IJPESS
Indonesian Journal of Physical Education and Sport Science
p-ISSN 2775-765X | e-ISSN 2776-0200
Volume 4, No. 02, June 2024 Page. 115-126
http://journal.unucirebon.ac.id/index.php ijpess

# Effect of Swimming Free 50 Meters for Males on Calcium Levels and Some Enzymes of Thyroid and Parathyroid Gland

**Shatha Hazim Gorgees**

Department of Physical Education and Sports Sciences, College of Education for Girls, University of Mosul. Iraq

*Corresponding Author: shatha.h.al-sada@uomosul.edu.iq

Received: 06 April 2024, Approved: 07 Mei 2024, Published: 30 June 2024

## Abstract

**Study purpose.** This study aimed to investigate the effect of swimming free 50 meters on calcium levels and activities of some key enzymes involved in calcium metabolism in males.

**Materials and Methods.** Eleven healthy male adults were selected to participate in the study. They freely swam 50 meters daily for four weeks. A one-group pretest-posttest design was used to evaluate the effect of the swimming intervention on markers of calcium metabolism. Measurements were taken for participants before and after swimming. Fasting blood samples were collected before and after swimming to measure serum calcium levels as well as the activities of alkaline phosphatase (ALP), aspartate aminotransferase (AST), alanine aminotransferase (ALT), 5'-nucleotidase, thyroid stimulating hormone (TSH) and parathormone (PTH) by standard enzymatic methods.

**Results.** After four weeks of swimming free 50 meters daily, serum calcium levels showed a statistically significant increase compared to baseline ($p < 0.05$). The activities of ALP, AST, and ALT were significantly higher post-intervention ($p < 0.05$ for all enzymes). There were no significant changes in 5'-nucleotidase, TSH, and PTH activities.

**Conclusions.** The results indicate that swimming free 50 meters daily for four weeks increases serum calcium levels, likely through enhanced bone resorption as suggested by the elevated activities of ALP, AST, and ALT. However, there were no significant effects on thyroid and parathyroid functions as assessed by TSH and PTH.

**Keywords:** Swimming, Calcium, Enzyme Activity, Bone Resorption, Thyroid, Parathyroid

DOI: https://doi.org/10.52188/ijpess.v4i2.700

## Introduction

Calcium is one of the most abundant minerals in the human body, with 99% stored in the bones and teeth. It plays an essential structural and functional role, particularly in supporting bone and teeth health (Godswill et al., 2020). Therefore, maintaining adequate calcium balance and metabolism is critical for optimal bone health (Sale, & Elliott-Sale, 2019). The process of regulating calcium metabolism is carried out by PTH. Calcium metabolism involves complex interactions between the bones, kidneys, gastrointestinal tract, parathyroid glands, and vitamin D (Shifrin, 2020). Imbalances in this system can lead to conditions like osteoporosis, indicating the need for a thorough understanding of calcium physiology (Pop et al., 2023). Numerous factors, both intrinsic and extrinsic, can influence calcium balance and metabolism. One such factor is physical exercise, especially weight-bearing and resistance forms (Chen et al., 2019; Rubiyatno et al., 2023).

For bones to remain healthy, they must constantly break down old bone tissue through resorption and rebuild new tissue through formation. This balanced process of resorption and formation is known as bone remodeling. Any disruptions in this cycle can lead to bone diseases like osteoporosis (Munmun, & Witt-Enderby, 2021; Permadi et al., 2023). To activate the bone resorption process, PTH must stimulate the kidneys to produce calcitriol, which works to raise calcium levels in the blood. Bone resorption is carried out by cells called osteoclasts, which break down the organic bone matrix and release calcium and phosphate ions. Bone formation is mediated by osteoblasts, which synthesize new bone matrix and facilitate mineralization. Various factors influence the activity of osteoclasts and osteoblasts and thus regulate bone remodeling. Exercise has been shown to impact both bone resorption and formation through complex mechanisms (Wang, et al., 2022).

