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The Effect of Metabolic Resistance Training (MRT) on Improving Muscle and Bone Density and Wing Shooting Accuracy in Young Handball Players

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ABSTRACT

This study explores how young wing handball players who are affected by Metabolic Resistance Training (MRT), an integration of resistance workouts and high-intensity cardio. The challenges faced by wing players are clear, needing not only physical stamina and strength but also accuracy when shooting from close quarters while the player jumping in the air. The participants' risk of injuries, such as bone stress and muscular strains, are increased by the frequent falls and different body positions that occur during the match. Therefore, increasing bone and muscle density are essential to reduce the risk of injuries while improving performance. Conventional training frequently fails to meet these needs. 12 wing handball players, ages 16 to 18, participated in this study using an experimental approach. Over the course of 8 weeks, they attended MRT sessions three times a week. To improve technical proficiency for this physically demanding position, the study intends to evaluate how MRT affects muscle and bone density as well as wing shooting accuracy.

Keywords: Metabolic Resistance Training (MRT); Muscle and Bone Density; Wing Shooting Accuracy

ABSTRAK

Studi ini mengeksplorasi bagaimana pemain bola tangan sayap muda yang dipengaruhi oleh Metabolic Resistance Training (MRT), integrasi latihan ketahanan dan kardio intensitas tinggi. Tantangan yang dihadapi oleh pemain sayap jelas, tidak hanya membutuhkan stamina dan kekuatan fisik tetapi juga akurasi saat menembak dari jarak dekat saat pemain melompat di udara. Risiko cedera peserta, seperti stres tulang dan ketegangan otot, meningkat dengan seringnya jatuh dan posisi tubuh yang berbeda yang terjadi selama pertandingan. Oleh karena itu, meningkatkan kepadatan tulang dan otot sangat penting untuk mengurangi risiko cedera sekaligus meningkatkan kinerja. Pelatihan konvensional seringkali gagal memenuhi kebutuhan ini. 12 pemain bola tangan sayap, berusia 16 hingga 18 tahun, berpartisipasi dalam penelitian ini dengan menggunakan pendekatan eksperimental. Selama 8 minggu, mereka menghadiri sesi MRT tiga kali seminggu. Untuk meningkatkan kemahiran teknis untuk posisi yang

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menuntut fisik ini, penelitian ini bermaksud untuk mengevaluasi bagaimana MRT memengaruhi kepadatan otot dan tulang serta akurasi menembak sayap.

Kata Kunci: Pelatihan Ketahanan Metabolik (MRT); Kepadatan otot dan tulang; Akurasi Menembak Sayap

INTRODUCTION

The scope and significance of sports training science have greatly increased, moving from trial-and-error techniques to exact, evidence-based, research-based approaches. This development has had a significant impact on a number of sports, most notably handball, where notable advancements are the result of carefully thought-out training regimens, a variety of tactics, and strategies that assist coaches and players (Jakšić et al., 2023). Due to its crucial role in goal scoring, the wing position stands out as a crucial component for team success in handball, a team sport that requires high levels of technical proficiency and physical condition. One of the most difficult and creative responsibilities in the game is making room for teammates and efficiently contributing to both offensive and defense, which calls for extraordinary physical and technical skill (Hermassi et al., 2019).

In order to increase energy production both during and after workouts, Metabolic Resistance Training (MRT) combines resistance exercises with high-intensity cardio. This approach simultaneously challenges muscles and the cardiovascular system for a metabolic effect that improves fat loss, muscle growth, and general fitness (Moro et al., 2020; Westcott, 2012). MRT increases muscle mass, improves energy efficiency, sustains effort longer, and improves strength and endurance capabilities by using multi-joint movements that engage multiple muscle groups. It also uses bodyweight or resistances to recruit more muscles, which triggers a hormonal response that improves muscle strength and endurance without excessive hypertrophy, concentrating instead on performance efficiency (Dorgo et al., n.d., 2023; Terrazas et al., 2025).

In handball, wing players must be extremely fit and resilient in the face of changing defenses that restrict accurate shooting possibilities since they move at rapid speeds, cover more distances than others, and have a difficult time achieving ideal shooting angles (Michalsik K.; Aagaard P., 2014). Their periphery location on the court limits their shooting possibilities with narrow angles, necessitating fast speed, constant movement, prolonged flight time, and jump power all of which, when enhanced, provide access to higher, better angles above goalkeepers and defenders for more scoring opportunities. The performance of wing players requires specialized training in jumping, balance, and high-powered, accurate shooting technique (Font et al., 2021). Greater muscle and bone density is essential to enhance strength and prevent injuries, given the frequent jumping, falls, and changes in body position during aerial shots, which increase the risk of injuries such as muscle and bone strain. This study investigates the effect of metabolic resistance on enhancing muscle and bone density and shooting accuracy from the wing position in young wing players aged 16-18, through an eight-week program with three sessions per week. The study provides coaches with valuable information on how to use motion training (MRT) to make training more effective, reduce injuries, and improve competitive success.

