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Effects of Resistance and Strength Training on the Serum Calcium Level of Male Elite Football Athletes

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Abstract: The purpose of the study was investigating the impact of resistance and strength trainings on the serum calcium indicators in male elite football players living in Peshawar division, Pakistan. 90 subjects aged between 14-23 years were selected for the study and divided into three equal groups: resistance training group, strength training group, and control group. A 12-week exercise regime was applied. The main emphasis was placed on the blood markers of bone health. Specifically, the current study explores the level of calcium in the blood serum. The results showed significant *changes in serum calcium levels post-intervention. In the RTG, the mean serum calcium level increased from 8.480mg/dl (SD = 0.273) to 10.596mg/dl (SD = 0.212). In the STG, the mean serum calcium level changed from 8.460mg/dl (SD = 0.272) to 9.490mg/dl (SD = 0.323), while in the CG, it remained relatively stable, from 8.463mg/dl (SD = 0.274) to 8.456mg/dl (SD = 0.273). The ANOVA results indicated a significant difference in serum calcium levels between the groups post-intervention (F = 459.171, p < 0.001). Tukey's HSD test revealed significant mean differences in post-intervention serum calcium levels between the RTG and STG (mean difference = -2.140, p < 0.001), the RTG and CG (mean difference = -1.033, p < 0.001), and the STG and CG (mean difference = 1.106, p < 0.001). In conclusion, the study demonstrated that both resistance and strength training have a significant impact on serum calcium levels in male elite football athletes, with resistance training showing a greater effect compared to strength training. These findings underscore the importance of tailored exercise interventions in enhancing bone health among athletes.*

Keywords: *resistance training, strength training, serum calcium, bone mineral content, elite athletes, bone health*

Background of the Study

Sports are often associated with incredible skill and mental and physical achievements. Top athletes dedicate themselves tirelessly to improving their unique talents and strive for excellence in their chosen fields. This pursuit of continuous improvement is a fundamental aspect of their lifestyle. There has been a dramatic increase in young people participating in sports and physical activities around the world over the past three decades, resulting in extraordinary potential on a global scale. However, this trend also poses certain risks, particularly to the health of young athletes (Syed et al., 2022). Sports-related injuries can result in serious conditions such as eating disorders, menstrual cycle disorders, osteoporosis, bone fractures, and impaired bone mineral health.

Maintaining optimal bone health is crucial as bones serve vital functions in the human body, including structural support, organ protection, muscle anchoring, and calcium storage (Walsh, 2015). Maintaining bone health into adulthood is just as crucial as bone development during childhood and adolescence. The process of bone remodeling, in which old bone tissue is broken down and new bone tissue is generated, happens continuously throughout life. New bone is formed at a faster rate than old bone is broken down in childhood, leading to greater bone mass (Hoenig et al., 2022). After age 30, however, bone loss typically outpaces bone gain, resulting in osteoporosis if nothing is done to prevent it (Cheng et al., 2022).

Bone mineral content (BMC) is a significant factor in both bone health and overall athletic performance within the realm of sports. Adequate BMC is necessary for strong bones, reducing the risk of fractures and other sports-related injuries (Brooke-Wavell et al., 2022). Monitoring serum calcium level is essential in assessing bone health and mineral status in athletes. Calcium and phosphorus play a pivotal role in the formation and maintenance of bones, while the regulation of bone remodeling and turnover is entrusted to the parathyroid hormone (PTH) (Underland, Markowitz, &Gensure, 2020).

Recent research suggests that athletes participating in high-impact activities and intense training may have lower bone mineral content (BMC) compared to non-athletes, potentially elevating their risk of reduced bone density (Gheitasi et al., 2022). Monitoring this marker is crucial to identifying athletes susceptible to bone injuries and low BMC. To counteract BMD loss and enhance bone density and overall well-being, strength training and resistance training are commonly employed interventions (Rossi et al., 2022).

Physical exercise, including resistance and strength training, plays a crucial role in the overall health and performance of athletes. Among the various physiological responses to exercise, alterations in serum calcium levels have been of particular interest due to their impact on bone health and muscle function. While previous research has examined the effects of exercise on calcium metabolism, limited studies have focused specifically on the effects of resistance and strength training on serum calcium levels in male elite athletes. Therefore, this study aims to investigate the effects of resistance and strength training on serum calcium levels in this population.