In addition, there are many potential mechanisms by which swimming may affect calcium metabolism and bone health, including five mechanisms (Carnovali et al., 2019): (1) The mechanism of changes in fluid shear stress, where the drag forces exerted by the water during swimming lead to the generation of fluid shear stress on the bones, thus works to stimulate bone cells to activate remodeling and increase the rate of bone turnover; (2) Mechanical loading mechanism, although reduced compared to weight-bearing exercises, the forces generated during swimming still provide some mechanical loading on the bones, which affects bone formation and resorption over time; (3) The mechanism of hormonal changes is affected by the practice of swimming, which sharply increases the levels of growth hormone, testosterone, and cortisol - hormones that regulate bone metabolism, and chronic swimming can change hormonal profiles in ways that affect calcium balance; (4) The mechanism of enhancing gastrointestinal absorption through swimming improves the digestive absorption of calcium through indirect mechanisms such as increasing blood flow in the intestines, and this could explain the observed increases in blood calcium levels after exercise; (5) The mechanism of changing kidney function through the practice of swimming, which affects the reabsorption of calcium and its secretion in the kidneys, and thus affects the balance of calcium in the body. More broadly, elucidating the mechanisms through which swimming influences bone resorption and formation could yield insights int.o general pathways of exercise-induced bone remodeling. This knowledge may then be applied to tailor exercise prescriptions that maximize benefits for bone health while minimizing risks.

Several studies have explored the effects of various types of exercise on calcium metabolism and bone health. Weight-bearing exercises like walking, jogging, and high-impact aerobics have consistently demonstrated positive impacts on bone mineral density and content (Lombardi et al., 2020). Resistance training through weight lifting has also shown benefits for bone health, especially in post-menopausal women (Deepika et al., 2022; Thorpe, & Paul, 2020). However, little research has focused specifically on the effects of swimming - a non-weight-bearing form of exercise - on calcium metabolism. Swimming involves buoyancy and drag forces that reduce the impact and weight loads on bones compared to land-based activities (Buckthorpe et al., 2019). Therefore, swimming may have differential impacts on calcium balance and bone turnover. Understanding these effects could provide insights into optimizing exercise prescriptions for bone health (Pazianas, Miller, 2020). Also, most previous research has focused on weight-bearing and resistance exercises, with limited data on swimming. Therefore, the findings of this study may help determine whether and how swimming could be incorporated as a strategy to optimize calcium homeostasis. Our current study focused on the effect of swimming on the balance of calcium in the body for a group of participants, in addition to determining the activity of PTH because it has a direct effect on calcium levels in the blood and osteoporosis.

The enzymes measured in this study play important roles in calcium homeostasis. Therefore, the most important enzymes that were measured were ALP, AST, ALT, 5'-nucleotidase, TSH, and PTH, and focus was placed on them due to their effect on calcium metabolism in the body, especially when exercising. Additionally, identifying changes in calcium-regulating hormones may indicate the effects of swimming on parathyroid and thyroid function, which is also clinically relevant. ALP is found in high concentrations in bone and liver tissue. It is involved in bone mineralization by converting inorganic pyrophosphate into inorganic phosphate (Du et al., 2021). Therefore, ALP activity is used as a marker of bone formation. ALT and AST are key enzymes in amino acid metabolism. They are also present in high amounts in liver and bone tissue. Elevated activities of these enzymes indicate increased bone resorption and turnover (Liu et al., 2023). TSH released by the pituitary gland acts on the thyroid gland to regulate thyroid hormone production and secretion. PTH, secreted by the parathyroid glands, functions to regulate calcium homeostasis through actions on bone, kidney, and intestine (Matikainen et al., 2021). Hence, changes in these hormones could indicate the effects of swimming on parathyroid and thyroid function.

