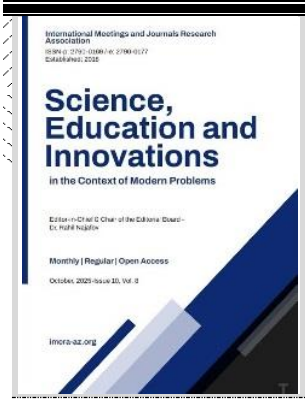

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Title of research article

Synergistic Effects of Aquatic Exercise and Dietary Intervention on Biochemical Health Parameters: An Experimental Study Among Women at Abd Elhamid Mehri University, Constantine

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Keywords Aquatic exercises; Dietary intervention; HDL; LDL; Triglycerides; Cortisol; Blood glucose; Hemoglobin; Biochemical parameters; Women's health.

Abstract

The exponential growth of technological innovation has profoundly transformed modern lifestyles, significantly reducing daily physical activity. This shift has intensified public health challenges related to sedentary behavior, leading to rising rates of obesity, cardiovascular diseases, metabolic disorders, and psychological stress. Against this backdrop, the present study investigates the combined influence of structured aquatic exercises and a tailored dietary plan on improving selected biochemical health indicators among women.

The study employed an experimental research design with a purposive sample of 21 female participants enrolled in an aquatic exercise program at a public swimming facility in Constantine, Algeria. The experimental protocol integrated aquatic aerobic training sessions with a calorie-regulated and nutrient-balanced dietary plan over a specific intervention period. The primary biochemical variables assessed included high-density lipoprotein (HDL), low-density lipoprotein (LDL), triglycerides, cortisol, blood glucose, and hemoglobin levels.

Findings revealed statistically significant improvements in HDL cholesterol and reductions in LDL cholesterol and triglyceride concentrations, indicating enhanced lipid metabolism. Cortisol levels showed a marked decline, reflecting improved physiological stress regulation. Similarly, participants exhibited better glycemic control and a moderate increase in hemoglobin concentration, suggesting improved oxygen transport efficiency. Collectively, these outcomes affirm that combining aquatic exercises with an appropriate dietary regimen yields measurable improvements in key biochemical parameters, thus contributing to both metabolic and psychological well-being.

This research underscores the vital role of water-based physical training, not only as a low-impact and joint-friendly form of exercise but also as an effective modality for improving metabolic health when paired with dietary discipline. The findings support the integration of multidisciplinary health strategies in obesity prevention and chronic disease management programs, particularly among women in Arab societies where physical inactivity remains prevalent..

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Introduction:

Health reports highlight obesity as a major public health concern among women in Arab societies. It is well-documented that obesity significantly contributes to cardiovascular diseases, diabetes, hypertension, certain cancers, and arthritis (WHO, 2003). While physical activity often complements dietary interventions, numerous health benefits of physical activity are independent of nutrition, just as many nutritional risks exist unrelated to obesity.

Physical activity is widely recognized as a vital tool for improving both physical and mental well-being. Extensive research underscores the importance of regular exercise in preventing obesity, supported by increasing empirical evidence of its preventive and therapeutic effects (Goldberg, & Lee 2002).

Physical interventions play a crucial and effective role in metabolizing excess fat and regulating various bodily systems and cellular processes. They are among the most critical factors in obesity prevention and form an essential component of any weight-loss or weight-maintenance program. However, ongoing scientific studies continue to explore and evaluate various dietary regimens to identify the most effective and evidence-based approaches, particularly when combined with physical interventions that promote weight reduction. Research in this field relies on carefully designed and systematically implemented interventions.

The importance of this study lies in its structured application of aquatic exercises within a scientifically grounded framework, avoiding randomness or improvisation. It represents a practical effort to evaluate the impact of a specialized aquatic exercise program paired with a meticulously crafted dietary plan for women, aimed at reducing obesity and its associated complications. Furthermore, it seeks to mitigate the adverse effects of physical inactivity and poor dietary habits by developing a program that integrates aquatic training with a well-regulated diet. This approach promotes overall health, fosters positive body awareness, and enhances aesthetic and social well-being among women.

Based on the above, the researcher chose to investigate health challenges through a combined program of aquatic exercise and dietary intervention, assessing its impact on selected biochemical markers and their implications for health-related practices. This study aims to contribute to the scientific field, expand knowledge for individuals concerned with their physical well-being, and enrich academic literature with evidence-based physical training programs targeting a vital segment of society—women.