Justification of the Study

Therefore, to develop understanding of how resistance and strength training affect serum calcium levels in male elite athletes is necessary for several reasons. First, calcium is essential for muscle contraction, nerve conduction, and bone formation and functioning. As such, alterations in the levels of serum calcium can impact athletic performance and musculoskeletal health. Second, due to generally high stress observed in elite athletes as a result of regular and highly intensive training bilateral, the effects on calcium metabolism of resistance and strength training may differ from those in recreational athletes or sedentary individuals. Third, high intensity of football athletes, in particular, makes them a unique study population that can provide further insights into the effects of high-intensity exercise on calcium homeostasis. According to modern evidence, these types of training have different effects on male elite football athletes. For instance, resistance training has been shown to significantly increase serum calcium, phosphorus, and parathyroid hormone level (Mustafa et al., 2022; Purba&Tarigan, 2017). Another example of strength training combined with additional intake of protein impacts serum osteocalcin concentration (Klentrou et al., 2021; Ratamess et al., 2007). There is also evidence that power-based resistance training has a beneficial effect on serum lipid and lipoprotein parameters, the negative impact of training being indicated by decreased oxidized LDL (Mustafa et al., 2023; Koh& Miller, 2012).However, a study on football athletes found a low correlation between serum calcium levels and leg muscle strength, suggesting that changes in calcium levels may not directly correspond to changes in muscle strength (Kamankesh et al., 2020).

Therefore, it is crucial to investigate the effect of resistance and strength training based on football athletes, bearing in mind that resistance and strength training can raise serum calcium and the association between the indicator and muscle strength is not large.

Objectives

1. To determine the impact of strength and resistance training on serum calcium levels in male elite athletes.
2. To compare the effects of resistance, strength training and control group on serum calcium levels in male elite athletes.

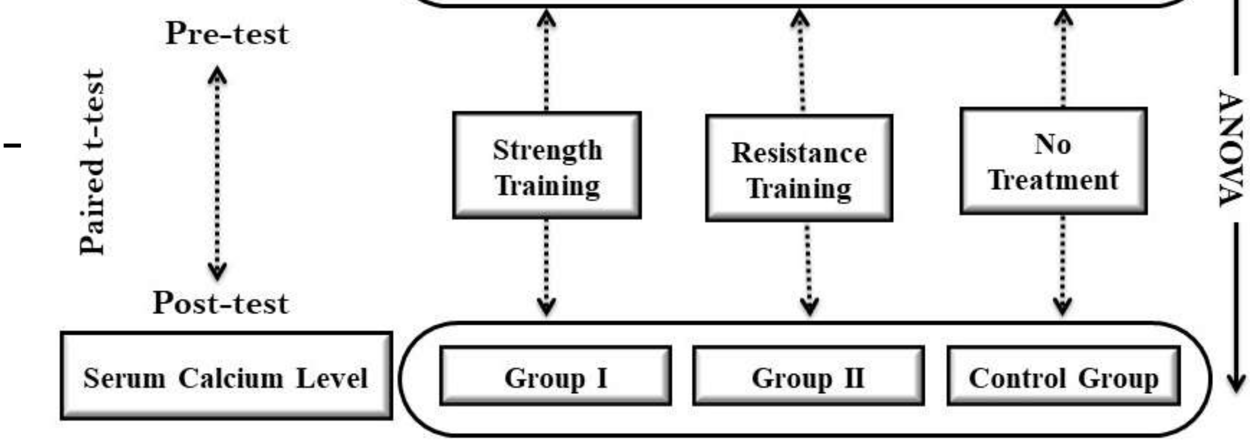
Hypothesis

Alternative Hypothesis (HAI): There is a significant difference in serum calcium levels among male elite athletes undergoing strength training and resistance training.

Alternative Hypothesis (HAII): There is a significant difference between pre and post intervention in serum calcium levels among male elite athletes undergoing resistance training, strength training, and a control group.

