that 12 weeks of supervised moderate intensity treadmill training produced a significant decrease in the serum parathyroid hormone level by percentage 5.98%, along with a substantial rise in serum calcium level by percentage 0.44% .

Hormones help to maintain the structure and integrity of the bone matrix by controlling the quantity of calcium in the blood. When there is a calcium deficiency in the blood, the parathyroid glands react by secreting parathyroid hormone (PTH). This hormone causes osteoclasts to decompose bone tissue, releasing calcium salts into the bloodstream. The thyroid gland, on the other hand, responds to an increase in blood calcium levels by generating a hormone known calcitonin; It suppresses osteoclast activity, permitting osteoblasts to create bone tissue, in the opposite way that parathyroid hormone does. As a consequence, extra calcium is stored in the matrix of the bone. Both of these hormones' effects are great examples of significant negative feedback loops found in the human body. The bones will not build or function normally if they do not receive appropriate quantities of these key substances (16).

The finding of the present research can be explained; Independent of osteoclastic activity as strenuous endurance exercise increases calcium excretion from the kidney due to diminished tubular reabsorption (7). Given the usual link between PTH secretion and systemic calcium concentrations, calcium concentrations could explain post-exercise variations in PTH. The higher reduction in post-exercise PTH was followed by a proclivity for a further rise in post-exercise Ca+ after intensive activity. It's probable that the magnitude of changes in PTH is determined by the relative changes in Ca+ and phosphate ion (PO4) (17).

The current study comes along with Figueroa et al.,(18) who ended up finding that PTH concentrations declined below baseline after comparing a 60-minute treadmill run at 65 percent of maximal rate of oxygen uptake (exercise) with semi recumbent rest in ten healthy men. However, they found no significant effect on albumin-adjusted calcium concentrations.

The present research is also endorsed by the results of Tartibian et al.,(19) who deduced that PTH was reduced after a 24-week program of exercise and supplements in 79 healthy sedentary postmenopausal women aged between 58-78 years. Serum estrogen, 1,25 Vit D levels, and femoral neck bone mineral density (BMD) measurements all increased, indicating that long-term aerobic exercise training combined with Omega−3 fatty acids supplementation has a synergistic effect in reducing inflammation and increasing BMD in postmenopausal osteoporosis; however, calcium concentration remained constant throughout the 24 week intervention groups .

The result of the current study came in accordance with those of Josse et al.,(20) who noted substantial decrement in blood PTH in the participants who was exercising 5 days a week for 12 weeks and drinking either fat-free milk or iso-energetic carbohydrate immediately after exercise or 1 hour later. The increased dietary calcium intakes resulted in a reduction in PTH, They concluded that heavy and resistive training for the entire body resulted in probable decrease in bone resorption in females following 12 weeks.

Moreover Falk et al.,(21) reported mixed results that PTH levels were same in male adolescents and adult; at rest and during experiment, increasing considerably 5 minutes after activity, decreasing after 60 minutes post-exercise, and returning to resting values within 24 hours.

The current study's findings were reinforced by Sharma-Ghimire et al.,(22) who discovered that in young women, there was no transient increase in PTH in response to transient whole-body vibration and resistive training, but it did exhibit a significant drop after 30 minutes for both treatments. The mechanisms of PTH exercise reactivity are not really recognized, according to their study; which showed that the amount of PTH produced in response to acute physical stimuli varies based on the kind of exercise .

The present research findings were evidenced by Rogers et al.,(23) who observed that transitory elevation in PTH following short resistance training, but a PTH drop 2 h following exercise.

Also Alghadir et al.,(24) affirmed that twelve weeks of moderately intense endurance training has a strong considerable impact on bone formation markers in all bone metabolism attributes, including serum bone-specific alkaline phosphatase (BAP), serum osteocalcin, serum free calcium, and bone mineral density (BMD) in 65 healthy adults, as well as a substantial reduction in bone turnover, which can also aid in the prevention or treatment of bone resorption.

Alghadir et al., (25) also reported that on 100 healthy subjects, moderate aerobic training enhanced BAP, BMD and trace elements like calcium, magnesium, and zinc. They did find, however, that parathyroid glands secrete a higher level of parathormone, which regulates the release of calcium from its reserves into the bloodstream. Along with Chien et al.,(26) who concluded that aerobic mixed with moderate-intensity high-impact exercise was beneficial in restoring BMD decrease in osteopenic postmenopausal women.

The present finding were backed by Hatori et al.,(27) concluded that a treadmill exercise with intensity above the aerobic threshold is safe and effective in preventing postmenopausal bone loss. Low physical activity has been identified as a modifiable potential risk variable for the development of primary hyperparathyroidism in women, and high physical activity during the week was linked to a significantly reduced hazard when compared to a more sedentary lifestyle (28).

On the contrary, the study contradicted the study of Nikander et al.,(10) who found that In children, exercise can considerably improve bone density at loaded areas, but not in adults.. This contradiction may be explained by the difference in sample age in both studies.

Shea et al.,(29) Ca supplement started 1 hour prior exercise and continued during exercise reduced increases in PTH and type I collagen C-terminal telopeptides, indicating that the reduction of Ca throughout activity is the physiological triggering for the rise in PTH. However, the long-term consequences of frequent perturbations in Ca balance all through aerobic activity on BMD are still unknown.

Moghadasi and Siavashpour (30) contradicted the current findings; they claimed that resistance training boosts bone-forming hormones, and that after 3 months of resistance exercise, growth hormone, estrogen, parathyroid hormone, and testosterone were significantly increased in 20 young sedentary women.

Also Bouassida et al.,(5) noted that only high-intensity, long-duration or low-intensity, very long-duration exercise caused a significant increase in PTH concentration, implying that only a minimal intensity and time is required to cause a change in PTH concentration. Short-duration maximum activity and long-duration low-intensity exercise, on the other hand, appear to have little effect on PTH secretion. As a result, they discovered that the initial mineral content of the bones, age, sex, training condition, and other hormonal and metabolic parameters all influence PTH regulation (catecholamines, lactic acid and calcium concentrations).

The current study has some limitations; first, the study just investigated post menopause stage with normal calcium blood level. Second, BMD assessment was not performed so we could not identify direct effect on bone density because we only investigated the change in the hormonal and metabolic parameters so future studies are recommended to investigate such aftereffects. Finally, follow-up study is needed to examine the long-term effect of the current intervention

5. Conclusion

The findings of this research back up the significance of moderate intensity aerobic training in decreasing risk of post-menopausal osteoporosis by decreasing parathyroid hormone serum level and increasing total serum calcium level. Therefore, in a clinical setting, we recommend adding moderate intensity treadmill exercise to geriatric physical therapy programs for elderly.

Conflict of Interests

The authors declare no conflict of interest.

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