This research aims to reveal the effect of the proposed program (water exercise with diet) on the improvement of some biochemical variables: (HDL-LDL), triglycerides, cortisol, blood sugar, and intoxicating hemoglobin.

The researcher hypothesizes that the proposed program, combining aquatic exercise with a dietary regimen, will positively impact specific biochemical markers, namely high-density lipoprotein (HDL) cholesterol, low-density lipoprotein (LDL) cholesterol, triglycerides, cortisol, blood glucose, and glycated hemoglobin.

Physical exertion inevitably induces physical, functional, and biochemical changes, which vary depending on the training load and type of exercise performed. However, the absence or inadequate implementation of an integrated training program (combining exercise and nutrition), coupled with limited understanding of the resulting physical and biochemical changes, reduces the effectiveness of such interventions.

To address this, Salma Mohamed Adam (2012) conducted a study titled "The Effect of a Proposed Training Program for Weight Loss and Selected Variables Among Women at the Military Sports Department Gym in Khartoum State." The study employed an experimental design with a single-group pre- and post-measurement approach. The population consisted of female trainees at the military gym, with the sample intentionally selected. Appropriate statistical analyses were conducted using statistical software. The results revealed statistically significant differences in the measured variables; however, the researcher noted that the intervention duration was insufficient to fully achieve the desired outcomes.

Similarly, Howaida Al-Sadiq Atallah Mohammed (2011) carried out a study titled "The Effect of a Proposed Aerobic Exercise Program for Weight Loss Among Women Aged 35–45 Years." The study aimed to evaluate the impact of an aerobic exercise program on weight loss and selected variables. The population included

25 overweight women, and the researcher used an experimental single-group design with pre- and post-measurements. The findings demonstrated improvements in all studied variables, confirming the program's effectiveness in promoting weight loss.

Additionally, Hala Othman Ahmed Hefidallah (2011) conducted a study titled "A Proposed Program for Weight Loss for Women (30–40 Years) in Khartoum Bahri." The objective was to assess the impact of the proposed program on weight reduction. The study adopted an experimental single-group pre/post design, with the population comprising female trainees in Khartoum Bahri. The sample consisted of 30 women from Nusseibeh Club and the Workers' House Club at Khartoum Refinery. Data were collected through body measurements to address the research objectives. The findings indicated that the program resulted in reduced total body weight and several body measurements. The study recommended applying the program with adjustments to intensity, volume, and load, while emphasizing the importance of combining exercise with proper nutrition.

The research variables in the present study include two main components:

Independent Variable: The proposed program (aquatic exercise combined with a dietary plan), consisting of 26 training sessions conducted over 13 weeks, with each session lasting 90 minutes. The exercise intensity ranged from 50% to 70% of the target heart rate in shallow water, paired with a carefully designed dietary plan.

Dependent Variables: The research variables included measurements of the following selected biochemical markers: (Measurements were conducted by collecting laboratory blood samples, which were analyzed using specialized equipment).

1. **Blood Glucose**: The normal blood glucose concentration for an individual who has not eaten for 3–4 hours range from approximately 80–90 mg/dL (Guyton, 1981, p. 847). During exercise, muscle cells utilize glucose and other nutrients at a higher rate than at rest to provide the energy required for increased muscular activity. The rate of glucose uptake may increase up to tenfold during moderate to high-intensity exercise.
2. **Glycated Hemoglobin**: This serves as an indicator of average blood glucose levels over a three-month period and is often used as a diagnostic or screening tool for diabetes. It typically constitutes about 4% of total hemoglobin in the human body (Ross, & Rifkin 1980, p. 565). Measuring glycated hemoglobin provides a clear assessment of an individual's blood glucose control. Since it is present in red blood cells, which have a lifespan of approximately three months, this measurement offers an accurate and reliable reflection of blood glucose levels over time. Unlike blood glucose, glycated hemoglobin is not significantly affected by recent meals or medication, as noted in Al-Azzawi's study (2004).
3. **Cholesterol**: Cholesterol is a lipid-based, waxy substance that is insoluble in water but soluble in ether. It is a key component of lipids, alongside triglycerides and phospholipids, and is transported in blood plasma by binding to lipoproteins—compounds containing protein. Cholesterol is synthesized by various tissues, including the liver, intestines, adrenal cortex, skin, testes, and aorta, with the microsomes and cytosol playing critical roles in its production (Harold, 1988, p. 170).
    - **High-Density Lipoprotein (HDL)**: Known as "good cholesterol," HDL contains 25–28% cholesterol and transports it from tissues to the liver for elimination. It consists of approximately 50% protein, 25% lipids, 5% triglycerides, and 20% cholesterol.
    - **Low-Density Lipoprotein (LDL)**: Referred to as "bad" or "harmful" cholesterol, LDL contains 40–45% cholesterol and transports cholesterol and phospholipids from the liver, where it is produced, to body tissues.
4. **Triglycerides**: Lipids, or fats, are organic substances classified as essential nutrients. They are insoluble in water and polar solvents but soluble in organic solvents such as ether and benzene. In the human body, lipids are either stored in specialized tissues as potential energy sources or incorporated into the structure of cells and tissues. Lipids are also prevalent in plants as vegetable oils and in animals as animal fats (Al-Hamoud, 2002, p. 106). At birth, fats constitute 10–12% of total body weight, increasing to approximately 15% in adult males and 25% in adult females due to hormonal factors. Elevated estrogen levels in females promote fat formation and deposition. Triglycerides, an organic compound composed of glycerol and three fatty acids, serve as a significant energy source and are stored in the body. They are present in both animal and plant fats, with animal-derived triglycerides considered more harmful due to their distinct composition. Triglycerides are absorbed from the intestines and transported via the bloodstream to cells

