Response of Parathyroid Hormone and Blood Calcium Level to Moderate Intensity Aerobic Exercise In Elderly

Amina Fadl Hosny Abozethar, Mariam El-Sayed Mohamed*,Hany Farid Eid Morsy Elsisi*, Walaa ArafaKeshak*****

** Physiotherapist at Egyptian Ministry of Health and Population.

*Assistant professor of Physical Therapy for Cardiovascular/Respiratory Disorder and Geriatrics, Faculty of Physical Therapy, Cairo University.

***Lecturer in Department of BiochemistryFaculty of Medicine, Tanta University.

ABSTRACT

Background: One of the main aging biological changes is bone deterioration which affected more by estrogen deficiency in elderly women, Parathyroid hormone is one of the osteoporotic indicesand a major regulator of bone metabolism and calcium homeostasis, the objective is to determine the response of parathyroid hormone and total calcium level to moderate aerobic training in elderly. **Methods:** Thirty five female subjects were selected from out-patient clinic in Um El-Masryeen General Hospital /Giza/Egypt, Their age ranged between 60 to 70 years with mean age is 64.45, and study was conducted between October 2017 and April 2018. All subjects had participated in moderate intensity aerobic training calculated as 60% to 70% of their predetermined maximum heart rate. The program was applied for three times per week for 12 weeks. Parathyroid hormone and calcium level were measured before and after the training program in laboratory analysis. **Results:** Statistical analysis showed a significant decrease in parathyroid hormone by 5.98% and a significant increase in total calcium level in the blood by 0.44%. **Conclusion:** It was concluded that moderate aerobic training decrease parathyroid hormone and increase total calcium serum level in elderly.

Key words: Calcium, Elderly, Osteoporosis, Parathyroid hormone.

Introduction

Aging is a biological process characterized by time-dependent functional declines [1]. One of these aging effects is bone weakening; the balance between the amounts of old bone removed and new bone formed during the remodeling process become negative. In addition, bone strength declines disproportionally to the decline of bone mass, leads to the bone fragility syndrome known as osteoporosis, Also Decline of ovarian function in women at menopause, Because of this estrogen centric view, the so-called postmenopausal form of

the disease and its therapy with estrogens or selective estrogen receptor modulators has held center stage [2]

The main responsible for skeletal mineralization is calcium. As it is responsible for much of the material properties of bone, It was reported that serum calcium contributes significantly as biomarker to measure bone metabolism [3]. Calcium homeostasis regulated by a set of interacting hormones, including parathyroid hormone (PTH), 1,25-dihydroxyvitamin D [1,25(OH)2D], ionized calcium itself, and their corresponding receptors in the gut, kidney, and bone[4].

Parathyroid hormone is a major regulator of bone metabolism and functions to maintain the calcium-ion concentration of the extracellular fluids within physiological limits. So it is a primary determinant of intracellular calcium homeostasis [5].The high bone turnover associated with elevated PTH levels is characterized by a lower degree of mineralization [6].

Physical activity has been recommended as one strategy for improving the mass, density, and the structural competence of bone [7], High intensity of exercise as jumping or resistive exercise has beneficial osteogenic effects on bon resorption and formation [8].

The effects of exercise on the skeleton have been examined predominantly in pre- and post-menopausal women [9]due to the higher rates of osteoporosis in women than in men. Reviews of these exercise trials indicate that, in women, the combination of high-impact loading exercises and moderate to high intensity resistance training is the most beneficial to prevent age-related bone loss[10].

Since, Aerobic weight bearing exercise training improves balance and muscle strength, and there were few studies that investigated the response of osteoporotic hormonal indices to moderate aerobic training as this intensity of exercise is suitable for elderly women. This study was conducted to determine the response of parathyroid hormone and blood calcium level to moderate intensity aerobic exercise in elderly.

Subject, materials and methods

- *Study design:*

Thirty five 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, and their age ranged was from 60-70 years.

The practical part of the study was carried out in the period between Oct. 2017 and April 2018.

All procedures, risks and benefits were explained to all participants, and informed consents for participation in the study and for publication of the resultswere collected. This study was approved by University Ethics Committee for scientific research [No: P.T.REC/012/001572].