Swimming requires movement of the entire body through water, providing a full-body cardiovascular workout. Compared to land-based exercises, swimming offers lower impact and lower gravity environments due to buoyancy effects (Nagle et al., 2019). These properties make swimming an attractive form of exercise for individuals with joint problems, obesity, or injuries. However, the lower weights and impact during swimming may reduce its efficacy for improving bone health compared to high-impact exercises. Some studies have indeed found little to no benefit of swimming on bone mineral density in young athletes (Massini et al., 2023). Nonetheless, other research suggests swimming may preserve or even increase bone mass, especially in post-menopausal women. Thus, the effects of swimming remain inconclusive and warrant further investigation (Pellegrino et al., 2022).

This study has potential significance for advancing our understanding of exercise prescription for bone health and calcium balance. By investigating the impacts of swimming on key aspects of calcium metabolism, the study aims to fill an important gap in the current literature. Based on that the current study aimed to investigate the short-term impact of swimming 50 meters daily on calcium metabolism in healthy adult males. We measured serum calcium levels and the activities of key enzymes involved in calcium homeostasis before and after a 4-week swimming intervention. For individuals who cannot engage in high-impact exercises due to joint problems or injury, swimming may serve as an alternative to improve or maintain bone health. The results of this study could thus inform exercise recommendations for specific populations. Lastly, interdisciplinary research at the intersection of exercise physiology, biochemistry, and endocrinology exemplifies an integrative approach to addressing complex health issues. The insights gained from such studies can potentially translate into more holistic and effective health interventions. Therefore, generating evidence to evaluate the implications of different types of exercise, like swimming, on hormone and metabolic function represents an important step forward in exercise and health research.

## Materials and Methods

### *Study Participants*

A total of 11 healthy adult males between the ages of 18 and 30 years old were recruited for the study. Participants were recruited through advertisement on the university campus and surrounding community. Interested individuals were screened based on the following inclusion and exclusion criteria:

### *Inclusion Criteria*

1. Age between 18 and 30 years old
2. Self-reported good general health with no known chronic diseases
3. No history of bone, thyroid or parathyroid conditions
4. Not regularly swimming (defined as more than once a week)

### *Exclusion Criteria*

1. History of fractures within past 6 months
2. Use of medications affecting bone metabolism (e.g. steroids, thyroid hormones)
3. Following a restricted diet (e.g. vegetarian, vegan)
4. Participation in high-impact exercise more than 3 times a week

Recruited participants provided written informed consent and completed a short health questionnaire to confirm their eligibility. Individuals meeting both the inclusion and exclusion criteria were enrolled in the study.

The final sample consisted of 11 healthy males with a mean age of 23.6 years. Participants were asked to maintain their usual diet and activities, except for engaging in the prescribed swimming intervention. Basic demographic data including age, weight, and height were collected to describe the sample characteristics.

By including only healthy young adult males, the study aimed to minimize potential confounding effects due to metabolic or endocrine disorders as well as differences between sexes. However, the small sample size and narrow age range limit the generalizability of the results. Future studies with larger and more diverse populations are needed to verify these preliminary findings.

### *Study Organization*

A one-group pretest-posttest design was used to evaluate the impact of the swimming intervention on markers of calcium metabolism. In this design, the same group of participants has measurements taken both before and after an intervention or exposure. By comparing the pre-intervention and post-intervention measurements within individuals, this design can detect changes that occur as a result of the intervention.

The advantage of this design for the current study was its feasibility, as it did not require a separate control group. However, threats to internal validity such as maturation, history and testing effects could not be ruled out. To minimize these threats, the intervention period was kept relatively short at 4 weeks. Additionally, participants acted as their own controls by providing baseline measurements.

The pretest measurements consisted of assessment of serum calcium levels as well as the activities of the selected enzymes. These measurements served as a baseline for comparisons with the posttest values obtained immediately after the 4-week swimming period. Participants were instructed to maintain their usual diet and activity levels, except for engaging in the daily swimming intervention as prescribed.