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Research Statement

Wing players require specific technical and physical skills, such as strong muscles, endurance, and precise execution. They must perform frequent jumps, leap from tight spaces, engage in aerial duels, and experience direct impacts with the court. They also need to make rapid runs and cover greater distances than their teammates. These demands place the body under significant stress, making players more susceptible to injury. Traditional training programs often fail to meet these needs, particularly regarding increasing bone and muscle density to withstand this type of repetitive stress. This study explores the use of metabolic resistance training (MRT) to improve shooting accuracy, bone density, and muscle strength in young handball wing players.

Research Goals

1. To create a training program focused on metabolic resistance for young handball wing players with the goal of enhancing bone density, muscle strength, and shooting accuracy from wing position during aerial movements.
2. The study aims to investigate the impact of metabolic resistance training on the bone density, muscular strength, and shooting accuracy of juvenile handball wing players during aerial movements.

Research Hypothesis

Young handball wing players' bone density, muscle strength, and shooting accuracy from wing position during aerial movements all improve with metabolic resistance training.

METHODS

The nature of the study determines the methodology to be used; it is not set in stone but represents the researcher's strategy for examining the issue and discovering the truth. Because the experimental approach best fits the research challenge, the researchers used it.

36 players, ages 16 to 18, from the Wasit Governorate's youth handball specialized facility participated in the study. Twelve players, or 33% of the community, were chosen at random by the researchers by drawing. Homogeneity was attained among sample members in the following characteristics to control factors influencing result accuracy: height, weight, age, and training age.

Field Procedures

Tests and Measurements Used (Faisal, G. G. (2014.)), Wing shooting accuracy test.

The GE Logiq 5 WX ultrasound machine is used to test muscle density.

Device Operation: High-frequency ultrasonic waves are produced by the device using a probe. To help with wave transmission, a gel is placed on the examining area. When the probe is dragged across the skin The pulses it releases puncture the body. Reflected waves are detected, converted into signals, analyzed, and measured.
Measurement Procedure: The vastus lateralis muscle is measured in centimeters close to the knee (proximal third) while the person is sitting or lying down.

DEXA device for bone density measurement

This apparatus uses dual-energy X-ray absorptiometry (DEXA) waves to measure bone density, gathering information based on averages for size, gender, and age.

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Examination Process and Mechanism: Put on cozy, metal-free cotton clothes that don't require dyes. In order to distinguish between soft tissue and bone, the subject lies on the table with the X-ray generator below and the detector above. Minimal safe X-ray dosages at two energies are used.

Research Procedures

During pretests, DEXA (bone density) and GE Logiq 5 WX (muscle density) devices were used to measure research variables. physical examinations, such the wing shot test. Exercises specifically designed to improve muscle/bone density and shooting accuracy. Training science and handball references were used to develop the research group's Metabolic Resistance Training (MRT) program during the initial stage. The intervention was administered to adolescent handball players over a three-month period in 24 sessions. Crucial traits Three goal-appropriate high-intensity MRT sessions a week. Main section included dumbbell/weight exercises and bodyweight moves (squats, deadlifts, presses, lunges, overhead presses, etc.) Intensity: 70-85% of body weight

Post-tests were held for the experimental group under identical pre-test conditions (time, place, specifications).

Statistical Tools: SPSS statistical package was used to analyze results



Figure 1. The GE Logiq 5 WX ultrasound machine

RESEARCH RESULTS

Following the completion of the pre- and post-measurement data collection, the researchers displayed the findings in tables for SPSS software analysis.

Key results for muscle density (vastus lateralis, cm), bone density (DEXA g/cm²), and side airborne shot accuracy (% success rate) for the 12 teenage handball wing players (ages 16-18) after the 8-week MRT program are summarized in the tables below.

Table 1. Reveals the differences between pre- and post-tests in muscle density values for experiment group.

Indicate	Sig	T	Posttests		Pretests		Units	Variables
			Standard dev.	Mean	Standard dev.	Mean		
significant	0.002	4.447	0,104	4,104	0,420	3,861	cm	Muscle density

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Based on Table 1, the results of the paired sample t-test in the experimental group showed that the average value of muscle density increased from pretest ($M = 3.861$ cm, $SD = 0.420$) to the posttest ($M = 4.104$ cm, $SD = 0.104$), with a value of $t = 4.447$ and a significance of $p = 0.002$ ($p < 0.05$), which means that there was a significant difference between the value of muscle density before and after treatment in the experimental group.