To avoid a type II error, a preliminary power analysis (power [1-β error probability] =0.8, α=0.05, effect size =0.5) determined a sample size of 35 for this study. This effect size was chosen because it yielded a realistic sample size. (11)

Participants:

Subjects were randomly selected and assigned into one experimental group:

Thirty five subjects received moderate intensity aerobic exercise training without any previous hormonal replacement therapy.

The subjects were selectedto be enrolled into this study after they had fulfilled the inclusion criteria of the study; their age ranged between 60-70 years, normal calcium blood level, normal Body mass index equal or less than 30, and in Post menopause stage.

And they were excluded if they have sever musculoskeletal dysfunction that affects lumbar region and lower limb, cardiopulmonary condition, such as uncontrolled hypertension, cardiovascular accident or myocardial infarction within the last 2 months, if they havehypercalcemia (chronic kidney disease or vit. D deficiency), or hyperparathyroidism, or Diabetes mellitus, also obese women that their BMI more than 30 kg/m2, and if they were taking any previous hormonal replacement therapy HRT.

- Evaluative equipment:

Height and weight scale: (Floor type Model ZT-120, made in China) to measure BMI (body mass index).

Digital sphygmomanometer: (Omron, made in Germany) to measure the blood pressure before, and after each exercise training session as a monitoring.

Pulse oximeter: manufactured in (Germany) was used to monitor the pulse rate and SPO2 prior and after exercise, and to control exercise intensity within the precalculated training heart rate during every exercise session.

Snibe device (Maglumi 8000): For analysis of the Parathyroid hormone.

ECO device: For analysis of total blood Ca+.

- Training equipment:

Electronic Treadmill: (MEGA FDX 8000S, made in Germany) It`s speed, inclination and timer are adjustable, and it also provided with control panel to display the exercise parameters. It was used for the training sessions.

- *Measurement Procedures:*

The experimental group was subjected to the all following evaluation procedures:

- Max. Heart rate was calculated for the subject using age predicted max heart rate equation = 206 - 0.88(age) [13].
- The exercise intensity had been prescribed as a training heart rate (THR) based on each subject's Maximal predicted heart rate (HRmaxpred), and resting heart rate (HR rest) obtained from the pulsometer, and calculated according to Karvonen formula as follow: THR=HRrest + (HRmaxpred –HRrest) TF
- (TF) = training fraction, it was 60-70% in moderate aerobic training.
- Venous blood sample was taken from all women before starting the treatment plan to measure parathyroid hormone and total calcium level and stored at −70°c until analysis.

Training procedures:

Program sessions were conducted 3 times per week for 12 weeks aerobic training in the form of walking on electronic treadmill based on moderate aerobic training program.

Training session was conducted as:

1. Warming up exercises for 5-10 minutes in the form of marching in place, Women started the exercise session with warming up exercise at 10% to 20% of their heart rate reserve for 5 mins to allow for conditioning of the body for the exercise [14].
2. Active phase: weight bearing exercise (loading training).

After warming up, continuous running was performed started by walking increased gradually in speed every 2 mins[14] to reach intensity of 60% to 70% of the heart rate reserve of the participant.

3. Cooling down phase:

Gradual reduction of the treadmill speed to allow another 5 to 10 minutes of very slow walking. At the end of each session, there was a cool down period consisting of slow running for 5 mins to avoid postural hypotension and venous pooling of blood [16].

Pulse rate was continuously monitored during the training session; women were instructed to report any significant symptoms she feels during the session to the physiotherapist [17].

- *Data analysis*

In this study, the descriptive statistics (the mean, the standard deviation, maximum, minimum and range) were calculated for subject characteristics.

Paired t-test was conducted for comparison between pre and post treatment mean values of PTH and Ca+. The level of significance for all statistical tests was set at $p < 0.05$.

All statistical measures were performed through the statistical package for social studies (SPSS) version 19 for windows.

Results

Data obtained from the study group regarding parathyroid hormone (PTH) and blood calcium levels (Ca+) pre and post treatment were statistically analyzed and compared.