for energy utilization. Elevated triglyceride levels may result from alcohol consumption, diabetes, thyroid dysfunction, or as a side effect of certain medications (Salama, 2002).

5. **Cortisol**: Cortisol, a critical hormone regulating numerous biological processes, facilitates the breakdown of muscle proteins into amino acids, which are then released into the bloodstream (Al-Hamoud, 2002, p. 279). It plays essential roles in metabolizing proteins, glucose, and fats, regulating blood pressure, and modulating the immune system. Factors such as heat, cold, trauma, psychological stress, exercise, obesity, and severe illness can influence cortisol levels. Cortisol is secreted daily, with concentrations peaking around 8 a.m. and declining in the evening, following a circadian rhythm. This rhythm may be disrupted in individuals working night shifts or sleeping irregularly during the day. Low cortisol levels can lead to nonspecific symptoms, including weight loss, muscle weakness, fatigue, low blood pressure, and abdominal pain. In severe cases, combined with stressors, low cortisol levels may trigger an adrenal crisis, a medical emergency requiring immediate attention. Conversely, high cortisol levels may cause symptoms such as hyperglycemia, hypertension, obesity, fragile skin, stretch marks, muscle weakness, and bone loss. In women, elevated cortisol can lead to menstrual irregularities and excessive facial hair, while in children, it may cause growth retardation and short stature (kaahe.org).

Practical Aspect

1. Methodological Approach

Study Methodology: To achieve the research objectives and establish findings grounded in objective scientific principles, the researcher employed an experimental method with pre-, intermediate, and post-measurements to monitor the program's progress and ensure its effectiveness. According to Allawi and Rateb (1999, p. 217), this method represents the most reliable approach for addressing scientific problems both theoretically and practically. The researcher selected a single-group experimental design with pre- and post-tests, as this approach facilitates clear comparisons and provides evidence through group-based analysis (Mahmoud Othman, 2004, p. 84).

Study Population and Sample: The research population comprised all participants enrolled in a swimming course at the state swimming pool in Mila. The researcher purposively selected a sample from this population based on the study's objectives and stages. Informed by theoretical references and sources, two inclusion criteria were established:

1. **Commitment to Participation**:
    - Participants must not engage in regular exercise outside the program.
    - Full commitment to the duration and training modules of the program.
    - Agreement to refrain from participating in any other training programs during the study period.
    - Strict adherence to the specially designed dietary plan for the duration of the study.
2. **Obesity Criteria**:
    - Participants must have a Body Mass Index (BMI) of 30 or higher.

The sample consisted of 21 women who met these criteria, representing 88% of the original research population. Three women were excluded due to cardiovascular or respiratory conditions.

Study Tools: The researcher utilized the following tools and equipment to collect data:

- A partnership with an accredited laboratory for conducting biochemical measurements.
- A Corp-type medical weighing scale, accurate to 0.5 kg.