Table 2. Reveals the differences between pre- and post-tests in muscle density values for control group.

Indicate	Sig	T	Posttests		Pretests		Units	Variables
			Standard dev.	Mean	Standard dev.	Mean		
Non-significant	0.285	1.120	0,530	3,811	0,510	3,731	cm	Muscle density

Based on Table 2, the results of the paired sample t-test in the control group showed the mean value of muscle density from pretest ($M = 3.731$ cm, $SD = 0.510$) to posttest ($M = 3.811$ cm, $SD = 0.530$), with a value of $t = 1.120$ and a significance of $p = 0.285$ ($p > 0.05$), which means that there was no significant difference between the value of muscle density before and after treatment in the control group.

Table 3. Reveals the differences between pre- and post-tests in bone density values for experiment group

Indicate	Sig	T	Posttests		Pretests		Units	Variables
			Standard dev.	Mean	Standard dev.	Mean		
significant	0.001	5,240	0,350	3,169	0,210	1,144	cm	Bone density

Based on Table 3, the results of the paired sample t-test in the experimental group showed that the average value of bone density increased from pretest ($M = 1.144$ cm, $SD = 0.210$) to posttest ($M = 3.169$ cm, $SD = 0.350$), with a value of $t = 5.240$ and a significance of $p = 0.001$ ($p < 0.05$), which means that there was a significant difference between the value of bone density before and after treatment in the experimental group.

Table 4. Reveals the differences between pre- and post-tests in bone density values for control group

Indicate	Sig	T	Posttests		Pretests		Units	Variables
			Standard dev.	Mean	Standard dev.	Mean		
Non-significant	0.405	0,850	0,235	1,149	0,220	1,142	cm	Bone density

Based on Table 4, the results of the paired sample t-test in the control group showed the mean value of bone density from pretest ($M = 1.142$ cm, $SD = 0.220$) to posttest

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(M = 1.149 cm, SD = 0.235), with a value of $t = 0.850$ and a significance of $p = 0.405$ ($p > 0.05$), which means that there was no significant difference between the value of bone density before and after treatment in the control group.

Table 5. Reveals the differences between pre- and post-tests in wing shooting values for experiment group

Indicate	Sig	T	Posttests		Pretests		Units	Variables
			Standard dev.	Mean	Standard dev.	Mean		
significant	0.001	4.546	2.567	11.756	2,576	9,564	Units	Wing Shooting

Based on Table 5, the results of the paired sample t-test in the experimental group showed that the average value of wing shooting increased from pretest (M = 9,564 units, SD = 2,576) to posttest (M = 11,756 units, SD = 2,567), with a value of $t = 4,546$ and a significance of $p = 0.001$ ($p < 0.05$), which means that there was a significant difference between the value of wing shooting before and after treatment in the experimental group.

Table 6. Reveals the differences between pre- and post-tests in wing shooting values for control group

Indicate	Sig	T	Posttests		Pretests		Units	Variables
			Standard dev.	Mean	Standard dev.	Mean		
significant	0.024	2.455	2.123	10.456	2,789	9,467	Units	Wing Shooting

Based on Table 6, the results of the paired sample t-test in the control group showed that the average value of wing shooting increased from pretest (M = 9,467 units, SD = 2,789) to posttest (M = 10,456 units, SD = 2,123), with a value of $t = 2,455$ and a significance of $p = 0.024$ ($p < 0.05$), which means that there was a significant difference between the value of wing shooting before and after treatment in the control group.

Table 7. Reveals the differences between post-tests in shooting values for control group

Indicate	Effect size (d)	Sig	T	Mean (post)	Variables
Large	0.85	0.001	4.546	2.789	Experimental
Small	0.39	0.024	2.455	9.467	Control

Based on Table 7, the results of the independent sample t-test on the wing shooting posttest value showed that the experimental group obtained an average posttest value (M = 2.789) with a value of $t = 4.546$, significance of $p = 0.001$ ($p < 0.05$), and effect size $d = 0.85$ (large category), while the control group obtained an average posttest value (M = 9.467) with a value of $t = 2.455$, significance of $p = 0.024$ ($p < 0.05$). and effect

size $d = 0.39$ (small category), which means that there was a significant difference between the two groups in the posttest score of wing shooting with a greater effect of treatment on the experimental group.

DISCUSSION

The Effect of Metabolic Resistance Training on Bone and Muscle Density

Muscle and bone density post-test results, which showed that the experimental group performed better. This improvement shows how the Metabolic Resistance Training (MRT) program has improved the players' muscle morphological properties. This study explains how this training approach can affect in significant muscular adaptations linked to enhanced muscle mass and bone density.