I- General characteristics of the subjects:

Thirty-five elderly women participated in this study. Their mean ± SD age was 64.45 ± 3.38 years. The mean ± SD BMI was 28.98 ± 0.97 kg/m² with maximum value of 30 kg/m² and minimum value of 26.2 kg/m². The mean ± SD target heart rate (THR) was 120.02 ± 2.09 beat/min with maximum value of 125 beat/min and minimum value of 115 beat/min (As shown in Table 1).

Table 1.Descriptive statistics for the mean age, BMI and THR of the study group.

	$\bar{X}$ ±SD	Maximum	Minimum	Range
Age (years)	64.45 ± 3.38	70	60	10
BMI (kg/m²)	28.98 ± 0.97	30	26.2	3.8
THR (beat/min)	120.02 ± 2.09	125	115	10

$\bar{X}$: Mean SD: Standard Deviation

I. Pre and post treatment mean values of PTH of the study group:

The mean difference between pre and post treatment was 1.89 mg/L and the percent of change was 5.98%. There was a significant decrease in the PTH of the study group post treatment compared with pretreatment (p = 0.02) (As shown in Table 2).

Table 2. Paired t test for comparison between pre and post treatment mean values of PTH of the study group:

	PTH (mg/L)	MD	% of change	t- value	p-value	Sig
	$\bar{X}$ ± SD					
Pre	31.57 ± 7.68	1.89	5.98	2.34	0.02	**S**
Post	29.68 ± 8.22					

$\bar{X}$: Mean MD : Mean difference p value : Probability value
SD : Standard deviation t value : Paired t value S : Significant

II. Pre and post treatment mean values of Ca+ of the study group:

The mean difference between pre and post treatment was -0.04 mg/dl and the percent of change was 0.44%. There was a significant increase in the Ca+ of the study group post treatment compared with pretreatment (p = 0.02) (As shown in Table 3).

Table 3. Paired t test for comparison between pre and post treatment mean values of Ca+ of the study group:

	Ca+ (mg/dl)	MD	% of change	t- value	p-value	Sig
	$\bar{X}$ ± SD					
Pre	8.92 ± 0.23	-0.04	0.44	-2.44	0.02	**S**
Post	8.96 ± 0.26					

$\bar{X}$: Mean MD : Mean difference p value : Probability value
SD : Standard deviation t value : Paired t value S : Significant

Discussion

This study was conducted to determine the response of Parathyroid hormone and total calcium level to moderate aerobic training in elderly women.

Thirty five sedentary elderly women aged 60-70 years were participated in this study. Each subject of this study had participated in aerobic training of moderate intensity with training fraction of 60% to 70% of each subject's predetermined HR max.

This program was applied three times per week for 12 weeks. The result of this study revealed that 12 weeks of supervised moderate intensity aerobic exercise training produced a significant decrease in the serum parathyroid hormone level by percentage 5.98%, And a significant increase in total calcium level in the blood by percentage 0.44%. This result may be due to the physiological effect of calcium metabolism which regulated mainly by parathyroid hormone, as when the serum calcium level was increased by exercise, the parathyroid hormone decreased not to stimulate the ca^+absorption from the skeleton, thus improve the anabolic skeletal effect of the aerobic exercise.

This result comes along with **Scott, et al.,** [18] who documented that PTH concentrations decreased below the baseline after comparing a 60-minute of treadmill running at 65% of the maximal rate of oxygen uptake (exercise) with semi recumbent rest on ten healthy men, Although they found no significant effect on the albumin-adjusted calcium concentrations.

It was supported by **Tartibian et al.,** [7] who reported that PTH was decreased after 24 weeks intervention of exercise and supplements in Seventy-nine healthy sedentary post-menopausal women aged 58-78 years participated, Also the Serum estrogen,1, 25 Vit D levels and femoral neck BMD measures increased, Explained that as long-term aerobic exercise training plus N-3 supplementation have a synergistic effect in attenuating inflammation and augmenting BMD in post-menopausal osteoporosis. But Calcium concentration remained stable through the 24 weeks intervention groups.