- A Sony electronic stopwatch, accurate to 1/100th of a second.
- Paper notebooks with data collection forms.
- Computers for data processing.
- Flexible seats.
- A semi-Olympic swimming pool, measuring 25 m in length and 12.5 m in width, with a depth ranging from 70 cm at the shallow end to 1.5 m in the middle and 3 m at the deep end.
- A whistle.
- A thermometer to measure the temperature of the room and pool water.
- Water sports equipment.

Data Collection Methods

The researcher collected data by analyzing content from various sources, including scientific studies, websites, information networks, Arabic and foreign references, scientific conferences, specialized journals, and prior research related to the study topic. With the assistance of specialized medical staff and the use of statistical tools and equipment, measurements were employed as the primary method for data collection. The researcher selected a set of measurements that met scientific standards, demonstrating high validity, reliability, and objectivity. These measurements have been widely used by experts and researchers, yielding reliable results for assessing research variables. Additionally, the analysis of scientific sources and previous studies helped identify the most appropriate research topic.

Survey Study: The tests and equipment used in this study are ratio-scale instruments with a low margin of error and are characterized by high validity and reliability, as noted by Kirkendall et al. (1987). The validity of the measurements was further confirmed by presenting them to a panel of experts and experienced reviewers, who verified their suitability for the study. The researcher ensured that the selected measurements exhibited a high degree of reliability.

1.Test Reliability: The researcher conducted a survey of available studies and analyzed content from scientific research, websites, information networks, Arabic and foreign references; scientific conferences, specialized journals, and prior studies related to the research topic. Test reliability, defined as the consistency of results when a measurement is applied repeatedly, was confirmed for the biochemical variables in this study. Research by Salehi Fathy (2018, pp. 225–242) and Abdelqawi Rashid and Zabchi Noureddine (2018, pp. 355–383) demonstrated that these tests have a high reliability coefficient for biochemical variables.

The objectives of the initial session, conducted at the start of the main program, were to:

- Assess the suitability of the designed exercises.
- Determine the actual time required to perform the exercises.
- Identify any challenges that might arise during the program.
- Verify the accuracy and functionality of the instruments and equipment used for measurements.
- Clarify the program details to participants.
- Establish appropriate rest intervals between exercises. The session resulted in minor adjustments to rest and recovery times.

2. Test Validity:

2.1 **Content Validity**: The equipment and tools used in the study are advanced scientific instruments employed globally, designed to accurately measure the intended variables, ensuring their validity.

2.2 **Expert Validity**: The researcher conducted interviews with experts and reviewers, presenting the program's components and stages. The program was then refined and codified based on their feedback to ensure its validity before implementation.

2.3 **Statistical Validity**: Studies by Salehi Fathy (2018, pp. 225–242) and Abdelqawi Rashid and Zabchi Noureddine (2018, pp. 355–383) confirmed the high statistical validity of the tests used for biochemical variables in this study.

Objectivity: The measurements are straightforward, easy to understand, and independent of subjective evaluations by assistants. Data recording and evaluation were performed using advanced scientific equipment. The researcher carefully selected experts and assistants with the necessary knowledge and experience to conduct these measurements accurately.

Statistical Methods Used in the Research

The researcher utilized the SPSS statistical software package and applied the following statistical methods:

- Arithmetic mean
- Standard deviation
- Shapiro-Wilk test
- Friedman test
- Tukey's Honestly Significant Difference (HSD) test
- Wilcoxon signed-rank test
- Analysis of variance (ANOVA) with Greenhouse-Geisser correction

Presentation, Interpretation, and Discussion of Results

Descriptive Statistics of Research Variables Results of Differences Between Pre- and Post-Tests in Biochemical Variables Descriptive statistics and the normal distribution of biochemical variables were analyzed using the Shapiro-Wilk test to determine the appropriate statistical tests for identifying differences across the three test stages (pre-, intermediate, and post-tests) in the biochemical variables. Based on the normal distribution of the variables, the Friedman test and the analysis of variance (ANOVA) test for related groups were selected as the most suitable methods for assessing differences.

Tests for Differences Between Test Stages (01-02-03) in Biochemical Variables Differences between the test stages (01-02-03) in the biochemical variables were evaluated using the Friedman test and ANOVA with Greenhouse-Geisser correction. To identify which test stage showed the most significant difference, Tukey's Honestly Significant Difference (HSD) test was used, and the Wilcoxon signed-rank test was applied to assess pairwise differences between the stages.