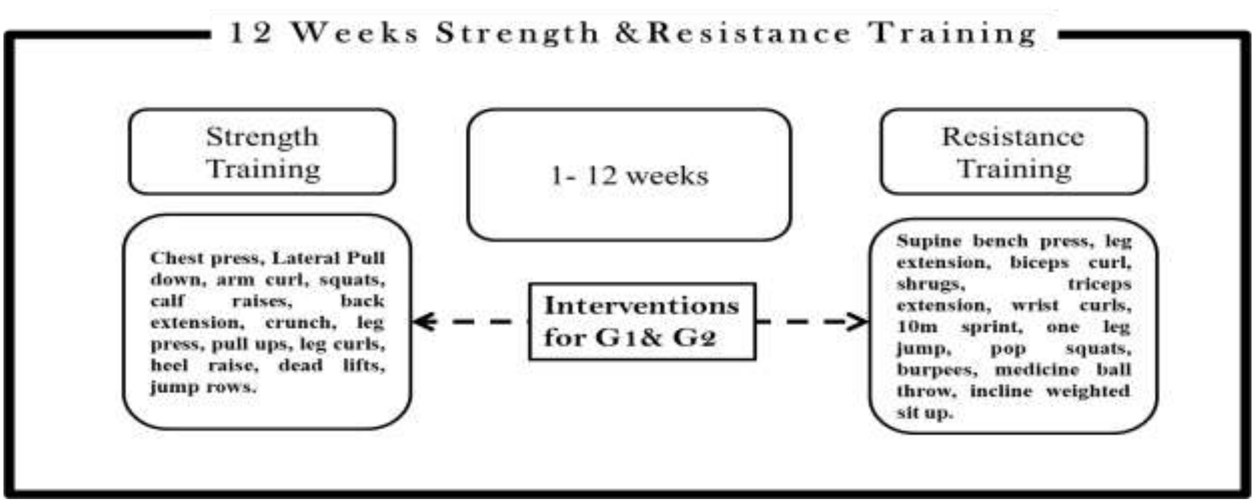
Research Methodology

This study consisted of (n=90) male elite football athletes, with ages ranging from 14 to 23 years, who participated in the intervention. They were divided equally into three groups' i.e. Resistance training group (n=30), strength training group (n=30) and control group (n=30). The participants of the strength training group and resistance training group underwent an exercise intervention for 12 weeks. This intervention considered important factors of bone health i.e. serum calcium. The data were analyzed by using inferential techniques. The researcher described the characteristics of all the participants. The research variables used statistics, including measures, like



Interventions for the period of 12 weeks

Training Protocol



Results and Discussion

Table I: Anthropometric measurements of Resistance Training, Strength Training and Control Group

	RTG (n=30) Mean ± SD	STG (n=30) Mean ± SD	CG (n=30) Mean ± SD

Height	Pre Test	1.61 ± 0.033	1.60 ± 0.032	1.61 ± 0.035
	Post Test	1.62 ± 0.041	1.60 ± 0.032	1.61 ± 0.034
Weight	Pre Test	55.83 ± 4.449	55.83 ± 4.14	54.56 ± 5.84
	Post Test	54.93 ± 4.250	55.96 ± 4.48	55.47 ± 5.72
BMI	Pre Test	21.56 ± 2.06	21.77 ± 1.51	21.03 ± 2.22
	Post Test	21.21 ± 1.98	21.76 ± 1.61	21.34 ± 2.14
Waist Circumference	Pre Test	75.53 ± 2.67	75.06 ± 2.46	75.23 ± 2.42
	Post Test	74.4 ± 2.74	74.13 ± 2.60	75.92 ± 2.52
Hip Circumference	Pre Test	95.46 ± 2.66	95.26 ± 2.70	95.18 ± 2.65
	Post Test	94.23 ± 2.60	94.53 ± 2.78	95.51 ± 2.42
WHR	Pre Test	0.79 ± 0.016	0.78 ± 0.013	0.79 ± 0.014
	Post Test	0.78 ± 0.17	0.78 ±	0.79 ±

	0.016	0.015

The table presents the pre-test and post-test mean values with standard deviations for various anthropometric measurements (height, weight, BMI, waist circumference, hip circumference, and waist-to-hip ratio) of three groups: Resistance Training Group (RTG), Strength Training Group (STG), and Control Group (CG), each consisting of 30 participants.