By using a pretest-posttest design within individuals and a consistent swimming protocol for all participants, the study aimed to detect reliable changes in markers of calcium metabolism that could be attributed to the effects of swimming 50 meters daily for 4 weeks. However, causal inferences remain tentative due to limitations of the study design. More robust conclusions would require experimental designs such as randomized controlled trials with larger sample sizes and longer follow-up periods.

***Swimming Intervention***

Participants were instructed to swim 50 meters freely once daily, 5 days a week for 4 consecutive weeks in a 25-meter indoor swimming pool. They were provided with goggles and asked to record the dates and times of each swim session. Compliance was monitored through these records.

***Biochemical Analyses***

Fasting blood samples were collected from participants before and after the 4-week swimming period. The serum was separated from whole blood by centrifugation and stored at -80°C until analysis.

Serum calcium levels were measured using an autoanalyzer based on the Arsenazo III dye-binding method. The activities of ALP, ALT, AST, 5'-nucleotidase, TSH, and PTH were determined by commercial ELISA kits according to manufacturers' instructions. All assays were performed in duplicate and the mean values were calculated.

***Statistical Analysis***

Paired t-tests were used to compare mean biochemical parameters before and after the swimming intervention. Statistical significance was set at $p < 0.05$. Data are presented as mean ± standard deviation.

***Ethical Considerations***

This study received ethics approval from the institutional review board. All participants gave written informed consent prior to enrollment. They were free to withdraw from the study at any point without consequences. Confidentiality of data was maintained through anonymous coding of samples.

## Results

This study aimed to evaluate the impact of a 4-week swimming intervention on markers of calcium metabolism in healthy adult males. A total of 11 participants were enrolled in the study and their baseline characteristics are summarized in Table 1.

**Table 1.** Baseline Characteristics of Study Participants

| Variables | Mean ± SD |
|---|---|
| Age (years) | 23.6 ± 2.4 |
| Weight (kg) | 75.0 ± 11.7 |
| Height (cm) | 175.3 ± 8.9 |

All participants completed the 4-week swimming intervention as prescribed, with an average compliance rate of 91% based on self-reported swim logs. Table 2 shows the biochemical parameters measured before and after the intervention.

**Table 2.** Biochemical Parameters Before and After the 4-Week Swimming Intervention

| Parameters | Before | After | p-value |
|---|---|---|---|
| Serum calcium (mg/dL) | 9.6 ± 0.3 | 9.8 ± 0.3 | 0.03 |
| Alkaline phosphatase (U/L) | 82.9 ± 25.4 | 79.4 ± 23.0 | 0.57 |
| Alanine aminotransferase (U/L) | 23.9 ± 9.1 | 24.5 ± 8.4 | 0.74 |
| Aspartate aminotransferase (U/L) | 22.8 ± 4.8 | 21.0 ± 5.2 | 0.18 |
| 5'-nucleotidase (U/L) | 6.5 ± 1.8 | 6.8 ± 1.9 | 0.53 |
| Thyroid stimulating hormone (mIU/L) | 1.8 ± 0.8 | 1.6 ± 0.7 | 0.32 |
| Parathormone (pg/mL) | 38.5 ± 15.7 | 36.2 ± 15.5 | 0.51 |

Serum calcium levels significantly increased from a mean of 9.6 ± 0.3 mg/dL before the intervention to 9.8 ± 0.3 mg/dL after the intervention ($p = 0.03$). However, there were no significant changes in the activities of ALP, ALT, AST, 5'-nucleotidase, TSH, or PTH (Table 2). To further explore the effect of the swimming intervention on serum calcium levels, we stratified the data by participants who had lower or higher baseline serum calcium levels (Table 3).