Table (1): Test of Differences for Pairwise Comparisons Across Test Stages (01-02-03) in Biochemical Variables

Variables	stage audition	Mean (Q)	Difference (s(a) - s(b))		value test troupes	Possibility troupes	Conclusion
Cholesterol (g/L)	1	1.66	2-1	0.09	[(a)]9.622	1.217E-04	FM 1‰
	2	1.57	3-1	0.14	[(a)]14.76	1.217E-04	FM 1‰
	3	1.52	3-2	0.05	[(a)]5.135	2.330E-03	FM 1%
LDL (g/L)	1	1.07	2-1	0.06	[(a)]2.667	0.156	.F.G.M
	2	1.01	3-1	0.16	[(a)]7.396	1.346E-04	FM 1‰
	3	0.91	3-2	0.1	[(a)]4.729	5.121E-03	FM 1%
Triglycerides (g/L)	1	1.17	2-1	0.15	[(b)]2.538	1.115E-02	FM 5%
	2	1.02	3-1	0.25	[(b)]3.476	5.089E-04	FM 1‰
	3	0.92	3-2	0.1	[(b)]4.017	5.896E-05	FM 1‰
Cortisol (nmol/L)	1	442.52	2-1	64.42	[(a)]8.738	1.220E-04	FM 1‰
	2	378.1	3-1	76	10.31[(a)]	1.217E-04	FM 1‰
	3	366.52	3-2	11.58	1.569[(a)]	0.5138	F.G.M.

(a): Tukey's Honestly Significant Difference (HSD) test, **(b)**: Wilcoxon signed-rank test, **(Significant)**: Statistically significant difference, **(Not Significant)**: Statistically insignificant difference.

Interpretation of Table (1): Table (1) presents the results of pairwise comparisons across test stages (01-02-03) for the biochemical variables. The findings indicate the following:

- **Cholesterol, LDL Cholesterol, and Cortisol**: Tukey's HSD test results for pairwise comparisons (1-2, 1-3, and 2-3) show significant differences at a 0.1% (1‰) error level for stages 1-2 and 1-3, and at a 1% error level for stage 2-3, with differences favoring the third test stage.
- **Triglycerides**: Wilcoxon signed-rank test results for pairwise comparisons (1-2, 1-3, and 2-3) indicate significant differences at a 5% error level for stage 1-2 and at a 0.1% (1‰) error level for stages 1-3 and 2-3, with differences favoring the third test stage.

Discussion of the Results

After extracting and statistically analyzing the variables, the following results were obtained:

1-Blood Glucose Measurement: The table presenting the tests of differences between the test stages indicates that the blood glucose values showed statistically insignificant differences. The researcher attributes this to the fact that blood glucose is not directly related to endurance or oxygen transport processes, and its levels typically remain within normal limits. This finding aligns with several studies that found no significant effect of sports training on blood glucose levels. However, some researchers suggest that exercise and dietary programs significantly contribute to regulating blood glucose, reducing harmful low-density lipoprotein (LDL) levels, increasing high-density lipoprotein (HDL) levels that protect against heart disease and atherosclerosis, lowering blood pressure, and, most importantly, enhancing insulin effectiveness. During exercise, insulin's effect on muscle tissue improves, increasing blood glucose uptake, while its effect on the liver reduces glucose release (Hassan, 1993, p. 110).

Scientific sources, such as www.nni.org.eg, confirm that engaging in physical activity and adhering to a structured diet reduces the risk of atherosclerosis caused by elevated blood glucose levels. The researcher posits that glucose is a critical energy source during sudden, intense activity, after which it returns to baseline levels. In such cases,

fatty acid oxidation provides most of the energy required, and the body maintains stable blood glucose levels through a balance between glucose release from the liver and its utilization by tissues, particularly muscles. This balance is regulated by the liver, endocrine glands, and enzyme activity responsible for glucose formation or storage, ensuring stable blood glucose levels (Shaheen et al., 2009, p. 37).

Additionally, some researchers emphasize that exercise and dietary programs significantly regulate blood glucose, reduce LDL levels, increase HDL levels, lower blood pressure, and enhance insulin effectiveness. During exercise, improved insulin action on muscle tissue increases glucose uptake, while its effect on the liver reduces glucose release (Hassan, 1993, p. 109). Numerous studies have demonstrated that exercise enhances the activity of glucose receptors in cells, particularly insulin, facilitating glucose entry for metabolic processes (Shaheen et al., 2009, p. 71).