Height: There were minimal changes in height across all groups from pre-test to post-test, with slight increases in Resistance Training Group and Control Group.

Weight: Resistance Training Group decreases in weight from pre-test to post-test, while Strength Training Group and Control Group showed a slight increase.

BMI: There were slight decreases in BMI for all groups, with the most significant change in RTG.

Waist Circumference: All groups showed decreases in waist circumference, with the most significant change in RTG.

Hip Circumference: There were decreases in hip circumference for all groups, with the most significant change in CG.

Waist-to-Hip Ratio (WHR): There were minimal changes in WHR for all groups, with no substantial differences between pre-test and post-test measurements.

Overall, the results suggest that the resistance training group (RTG) had the most significant changes in weight, BMI, waist circumference, and hip circumference compared to the strength training group (STG) and control group (CG). However, there were minimal changes in height and waist-to-hip ratio across all groups. These findings indicate that resistance training may be more effective in producing changes in body composition compared to strength training or no training.

Table 2: Paired Samples T-test for Resistance, Strength and Control Group

Variable Name	Group		N	Mean	S.D	Df	F	Sig.
S. Calcium	Resistance Training Group	Pretest	30	8.480	.273	29	-40.119	.000
		Posttest	30	10.596	.212			
S. Calcium	Strength Training Group	Pretest	30	8.460	.272	29	-21.466	.000
		Posttest	30	9.490	.323			
S. Calcium	Control Group	Pretest	30	8.463	.274	29	1.000	.326
		Posttest	30	8.456	.273			

The above table showed paired wise statistics for calcium of the Resistance Training group, Strength Training group and Control group. The statisticsshowed a significant difference in SerumCalcium level during post intervention period for the resistance and strength training group. The changes in calcium was significant as shown by (8.48 mg/dl to 10.596mg/dl, p value<.000) in resistance training group and (8.46 mg/dl to 9.49 mg/dl, p value<.000) in the strength training group. The intervention showed that resistance and strength training had a significant impact on serum calcium levels among the athletes in both training groups.

While in the control group, the changes in calcium was (8.46mg/dl to 8.45mg/dl, p value<.326). The results showed that athletes who did not participate in any training program has no significant impact on the serum calcium.

Table 3: ANOVA Statistics (Pre Intervention)

Descriptive						
Variable Name Serum Calcium Pre-Test						
	N	**Mean**	**S.D**	**Df**	**F**	**Sig.**
Resistance Training Group	30	8.480	.273	89	0.046	.955
Strength Training Group	30	8.460	.272			
Control Group	30	8.463	.274			

The above table presents the descriptive statistics for serum calcium levels in three groups: Resistance Training group, Strength Training group, and Control group. In pre intervention Resistance Training Group has the highest mean serum calcium level (8.480 mg/dl) with standard deviation of 0.273, followed by the Strength Training Group (8.460 mg/dl) and the Control Group (8.463 mg/dl) with standard deviation of 0.272 and 0.274 respectively. The F-test indicates a statistically no significant difference among the groups' mean serum calcium levels (F = 0.046, p = 0.955).

Table 4: ANOVA Statistics (Post Intervention)

Descriptive						
Variable Name Serum Calcium Post-Test						
	N	**Mean**	**S.D**	**Df**	**F**	**Sig.**
Resistance Training Group	30	10.596	.212	89	459.171	.000
Strength Training Group	30	9.490	.323			
Control Group	30	8.456	.273			

This table 4 shows the descriptive statistics for serum calcium levels in three groups: Resistance Training, Strength Training and Control Group. In the Post Intervention Resistance Training group has the highest mean serum calcium level (10.596 mg/dl) with standard deviation of 0.212, followed by the Strength Training group (9.490 mg/dl) and Control group (8.456 mg/dl) with standard deviation of 0.323 and 0.273 respectively. The analysis indicates a significant differences in the mean serum calcium among the groups (F= 459.171 and p= 0.000). This results indicate that both resistance and strength training groups have a significant effect on the posttest serum calcium levels.