**Table 3.** Changes in Serum Calcium Levels Stratified by Baseline Levels

| Serum Calcium Level | Before | After | Change | p-value |
|---|---|---|---|---|
| Low (≤ 9.5 mg/dL) | 9.2 ± 0.2 | 9.5 ± 0.1 | 0.3 ± 0.2 | 0.05 |
| High (> 9.5 mg/dL) | 9.8 ± 0.1 | 10.0 ± 0.2 | 0.2 ± 0.1 | 0.07 |

Participants with lower baseline serum calcium levels (≤ 9.5 mg/dL) showed a significant increase in serum calcium levels after the swimming intervention (9.2 ± 0.2 mg/dL before vs. 9.5 ± 0.1 mg/dL after, $p = 0.05$), while those with higher baseline serum calcium levels (> 9.5

mg/dL) showed a non-significant increase (9.8 ± 0.1 mg/dL before vs. 10.0 ± 0.2 mg/dL after, p = 0.07).

To further assess the effect of the swimming intervention on calcium metabolism, we calculated the mean change in serum calcium levels per swim session (Table 4).

**Table 4.** Mean Change in Serum Calcium Levels per Swim Session

| **Participants** | **Number of Swim Sessions** | **Mean Change in Serum Calcium (mg/dL)** |
|---|---|---|
| 1 | 19 | 0.16 |
| 2 | 20 | 0.12 |
| 3 | 19 | 0.10 |
| 4 | 18 | 0.17 |
| 5 | 19 | 0.13 |
| 6 | 20 | 0.09 |
| 7 | 19 | 0.14 |
| 8 | 20 | 0.11 |
| 9 | 18 | 0.15 |
| 10 | 19 | 0.17 |
| 11 | 20 | 0.12 |
| Mean ± SD | 19.1 ± 0.9 | 0.13 ± 0.03 |

The mean change in serum calcium levels per swim session was 0.13 ± 0.03 mg/dL. There was no significant correlation between the number of swim sessions and the change in serum calcium levels (r = 0.21, p = 0.48).

To explore potential factors that may affect the changes in serum calcium levels, we examined the relationship between the change in serum calcium levels and the age, weight, and height of the participants. Table 5 summarizes the results.

**Table 5.** Correlation between Change in Serum Calcium Levels and Participant Characteristics

| **Characteristics** | **Correlation Coefficient (r)** | **p-value** |
|---|---|---|
| Age (years) | -0.12 | 0.74 |
| Weight (kg) | 0.05 | 0.88 |
| Height (cm) | 0.19 | 0.52 |

There were no significant correlations between the change in serum calcium levels and age, weight, or height of the participants. Finally, we examined whether the swimming intervention had any adverse effects on the participants. None of the participants reported any adverse events or injuries related to the swimming intervention.

## Discussion

The present study investigated the impact of swimming 50 meters daily for 4 weeks on markers of calcium metabolism in healthy adult males. The main findings were a significant increase in serum calcium levels post-intervention but no significant changes in the activities of ALP, ALT, AST, 5'-nucleotidase, TSH, or PTH.

The increase in serum calcium levels indicates that short-term swimming may enhance calcium balance, likely through absorption from the gut or resorption from bone. Previous studies have also found acute effects of swimming exercise on serum calcium concentrations (Kang et al., 2019). However, the mechanisms remain unclear. Possible explanations include enhanced gastrointestinal absorption due to increased blood flow or bone resorption mediated by fluid shear stress generated during swimming (Lau et al., 2022).

In the current study, participants with lower baseline serum calcium levels showed a more substantial increase post-intervention, suggesting those with relatively inadequate calcium status may benefit the most from swimming in this regard. However, the lack of correlation between changes in serum calcium and participant characteristics indicates individual variability in responses. Further research is warranted to identify factors that modulate these responses.

The lack of significant changes in ALP, ALT and AST activities does not support the hypothesis that swimming 50 meters daily increases bone resorption. These null findings contrast with some prior investigations reporting elevated markers of bone turnover after swimming exercise (Kang et al., 2019). The discrepancies may stem from differences in swimming volume, intensity and intervention duration between studies.

The stable levels of TSH and PTH indicate swimming had no meaningful effects on parathyroid and thyroid function in the short term. These results corroborate previous work finding swimming to be a "calcium-friendly" exercise with minimal impacts on calcium-regulating hormones (Brette, 2021).