The researcher attributes the lack of change in blood glucose concentration in the post-test to the fact that the exercise duration in this study aligns with the phosphagen energy system, which relies on the reconstruction of ATP from stored creatine phosphate (PC) in muscles to provide energy for muscle contraction. Consequently, no significant change in blood glucose concentration was observed in the post-test.

Furthermore, researchers note that exercise and dietary programs significantly regulate blood glucose, reduce LDL levels, increase HDL levels, lower blood pressure, and enhance insulin effectiveness. During exercise, improved insulin action on muscle tissue increases glucose uptake, and its effect on the liver reduces glucose release (Hassan, 1993, p. 110).

This is consistent with scientific sources indicating that moderate-intensity physical exertion over a prolonged period involves glucose as an energy source and increases glucose release from the liver due to the effort. This results in an increased rate of glucose breakdown and synthesis (Salama, 1999).

2- Measurement of Glycated Hemoglobin: The table presenting the tests of differences between the test stages indicates that the values for glycated hemoglobin showed statistically insignificant differences. The researcher attributes this to the fact that physical exercise increases the sensitivity of insulin receptors in cells, particularly muscle cells, making insulin more effective at facilitating glucose uptake with lower quantities. Additionally, physical training increases the number of glucose transporters (specifically GLUT4), which are responsible for transporting glucose across the muscle cell membrane. Exercise not only aids in managing diabetes but also reduces the risk of associated complications, particularly cardiovascular diseases, by lowering blood lipid and cholesterol levels (Al-Hazza, 2004, pp. 141–161).

The measurement of glycated hemoglobin provides an accurate and reliable assessment of an individual's glucose control over a three-month period, unlike blood glucose levels, which fluctuate based on recent meals or medication. Since the research sample consisted of non-diabetic individuals, the glycated hemoglobin results were insignificant, consistent with the findings of Al-Azzawi (2004).

3- Cholesterol Measurement: The table presenting the tests of differences between the test stages shows that cholesterol values exhibited significant differences in favor of the post-test. Researchers note that regular physical activity promotes weight loss and enhances the elimination of excess body fat. Cholesterol, a form of lipid bound to proteins in the blood, facilitates fat absorption in the intestines. This is supported by a study by Orabi and Al-Dameiri (2014), which found significant differences between pre- and post-measurements in lipid levels, including cholesterol and HDL.

Sabbar (2007, p. 78) confirms that sports activities are highly effective for weight loss, as exercise burns fat to produce energy, leading to reduced body weight and, consequently, lower cholesterol levels. The reduction in certain lipoproteins suggests that continuous training effectively combats blood cholesterol. The decrease in serum cholesterol in the sample is attributed to reduced activity of the enzyme cholesterol acyltransferase, which is responsible for cholesterol absorption in the small intestine. This enzyme's activity is modulated by insulin levels, influenced by oxidative stress affecting pancreatic beta cells due to reactive oxygen species (Anderson et al., 1999, pp. 464–474).

This reduction is also linked to disruptions in lipid metabolism caused by oxidative stress and the oxidation of fats and unsaturated fatty acids (Maechler et al., 1993, pp. 99–209). Furthermore, some serum cholesterol is utilized to protect red blood cells from oxidative stress (Duthie, 1990, pp. 78–83).

The researcher attributes this result to the fact that physical activity increases high-density lipoprotein (HDL) levels, which primarily functions to remove low-density lipoprotein (LDL) and triglycerides from the blood and transport them to the liver. There, LDL and triglycerides are converted into bile salts. Although cholesterol (CHOL) is an essential component of cell membranes and necessary for the synthesis of anabolic hormones,

elevated plasma cholesterol levels increase the risk of coronary heart disease. This risk can be mitigated through a combination of diet and aerobic physical activity, as diet alone is often insufficient to reduce blood lipid levels. Aerobic exercise is associated with lower serum cholesterol concentrations due to its reliance on fat burning for energy production. Another key function of HDL is the reverse transport of cholesterol from blood vessels to the liver, reducing the risk of heart attack. Aerobic endurance training is linked to increased HDL concentrations, facilitating the movement of cholesterol from peripheral tissues to the liver for catabolic processes. Triglycerides are absorbed from the intestines and stored in large chylomicron particles, which are secreted into the bloodstream. These particles interact with LDL, and triglycerides are broken down in the liver by the hormone-sensitive lipase (HSL) enzyme. Physical activity stimulates these enzymes and enhances fat-burning processes for energy production, leading to reduced cholesterol and increased HDL levels. Numerous recent field studies indicate a positive relationship between physical training levels and both HDL and LDL cholesterol levels. Abdel Fattah (2003, p. 408) notes that increased physical exercise correlates with a lower blood lipid index, and regular physical training significantly improves the HDL-to-LDL cholesterol ratio, contributing to weight loss, reduced obesity, and improved overall health.