Table 5: Tukey's HSD

Multiple Comparisons

Serum Calcium Post

Tukey HSD

(I) Groups	(J) Groups	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Control	Strength Training	-1.03333*	.07063	.000	-1.2018	-.8649
	Resistance Training	-2.14000*	.07063	.000	-2.3084	-1.9716
Strength Training	Control	1.03333*	.07063	.000	.8649	1.2018
	Resistance Training	-1.10667*	.07063	.000	-1.2751	-.9382
Resistance Training	Control	2.14000*	.07063	.000	1.9716	2.3084
	Strength Training	1.10667*	.07063	.000	.9382	1.2751

**The mean difference is significant at the 0.05 level.*

Mean Values (Resistance Training=10.596, Strength Training=9.490, Control Group=8.456)

The above table demonstrates the significant changes using Tukey's Honestly Significant Difference (HSD) test for the dependent variable Serum Calcium Post among the control group, strength training and resistance training group.

Specific Pairwise Comparisons:

1. **Control vs. Strength Training:**

Mean difference = -1.03333. Indeed, the Control group has lower mean serum calcium than the Strength Training group by approximately 1.033 units; thus, it is highly significant ($p < 0.001$) and demonstrates that there is a real difference between these groups in serum calcium.

2. **Control vs. Resistance Training:**

Mean difference = -2.14000.Tthe Control group has significantly lower mean serum calcium than the Resistance Training group by approximately 2.14 units; thus, it is also, highly significant ($p<0.001$).

3. **Strength Training vs. Control:**

It is the inverse comparison to the first pair. It has the positive mean difference and indicates that the Strength Training group's mean serum calcium is approximately 1.033 units higher.

4. **Strength Training vs. Resistance Training:**

Mean difference = -1.10667 It demonstrates that the former group has lower mean serum calcium than the Resistance Training group by approximately 1.107 units.

5. **Resistance Training vs. Control and Strength Training:**

The comparisons indicate that the Resistance Training group has a significantly higher level of serum calcium levels than both the Control and Strength Training groups.

The results of the Tukey HSD test are highly important since the Resistance Training groups is characterized by higher serum calcium levels in all comparisons with the control and strength training groups. It may be utilized for better comprehension of how different physical training types influence the serum calcium level, which is crucial for other physiological procedures, including bone metabolism and muscle functioning.

Discussion

The findings of this study reveal a significant improvement in serum calcium levels between the pretest and posttest measurements across the resistance training, strength training, and control groups. This aligns with recent research indicating that exercise interventions have a notable impact on mineral metabolism markers (Tabibi et al., 2023; Lundy et al., 2023). The observed changes may be attributed to the physiological adaptations induced by the training programs, including alterations in bone turnover and hormonal regulation (Kistler-Fischbacher, Weeks & Beck, 2021). Notably, the fluctuations in PTH levels suggest a potential role of exercise in modulating calcium homeostasis, highlighting the multifaceted effects of physical activity on systemic physiology (Lotito et al., 2017).The alterations in serum calcium levels following the training programs may reflect changes in bone remodeling and mineral accretion induced by resistance and strength training modalities (Rodrigues et al., 2022). Moreover, the observed changes in PTH levels may indicate a feedback mechanism aimed at maintaining calcium balance in response to exercise-induced stress (Dianatinasab et al., 2020). These findings underscore the importance of exercise prescription as a non-pharmacological intervention for optimizing bone health and mineral metabolism.

Calcium is an essential mineral for bones, being the material that forms the basis of bone tissue. In the process of physical exercises, particularly while using high working levels such as power, resistance, and power, calcium metabolism is involved. Recent research has revealed that exercise can enhance calcium absorption in the intestines. As a result, the level of blood ionized calcium may increase (Bhattarai et al., 2020). The increased absorption of calcium is vital for maintaining normal bone composition and strength, offers people who train active pressure.