The result of the current study was supported by**Josse et al.,** **[19]**, who measured body composition changes of young women after exercising 5 days a week for 12 weeks and drink either fat-free milk or isoenergetic carbohydrate immediately after exercise or 1 hour after, measured by dual-energy x-ray absorptiometry, and subjects' strength and fasting blood were measured before and after, found out significant reductions in serum PTH in the milk group. This was accompanied by significant changes in markers of bone turnover; specifically an increase in serum osteocalcin; PTH stimulates bone resorption[20]and the increased dietary calcium intakes, resulted in a reduction in PTH, They concluded that heavy, whole-body resistance exercise resulted in a possible reduction in bone turnover in women after 12 wk.

This result comes in agreement with **Falk et al.,** [21]reported mixed results that PTH levels were similar in boys and men at rest and throughout the 24 hrs study period, increasing significantly 5 min after exercise, decreasing after 60 min post-exercise and returning to resting values within 24 hrs.

The results supported by **Sharma-Ghimire et al.,** [22]study of Sclerostin and parathyroid hormone responses to acute whole-body vibration and resistance exercise in young women, found out that there was no transient PTH increase, but it showed a large decrease after 30 minutes for both conditions. The study also reported that PTH exercise response patterns are not well understood, as in their study found

PTH responses variably to acute exercise stimuli depending on the type of exercise. Circulating PTH increased immediately post aerobic exercise and jumping protocols.

Also The transient increase in PTH did not occur after acute resistance exercise, but a PTH decrease by 2 h post exercise was observed by **(Rogers et al., 2011)** (23)

Alghadir et al., (24) agreed that 12 weeks of moderate intensity of aerobic training exerts significant positive effects on bone formation marker in all bone metabolism indices including Serum bone-specific alkaline phosphatase, serum osteocalcin, serum free Calcium and bone mineral density among 65 healthy adults associated with a significant decrease in the rate of bone resorption that could assist in preventing or decelerating osteoporosis.

Alghadir et al.,(25) study, also supported that moderate aerobic training on 100 healthy subjects significantly increased bone-specific alkaline phosphatase (BAP), BMD, and trace elements such as Calcium, Magnesium, and Zinc, Although they assumed that intense stress resulting from physical activity stimulates PTM gland and increases serum calcium.

The result of the current study was supported by**Chienet al.,** (26) who concluded thataerobic combined with high-impact exercise at a moderate intensity was effective in offsetting the decline in BMD in osteopenic postmenopausal women.

As**Grant and Holick,** (27)proved that the indicator of reduced bone remodeling is as a sufficient or higher 25[OH]D level, intestinal calcium absorption plateaus, both skeletal calcium resorption and PTH levels have been shown to stabilize.

The result was also supported by **Masako et al.** (28) concluded that short-term (7 months) exercise with intensity above the AT is safe and effective in preventing postmenopausal bone loss.

Current findings come in accordance with the study of**Vaidya,** (29)reported that low physical activity may be a modifiable risk factor for developing P-HPTH in women.And concluded in higher weekly PA was associated with a significantly lower risk of developing P-HPTH when compared with a more sedentary lifestyle.

Also study of **Figueroa et al.,** (30) agreed that Exercise training has significant beneficial changes in lean soft tissue and fat mass in early postmenopausal women. These changes in body composition were neither influenced by prolonged HRT use nor accompanied by changes in total levels of the hormones determined in this study.

On the other hand, the study contradicted the study of **Nikander et al.,** (31) who found that exercise can significantly enhance bone strength at loaded sites in children but not in adults.

Shea et al., (32)demonstrated that Ca supplementation that started 1 hour before and continued during exercise attenuates the increases in PTH andC-terminal telopeptides of type I collagen strongly suggests that it is the loss of Ca during exercise that is the mechanistic trigger for the increase in

PTH. But the long-term effects on BMD of repeated disruptions in Cahomeostasis during exercise training are not currently known.

Moghadasi, [33] contradicted the study as they concluded that resistance training increases the hormones of bone formation, After 12 weeks of resistance training to 20 young sedentary women, there was significant increase in the growth hormone, estrogen, parathyroid hormone and testosterone.

Also in contrary of the study, **Bouassida,**[5] noted that the marked rise in PTH concentration was only during high-intensity and long-duration or low-intensity and very long-duration exercise suggests that a minimal intensity and duration is needed to induce a modification in PTH concentration. On the other hand, short-duration maximal exercise or long-duration low-intensity exercise seems to have no impact on PTH secretion. Consequently, they reported that PTH regulation is influenced by the initial bone mineral content, age, gender, training state, and other hormonal and metabolic factors (catecholamines, lactic acid and calcium concentrations).