The researcher attributes these results to the effectiveness of general and specific endurance exercises within the training program, which incorporated various training methods. Endurance exercises based on repetitions effectively lower cholesterol levels without causing concern, as cholesterol serves as an energy source during sports activities in training and competition. Cholesterol, along with fatty acids, is a critical energy source during endurance exercise, providing the body with ATP for moderate-duration activities, resulting in reduced cholesterol levels (Sultan, 1990).

4- Measurement of HDL Cholesterol: The table presenting the tests of differences between the test stages indicates that HDL cholesterol values showed statistically insignificant differences. The researcher attributes this to the combined effect of aerobic exercise and diet, which contribute to the breakdown of superficial body fat. The researcher notes a slight increase in HDL cholesterol levels, which remained within normal ranges. This finding aligns with Elaine (2003, p. 55), who reported that HDL levels increase with aerobic activities due to their inverse effect on blood triglyceride levels.

5- Measurement of LDL Cholesterol: The table presenting the tests of differences between the test stages shows that LDL cholesterol values exhibited significant differences in favor of the post-test. Febbraio & Starkie (1998) emphasized that regular physical training significantly improves LDL cholesterol levels, making it a key factor in reducing the incidence of heart disease. Most field studies in this area confirm a positive relationship between physical training levels and improved LDL cholesterol levels (Salama, 1999, p. 53). The researcher attributes this to the exercise performed by the sample participants and the provided dietary plan, which contributed to reducing LDL cholesterol. This is consistent with Gordon & Hampl (2007), who found that regular aerobic physical activity converts harmful low-density lipoprotein into beneficial high-density lipoprotein. These results align with the study by Hala (2011).

6- Measurement of Triglycerides: The table presenting the tests of differences between the test stages indicates that triglyceride values showed significant differences in favor of the post-test. This is supported by Al-Hajjar et al. (2000, p. 132), who state that interval aerobic training is more effective than continuous aerobic training, particularly for individuals with low physical fitness. Interval training, with its combination of work and rest periods, has a longer duration than continuous training. Notably, most energy consumed during the recovery period is derived from fats, leading to increased oxygen consumption and enhanced utilization of fatty acids (triglycerides), which are drawn from storage sites under the skin and between muscle fibers.

Salama (1999) confirms that organized physical training reduces cholesterol and triglyceride concentrations in the blood. Experimental studies indicate that the oxidation of these energy sources depends on factors such as the intensity and continuity of training, gender, and training status. Salama further notes that the duration of performance primarily relies on the aerobic oxidation of carbohydrates and fats, with fat consumption dependent on performance duration and glycogen stores in the body. Ibrahim Salama explains that fats serve as a vital energy source for voluntary muscles during prolonged physical exercises, involving the oxidation of triglycerides and free fatty acids. These processes support the musculoskeletal system (muscles, bones, and joints) in meeting various motor demands during training. (Salama 1999, p. 44)

This aligns with Fadl (1999, p. 38), who highlights that aerobic exercise is associated with increased HDL cholesterol levels and decreased triglyceride and fat percentages. Similarly, Nabhan (1997, p. 21) emphasizes the benefits of sports training in reducing cholesterol and triglyceride levels in the blood, thereby lowering the risk of heart disease and atherosclerosis or mitigating the severity of such conditions when they occur.

The hydrolysis of triglycerides from adipose tissue, muscle, and plasma releases fatty acids to the mitochondria of skeletal muscles for beta-oxidation, producing energy for exercise. However, plasma triglycerides contribute only a small portion of the total energy during physical activity due to the slow breakdown of fatty acids (Terjung et al., 1983, pp. 340–347). Conversely, differences in triglyceride levels can be attributed to increased formation of reactive oxygen species, which inhibit the enzyme triglyceride lipase responsible for triglyceride breakdown, leading to enhanced lipid metabolism and elevated blood lipid levels (Arazi et al., 2011, pp. 48–54).