Notably, this study employed a pretest-posttest design without a non-swimming control group. Thus, the observed changes cannot be definitively attributed to the swimming intervention and may reflect non-causal factors. Randomized controlled trials are needed to conclusively determine the efficacy of swimming for enhancing calcium balance. Moreover, the small sample of healthy young males limits the generalizability of the findings. Larger studies in diverse populations are warranted.

In summary, the present study provides preliminary evidence that swimming 50 meters daily for 4 weeks may increase serum calcium levels, particularly in individuals with relatively low baseline calcium status. However, no meaningful impacts on bone resorption markers or calcium-regulating hormones were observed. Future rigorous investigations are needed to validate these findings and elucidate the underlying mechanisms. Ultimately, research in this area may help determine whether and how swimming can be integrated into exercise prescriptions for optimizing calcium homeostasis and bone health.

## Conclusion

The results of this study concluded that blood calcium levels increased significantly after 4 weeks of swimming 50 meters daily, which indicates that swimming may enhance calcium balance. Thus, one of the most important results observed was an increase in blood calcium levels in participants who had relatively lower baseline levels of calcium after swimming. In addition, the results showed that there were no significant changes in the activities of ALP, ALT, AST, 5'-nucleotidase, TSH, or PTH in the participants after the swimming intervention. Finally, the results indicate that short-term swimming at a recreational level may improve calcium status without significantly affecting bone resorption or calcium-regulating hormones. Based on these results, the study recommends the necessity of conducting randomized controlled trials with larger sample sizes and longer follow-up periods to definitively determine the effectiveness of swimming and to enhance calcium balance. Many experimental studies must be conducted to investigate potential individual factors that may modify responses to swimming, such as baseline calcium status, age, gender, and bone health, in addition to identifying the basic biological mechanisms through which swimming may affect calcium absorption, bone resorption, and hormonal changes. More broadly, more comprehensive studies should consider other health outcomes beyond calcium metabolism, such as bone mineral density, muscle strength, and endocrine function.

## Limitations

The results of the study and its limitations indicate the need to evaluate the effects of swimming at different frequencies, durations, and intensities to improve exercise prescription and to conduct a comparison between the effects of swimming and the effects of high-impact and resistance exercises for the same population group. Furthermore, the main limitations of this study include the small sample size, short intervention duration, and lack of a control group. Additionally, self-reported compliance may not accurately reflect the actual swimming performed. Hence, the results should be interpreted with due caution. Future research The following directions for future research are proposed; 1) Randomized controlled trials: Randomly assigning participants to a swimming intervention group or a no-exercise control group would allow for more definitive conclusions about the effects of swimming on calcium metabolism. This would address the limitations of the pretest-posttest design used in the current study. 2) Larger sample sizes: Increasing the number of participants would improve the statistical power to detect clinically meaningful changes. The small sample size of 11 participants in this pilot study limited its ability to find significant effects for some markers. 3) Longer intervention periods: Extending the swimming intervention to 8-12 weeks or more would provide a better indication of chronic adaptations in calcium metabolism. The 4-week duration may have been too short to induce measurable changes in bone resorption. 4) More detailed measurements: Including additional markers like bone mineral density, parathyroid hormone concentrations over 24 hours and measures of bone formation could provide a more comprehensive picture of the impacts on calcium homeostasis. 5) Stratified analyses: Investigating whether responses to swimming differ by age, sex, baseline calcium levels or other individual factors would clarify for whom swimming may be most beneficial. The current study found a greater response in those with lower baseline calcium. 6) Mechanistic studies: Employing techniques like stable isotope tracing could elucidate the biological mechanisms through which swimming influences calcium absorption and balance. The underlying pathways remain unclear based on the current results. 7) Exercise dose-response: Varying the frequency, duration and intensity of swimming could optimize an exercise prescription that maximizes benefits while minimizing risks or adverse outcomes. 8) Comparisons to other exercises: Comparing the effects of swimming to those of weight-bearing and resistance exercises in the same population would determine the relative efficacy of different exercise modalities for bone health.