The result of this study came in contradiction with**Neer et al.,** [34]who reported that treating osteoporosis with parathyroid hormone (1-34) decreases the risk of vertebral and non-vertebral fractures; increases vertebral, femoral., and total-body bone mineral density.

Based on the findings of this study, it could be concluded that the results of this study support the importance of moderate intensity aerobic training in decreasing risk of post-menopausal osteoporosis by decreasing parathyroid hormone serum level and increasing total serum calcium level.

Reference

1. Chung H.Y., Lee E.K., Choi Y.J., Kim J.M., And Kim D.H.: Molecular Inflammation as an Underlying Mechanism of the Aging Process and Age-related Diseases, *J Dent Res;* 2011; 90(7):830-840.
2. Manolagas S.C. and Parfitt A. M.: what old means to bone. *Trends in Endocrinology and Metabolism*, 2010; 21, 6, 369-374.
3. Marenzana M., Shipley AM., Squitiero P., Kunkel JG., and Rubinacci A.: Bone as an ion exchange organ: Evidence for instantaneous cell-dependent calcium efflux from bone not due to resorption. *Bone*; 2005, 37:545–554.
4. Peacock M.: Calcium Metabolism in Health and Disease Clinical Journal of the American Society of Nephrology, 2010; 5: S23–S30.
5. Bouassida A., Latiri I., Bouassida S., Zalleg D., Zaouali M, Feki Y., Gharbi N., Zbidi A., and Tabka Z.: Parathyroid hormone and physical exercise: a brief review. *J Sport Sci Med*, 2006; 5:367–374.
6. Lips P., Bouillon R., Natasja M., Schoor V., and Vanderschueren D.: Reducing fracture risk with calcium and vitamin D, *Clinical*

endocrinology, 2010; 73,3, 277-285.

7. Tartibian B. and MotabSaei N.: Effects of 9-weeks high intensity aerobic exercises on hormones and marker of metabolism of bone formation in young women. *Res J BiolSci*, 2008; 3:519–524.
8. Bemben DA., Buchanan TD., Bemben MG., and Kenhans AW.: Influence of type of mechanical loading, menstrual status, and training season on bone density in young women athletes. *J Strength Cond Res*.; 2004, 18:220–226.
9. Nikander R., Sievanen H., Heinonen A., Daly RM., Uusi-Rasi K., and Kannus P.: Targeted exercise against osteoporosis: A systematic review and meta-analysis for optimising bone strength throughout life. *BMC medicine;* 2010, 8:47.
10. Gómez-Cabello A., González-Agüero A., and Casajüs JA., Vicente-Rodríguez G.: Effects of Training on Bone Mass in Older Adults: A Systematic Review, *Sports Med*, 2012, 42: 301-325.
11. Welkowitz J., Ewen RB., and Cohen J.: Introductory statistics for the behavioral sciences. 3rd ed. San Diego, CA: Harcourt Brace Jovanovich; 1982.
12. World Health Organization (WHO): Obesity: Preventing and managing the global epidemic: Report of who consultation. *WHO technical report series*, 1999; 894, 253.
13. Gulati M., Shaw L. J., Thisted R. A., Black H. R., Merz C.B., and Arnsdorf M.F.:Heart Rate Response to Exercise Stress Testing in Asymptomatic Women, *Circulation*; 2010, 122:130–137.
14. Ehrman J.K., Gordon P.M., Visich P.S., and Keteyian S. J.,: Guidelines for exercise testing and exercise prescription., Clinical exercise physiology, *Human Kinetics*, 2013, 61-88:
15. Hill E., Zack E., Battaglini C., Viru M., Viru A., et al.,: Exercise and circulating cortisol levels: The intensity threshold effect, *Journal of endocrinological investigation*, 2008; 31(7), 587-591.
16. Kim HK., Suzuki T., Saito K., Yoshida H., Kobayashi H., Kato H., and Katayama M.: Effects of exercise and amino acid supplementation on body composition and physical function in community-dwelling elderly Japanese sarcopenic women: a randomized controlled trial. *J Am Geriatr Soc*.; 2012, 60(1):16-23.
17. Farag A., Akram A. and Khaled F.: Efficacy of Moderate Exercise Training on Cardiopulmonary Fitness among Elderly Women, *Bull. Fac .Ph .Th., Cairo Univ*., 2008; 13 (1): 27.