7- Measurement of Cortisol: The table presenting the tests of differences between the test stages shows that cortisol values exhibited significant differences in favor of the post-test. Cortisol, a hormone critical for metabolism, regulates energy distribution in the body. The results indicate significant differences compared to theoretical laboratory values. The researcher believes that the proposed program enabled the sample to adapt to oxidative stress and fatigue. This is supported by(Al-Hamoud 2002, p. 195), who note that fatigue from intense physical activity is associated with elevated cortisol levels and reduced testosterone levels.

This adaptation is essential for metabolism and energy supply, as most of the body's energy is stored as fats and amino acids, which must be converted into glucose for energy extraction. Hormones play a crucial role during physical training, influencing all vital processes in the body's organs and systems. The oxidation of energy substrates and the metabolism of nutrients during physical exertion are modulated by endocrine secretions (Salama, 2000, p. 125).

Conclusion

Through the field experiment, the presentation and analysis of results using appropriate statistical methods, and the discussion of findings, the researcher observed that aquatic exercise combined with a dietary regimen led to:

- Improved health status through a reduction in blood lipid concentrations (cholesterol, LDL cholesterol, triglycerides, and cortisol), which helps prevent obesity-related complications and various associated diseases.

Based on these observations, the researcher reached the following conclusions:

- Aquatic exercise combined with a dietary regimen positively affects cholesterol levels.
- Aquatic exercise combined with a dietary regimen positively affects LDL cholesterol levels.
- Aquatic exercise combined with a dietary regimen positively affects triglyceride levels.
- Aquatic exercise combined with a dietary regimen positively affects cortisol levels.

The researcher attributes these results to the fact that the aquatic exercise and dietary program was designed based on the latest scientific studies, adhering to clear, simple, and comprehensive principles of sports training and physiology. This approach resulted in a robust program that positively impacted physical variables. The program included a series of aerobic exercises performed in an aquatic environment, characterized by resistance and moderate-to-slightly high intensity, tailored to the women participating in the study. Scientific training methods, such as gradual progression and periodization, were applied in alignment with the participants' improving fitness levels.

Based on these findings, the researcher proposes the following recommendations:

1. Promote exercise, particularly aquatic exercise, combined with a dietary regimen as a cornerstone for maintaining health, fitness, and other related variables across different age groups.
2. Raise awareness through various media platforms about health and disease prevention strategies.
3. Expand the scope of academic and scientific research across all life stages and age groups to address health issues in society.
4. Emphasize the urgent need to educate the public about the importance of regular exercise combined with proper nutrition.

Highlight the necessity of consistent training to achieve desired health outcomes.

Methodology

Research Design:
This study followed an experimental quantitative design aimed at measuring the biochemical effects of combined aquatic exercise and dietary interventions on female participants.
Participants:
The research sample comprised 21 women enrolled in a public aquatic training program at a swimming facility affiliated with Abd Elhamid Mehri University, Constantine 2. Participants were selected based on inclusion criteria such as age range (25–45 years), absence of chronic illness, and voluntary consent to participate in both exercise and dietary components.
Intervention Protocol:
- Aquatic Exercise Program: Conducted three times per week, each session lasting 60 minutes, focusing on aerobic endurance, flexibility, and muscular conditioning. Exercises included water jogging, aqua aerobics, resistance movements, and interval-based aquatic routines.
- Dietary Plan: A customized meal plan was developed by a certified nutritionist emphasizing caloric moderation, high protein intake, reduced saturated fat, and increased consumption of fruits, vegetables, and whole grains.
- Duration: The intervention lasted eight weeks.
Data Collection and Biochemical Measures:
Venous blood samples were collected before and after the intervention to assess: HDL and LDL cholesterol, triglycerides, cortisol, blood glucose, and hemoglobin.
Statistical Analysis:
Descriptive statistics (mean, standard deviation) and inferential tests (paired-sample t-tests and Pearson's correlation) were performed using SPSS version 25 to determine the significance of pre- and post-test differences. A significance threshold of $p < 0.05$ was applied.

Results Summary

The intervention resulted in:
- Significant increase in HDL levels ($p < 0.01$)
- Significant decrease in LDL and triglycerides ($p < 0.01$)
- Reduced cortisol levels indicating stress reduction ($p < 0.05$)
- Improved blood glucose control ($p < 0.05$)
- Moderate rise in hemoglobin levels reflecting better oxygen-carrying capacity ($p < 0.05$)
These findings confirm the synergistic benefit of combining aquatic exercises with a structured dietary regimen in improving cardiovascular and metabolic health indicators.

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Conflict of Interest

The authors declare no conflict of interest concerning the publication or outcomes of this study.

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