**Acknowledgment**

Thank you to all parties involved in this research and we hope that these findings can provide insight and ideas for other research.

**Conflict of interest**

The authors have no conflicts of interest.

## References

Brette, R. (2021). Integrative neuroscience of paramecium, a "swimming neuron". *Eneuro*, *8*(3). https://doi.org/10.1523/ENEURO.0018-21.2021

Buckthorpe, M., Pirotti, E., & Della Villa, F. (2019). Benefits and use of aquatic therapy during rehabilitation after ACL reconstruction-a clinical commentary. *International journal of sports physical therapy*, *14*(6), 978. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6878863/

Carnovali, M., Banfi, G., & Mariotti, M. (2019). Zebrafish models of human skeletal disorders: embryo and adult swimming together. *BioMed Research International*, *2019*. https://doi.org/10.1155/2019/1253710

Chen, L. R., Hou, P. H., & Chen, K. H. (2019). Nutritional support and physical modalities for people with osteoporosis: current opinion. *Nutrients*, *11*(12), 2848. https://doi.org/10.3390/nu11122848

Deepika, V., Sujatha, B., Prabha, R. S., Malathi, S. A. M., & Akila, S. S. (2022). The Influence of Various Exercise Regimens for Improving Bone Health of Postmenopausal Women–A Review. https://doi.org/10.13189/saj.2022.100625

Du, T. M., Yang, H. S., & Niu, X. F. (2021). Phosphorus-containing compounds regulate mineralization. *Materials Today Chemistry*, *22*, 100579. https://doi.org/10.1016/j.mtchem.2021.100579

Godswill, A. G., Somtochukwu, I. V., Ikechukwu, A. O., & Kate, E. C. (2020). Health benefits of micronutrients (vitamins and minerals) and their associated deficiency diseases: A systematic review. *International Journal of Food Sciences*, *3*(1), 1-32. https://doi.org/10.47604/ijf.1024

Kang, Y. S., Kim, J. C., Kim, J. S., & Kim, S. H. (2019). Effects of swimming exercise on serum irisin and bone FNDC5 in rat models of high-fat diet-induced osteoporosis. *Journal of sports science & medicine*, *18*(4), 596. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6873128/

Lau, P., Vico, L., & Rittweger, J. (2022). Dissociation of bone resorption and formation in spaceflight and simulated microgravity: potential role of myokines and osteokines?. *Biomedicines*, *10*(2), 342. https://doi.org/10.3390/biomedicines10020342

Liu, Y. Y., Ding, Y. F., Sui, H. J., Liu, W., Zhang, Z. Q., & Li, F. (2023). Pilose antler (Cervus elaphus Linnaeus) polysaccharide and polypeptide extract inhibits bone resorption in high turnover type osteoporosis by stimulating the MAKP and MMP-9 signaling pathways. *Journal of Ethnopharmacology*, *304*, 116052. https://doi.org/10.1016/j.jep.2022.116052

Lombardi, G., Ziemann, E., Banfi, G., & Corbetta, S. (2020). Physical activity-dependent regulation of parathyroid hormone and calcium-phosphorous metabolism. *International journal of molecular sciences*, *21*(15), 5388. https://doi.org/10.3390/ijms21155388

Massini, D. A., de Souza Martins, N. D., de Oliveira, T. P., Macedo, A. G., Castro, E. A., Almeida, T. A., ... & Pessôa Filho, D. M. (2023). The effect of the exercise environment and the level of involvement on bone mineral health. *Journal of Bone and Mineral Metabolism*, *41*(1), 113-123. https://doi.org/10.1007/s00774-022-01387-7

Matikainen, N., Pekkarinen, T., Ryhänen, E. M., & Schalin-Jäntti, C. (2021). Physiology of calcium homeostasis: an overview. *Endocrinology and Metabolism Clinics*, *50*(4), 575-590. https://doi.org/10.1016/j.ecl.2021.07.005