This improvement is due to the fact that metabolic resistance training combines resistance exercises with high intensity endurance activities during training periods that are high-intensity and have short rest periods. These conditions enhance the metabolic stress on the muscles that are working and encourage muscle fibers to make more proteins. Because of the changes that happen in muscle tissue when you do resistance training, previous studies have shown that it is one of the best ways to make muscles bigger and stronger. (Paquin et al., 2024).

Significant muscle hypertrophy as a result of the exercise regimen is also indicated by the experimental group participants increased muscular circumference and thickness. Research demonstrates that resistance training regimens with suitable intensity and regular repetition result in discernible increases in muscle fiber size, which is linked to gains in athletes' muscular capacity and physical performance. In this regard, a recent study discovered that metabolic alterations in muscle tissue, namely in amino acid metabolism pathways, are linked to muscular responses to resistance exercise. These alterations enhance the hypertrophy process and increase muscle growth (Lim et al., 2026).

The results of the present study indicate that the metabolic resistance training program is superior to traditional training in enhancing bone and muscle density among wing handball players. O'Brien et al. (2022) conducted an extensive review and meta-analysis of 14 trials, confirming this assertion. Progressive resistance training significantly increased the bone mineral density in the hip and thigh areas. This shows that metabolic programs (with high frequencies and progressive volume) can help bones grow and strengthen athletes' skeletal structures without needing to lift heavy weights. Consequently, it elucidates the reasons behind the experimental group's superior physical capabilities in relation to athletic performance.

These findings are in line with other research showing that constant resistance exercise resulted in notable gains in muscle mass because muscle fibers undergo structural and functional changes (Paquin et al., 2024).

These findings leave absolutely no room for doubt that a MRT program is more effective in the improvement of muscular density among wings handball players than is exercise of a traditional kind. The result of Shönfeld's study (2013) is easy to understand if we examine it in terms of a number of processes—an increase in mass-tz from lactate accumulation, cell growth, and an increase of anabolic hormones (GH-IGF) due to the stress metabolic with high reps or short rests.

Wing shooting Results for Young Handball Players in Pre- and Post-Measurements

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Table 5 shows that among young handball players in the experimental group, wing shot accuracy improved statistically significantly between pre- and post-test measurements, favoring post-test performance. Researchers credit this improvement to metabolic resistance training (MRT), which successfully combines strength training and cardiovascular conditioning to promote significant increases in bone mineral density and muscle density through repeated mechanical loading that promotes osteoblast activity, muscle hypertrophy, and skeletal adaptation for increased power output and injury resilience.

These findings suggest that (MRT) enhances the density of muscles and bones in wings handball players compare with conventional training methods., this explains why the experimental group outperformed the control group on the post-test. This superiority results from MRT's ability to recruit more muscle fibers and motor units, promoting better neuromuscular adaptations and muscular work efficiency, especially shooting skill from wing position, which requires explosive power, coordination, and dynamic balance during jumps and shots especially shooting skill from wing position, which requires power, coordination, and dynamic balance during jumps and shots. (Marques, M. C., & González-Badillo, J. J. (2020).

Even though the control group's shot accuracy improved statistically significantly, the experimental group's superiority was evident due to the greater effect size. This distinction is due to the fact that wing players' increased muscle and bone density from metabolic resistance training improved their explosive power, dynamic balance, and neuromuscular efficiency, allowing them to jump higher, select the best shooting angles, and execute quick articulation with exceptional accuracy during the shooting. (Andreasen, C. S., et al. (2020).

According to Marques and González-Badillo's (2020) study, resistance training can boost a handball player's throwing speed by up to 18% after 6–8 weeks, which directly improves their ability to score by increasing their maximal upper limb strength and explosive power. The higher scoring that results from metabolic programs that combine high repetitions and moderate loads, stimulating the recall of more muscle fibers and improving neuromuscular efficiency to ensure greater power transfer and higher accuracy during wing shots.

CONCLUSIONS AND RECOMMENDATIONS

Research reached following conclusions existence of media coverage for educational championships, in addition to effective role in spreading sportsmanship, away from hatred and fanaticism. Audio-visual media helps spread sports culture among members of society. Working on disseminating sports-related information, news, and obstacles. Consolidating sports values, principles, trends, and sustainability. It is clear that every society possesses a value system that determines patterns of sports behavior.

Recommendations

Based on research findings, researcher recommends following necessity of paying attention to reality of sports audio-visual media at all administrative, financial, and professional levels. Emphasizing that media outlets, in all forms, shed light on all sports games. Sports media enjoys an effective role in delivering its activities, goals, and message to national team players, and its contributions to sports awareness and

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education. Shedding light on roles of heroes, stars, and teams, as well as highlighting history of activities directly or indirectly.

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