18. Figueroa A., Scott B., Laura A., Robert M.,: Effects of Exercise Training and Hormone Replacement Therapy on Lean and Fat Mass in Postmenopausal Women Journal of Gerontology: *Medical Sciences*, 2014; 58A, 3, 266–270
19. Josse AR., Tang JE., Tarnopolsky MA., and Phillips SM.: Body composition and strength changes in women with milk and resistance exercise. Med Sci Sports Exerc.; 2010, 42(6):1122-30.
20. HolickMF.: Vitamin D: a D-lightful health perspective. Nutr Rev.; 2008, 66(10 suppl 2):S182Y94.
21. Falk B., Haddad F., and Klentrou P.: Differential sclerostin and parathyroid hormone response to exercise in boys and men *Osteoporosis International*; 2016, 27, 3, 1245.
22. Sharma-G.P., Zhaojing C., and Vanessa S.: Sclerostin and parathyroid hormone responses to acute whole-body vibration and resistance exercise in young women *Journal of Bone and Mineral Metabolism*, 2018,1
23. Rogers RS., Dawson AW., Wang Z., Thyfault JP., and Hinton PZ.: Acute response of plasma markers of bone turnover to a singleabout of resistance training or plyometrics. *J ApplPhysiol*; 2011, 111:1353–1360.
24. Alghadir A., Aly F., and Gabr S.:Effect of Moderate Aerobic Training on Bone Metabolism Indices among Adult Humans, *Pak J Med Sci;* 2014, 30(4): 840–844.
25. Alghadir, A.H., Gabr, S.A., Al-Eisa, E.S., and Alghadir, M.H.: Correlation between bone mineral density and serum trace elements in response to supervised aerobic training in older adults. *Clinical interventions in aging*, 2016, *11*, 265-73
26. Chien M.Y., Wu Y.T., Hsu A.T., Yang R. S., and Lai J. S.: Efficacy of a 24-Week Aerobic Exercise Program for Osteopenic Postmenopausal Women, *Calcif Tissue Int*, 2000; 67:443–448
27. Grant WB., and Holick MF.: Benefits and requirements of vitamin D for optimal health: a review. *Altern Med Rev*.; 2005, 10 (2):94Y111.
28. Masako H., Akira H., Hitoshi A., Akemi S., and Rikuro H.: The Effects of Walking at the Anaerobic Threshold Level on Vertebral Bone Loss in Postmenopausal Women *Calcif Tissue Int*, 1993, 52:411-414.
29. Vaidya A., Curhan G C., Paik J M., and Wang M.: Physical Activity and the Risk of PrimaryHyperparathyroidism, *J ClinEndocrinolMetab*, 2016; 101(4):1590–1597
30. Figueroa A., Scott B.G., Laura A.M., and Robert M.B.: Effects of Exercise Training and Hormone Replacement

Therapy on Lean and Fat Mass in Postmenopausal Women Journal of Gerontology: *Medical Sciences*, 2014; 58A, 3, 266–270

31. Nikander R., Sievanen H., Heinonen A., Daly RM., Uusi-Rasi K., and Kannus P.: Targeted exercise against osteoporosis: A systematic review and meta-analysis for optimising bone strength throughout life. *BMC medicine;* 2010, 8:47.
32. Shea KL., Barry DW., Sherk VD., Hansen KC., Wolfe P., and Kohrt WM.: Calcium supplementation and parathyroid hormone response to vigorous walking in postmenopausal women. *Med Sci Sports Exerc,* 2014; 46:2007–2013
33. Moghadasi M., and Siavashpour S.: The effect of 12 weeks of resistance training on hormones of bone formation in young sedentary women*; Eur J ApplPhysiol*, 2013; 113:25–32
34. Neer R., and Arnaud C.: Effect of parathyroid hormone (1-34) on fractures and bone mineral density in postmenopausal women with osteoporosis, *N Engl J Med*; 2001, 344:1434-41.