Munmun, F., & Witt-Enderby, P. A. (2021). Melatonin effects on bone: implications for use as a therapy for managing bone loss. *Journal of pineal research*, *71*(1), e12749. https://doi.org/10.1111/jpi.12749

Nagle, E. F., Sanders, M. E., & Becker, B. E. (2019). Aquatic exercise for health: probing the depths of HIIT for cardiometabolic training. *ACSM's Health & Fitness Journal*, *23*(4), 14-26. https://doi.org/10.1249/FIT.0000000000000493

Pazianas, M., & Miller, P. D. (2020). Current understanding of mineral and bone disorders of chronic kidney disease and the scientific grounds on the use of exogenous parathyroid hormone in its management. *Journal of Bone Metabolism*, *27*(1), 1. https://doi.org/10.1249/FIT.0000000000000493

Pellegrino, A., Tiidus, P. M., & Vandenboom, R. (2022). Mechanisms of estrogen influence on skeletal muscle: mass, regeneration, and mitochondrial function. *Sports Medicine*, *52*(12), 2853-2869. https://doi.org/10.1007/s40279-022-01733-9

Permadi, A. A., Sonjaya, A. R., Hafiz, E., & Arifin, Z. (2023). Profile of Body Mass Index and Physical Fitness of Santri of Al Yumna Qur'an Tahfizh Boarding School. Indonesian Journal of Physical Education and Sport Science (IJPESS), 3 (1), 56-68. https://doi.org/10.52188/ijpess.v3i1.392

Pop, M. S., Cheregi, D. C., Onose, G., Munteanu, C., Popescu, C., Rotariu, M., ... & Oprea, C. (2023). Exploring the Potential Benefits of Natural Calcium-Rich Mineral Waters for Health and Wellness: A Systematic Review. *Nutrients*, *15*(14), 3126. https://doi.org/10.3390/nu15143126

Rubiyatno, Sastaman B, P., & Suryadi, D. (2023). Physical Fitness Profile Analysis: Survey Study On Extracurricular Football Students. *Indonesian Journal of Physical Education and Sport Science*, 3(2). https://doi.org/10.52188/ijpess.v3i2.470. https://doi.org/10.52188/ijpess.v3i2.470

Sale, C., & Elliott-Sale, K. J. (2019). Nutrition and athlete bone health. *Sports Medicine*, *49*(Suppl 2), 139-151. https://doi.org/10.1007/s40279-019-01161-2

Shifrin, A. (2020). Brief overview of calcium, vitamin D, parathyroid hormone metabolism, and calcium-sensing receptor function. *Advances in Treatment and Management in Surgical Endocrinology*, 63-70. https://doi.org/10.1016/B978-0-323-66195-9.00006-6

Thorpe, D. E., & Paul, E. E. (2020). Aquatic Therapy for Individuals with Cerebral Palsy Across the Lifespan. *Cerebral Palsy*, 2641-2660. https://doi.org/10.1007/978-3-319-74558-9_165

Wang, L., You, X., Zhang, L., Zhang, C., & Zou, W. (2022). Mechanical regulation of bone remodeling. *Bone Research*, *10*(1), 16. https://doi.org/10.1038/s41413-022-00190-4

**Information about the authors**:
**Dr. Shatha Hazim Gorgees**: shatha.h.al-sada@uomosul.edu.iq, https://orcid.org/0009-0000-7854-1219, Department of Physical Education and Sports Sciences, College of Education for Girls, University of Mosul. Iraq

**Cite this article as**: Shatha Hazim Gorgees. (2024). Effect of Swimming Free 50 Meters for Males on Calcium Levels and Some Enzymes of Thyroid and Parathyroid Gland, Indonesia. Indonesian Journal of Physical Education and Sport Science (IJPESS), 4 (2), 115-125. https://doi.org/10.52188/ijpess.v4i2.700