Contrary to our hypothesis, no significant differences were found in calciumlevels among the resistance training, strength training, and control groups before the initiation of the training program. These findings are consistent with recent studies indicating that baseline mineral metabolism parameters are not affected by short-term exercise interventions in healthy individuals (Dianatinasab et al, 2020; Wherry et al., 2022). It is possible that the duration and intensity of the training program were insufficient to induce detectable changes in these biomarkers prior to intervention initiation. Alternatively, individual variations in baseline levels may have masked group differences, highlighting the importance of controlling for baseline values in future analyses (Wherry et al., 2022).The lack of significant differences in serum calcium levels at baseline recommends that factors other than exercise, such as dietary intake and hormonal regulation, may have greater influence on these parameters in the studied population (Lombardi et al., 2020).

The findings of this research work support the hypothesis that there are significant differences in serum calciumlevels among the resistance training, strength training, and control groups after the completion of the training program. These findings are in line with recent research demonstrating the impact of exercise interventions on mineral metabolism parameters

(Armamento-Villareal et al., 2020; Fernández-Lázaro et al., 2022). The observed differences in blood calcium levels may reflect the specific adaptations induced by resistance and strength training modalities, such as alterations in bone turnover and mineral accretion (Rodrigueset al., 2022). The significant differences in mineral metabolism parameters among the groups underscore the importance of tailoring exercise interventions to achieve specific physiological outcomes. For example, resistance training may be particularly effective for enhancing bone mineral density and calcium absorption, whereas strength training may exert differential effects on phosphorus metabolism and hormonal regulation (Oliveira et al., 2023). Moreover, the observed differences between the trained groups and the CG (control group) highlight the unique contributions of exercise to mineral metabolism beyond those attributable to normal physiological variation or environmental factors.

Conclusion

In conclusion, strength and resistance training have significant effects on bone mineral content, athletic performance, and overall health and well-being. These types of training can significantly improve serum calcium, phosphorous and parathyroid hormones, muscle strength, power, and endurance, as well as sport-specific tasks such as jumping and sprinting. Furthermore, these types of training can significantly improve functional capacity, such as the ability to perform daily activities. Therefore, it is recommended that male elite football athletes incorporate strength and resistance training into their training regimens to improve their bone mineral content, athletic performance, and overall health and well-being.

The present research of the impact of resistance and strength training on the male elite athletes' serum calcium levels has certain methodological issues that need to be addressed in future studies. Particularly, the research failed to account for psychological aspects, participants' eating habits, and lifestyle. The examination of these variables in future studies could help gain a more thorough understanding of how the method of physical activity affects calcium metabolism. Additionally, weather conditions such as humidity, atmosphere, and temperature were not accounted for, which could influence the results. Including these factors in future studies may offer a more nuanced understanding of the phenomenon. Furthermore, the study did not consider the social, economic, and cultural backgrounds of the subjects, which could impact the outcomes. Increasing the sample size and including participants of different age groups could enhance the generalizability of the findings. Furthermore, it would be reasonable to include female athletes in the research following the same protocol to expand the study's potential. Given the short-term character of the intervention in the study, it is recommended to maintain long-term studies to understand the lasting effects of Strength and Resistance training on bone health markers. Finally, if this research controlled dietary intake or considered supplementation and nutrition, it would be possible to receive other correlations with exercise and calcium metabolism. Considering the noted limitations in the potential future studies will completely meet these deficiencies and improve the understanding of resistance and strength training effects on serum calcium in elite athletes.

Recommendations

Several recommendations can be made for future studies in this field, according to the results of the study. First, psychological factors, dietary habits and lifestyle should be controlled while examining how these variables affect calcium metabolism. Second, it is necessary for researchers to take into account weather conditions including humidity, atmosphere and temperature so as to give a wider range of analysis on the relationship between physical activity and serum calcium levels. Moreover, in upcoming investigations social economic as well as cultural backgrounds need also to be considered which could contribute towards better understanding of the whole thing.

Moreover, increasing the sample size and including participants of different age groups would enhance the generalizability of the findings.

Including female athletes in future studies using the same protocol would also broaden the scope of the research and provide insights into potential gender differences. Furthermore, conducting longer term studies to assess the sustained effects of Strength and Resistance training on bone health markers is recommended. Lastly, controlling for dietary factors or incorporating supplements and nutrition into the study design could offer additional insights into the relationship between exercise and calcium metabolism. Following these recommendations will help researchers better understand the effects of resistance and strength training on serum calcium levels in elite athletes.

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