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The Effect of Deep Aquatic Training Supported by Nutritional Guidance on Vital Capacity, HbA1c, and Physical Efficiency in Individuals with Type 2 Diabetes Aged 40–45

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ORIGINAL STUDY

The Effect of Deep Aquatic Training Supported by Nutritional Guidance on Vital Capacity, HbA1c, and Physical Efficiency in Individuals with Type 2 Diabetes Aged 40–45

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Abstract

The research problem lies in the high levels of glycated hemoglobin (HbA1c) and the weakness of some functional and physical indicators in individuals with type 2 diabetes. Some of these individuals also experience difficulty continuing traditional exercise, necessitating the search for safe and effective training methods that contribute to improving their health. The research aimed to develop a deep-water training program supported by nutritional guidelines and to identify its effect on improving vital capacity (FVC), reducing HbA1c levels, and developing physical efficiency in men with type 2 diabetes aged 40–45 years. The researcher used a pre-experimental with a single group pre-test and post-test. The research sample included six men with type 2 diabetes. The training program was implemented for eight weeks, with three sessions per week, totaling 24 training sessions, along with accompanying nutritional guidelines. The results presented according to the data notable contrasts related to the post-test throughout all of the research factors. Vital capacity increased from 3.88 liters to 4.77 liters, a 22.94% improvement, while HbA1c levels decreased from 7.00% to 6.30%, a 10.00% improvement. Physical fitness also increased from 63.32 to 74.23, a 17.23% improvement. The researcher determined that deep-water aquatic training supported by nutritional guidance can effectively enhance the respiratory function, lowered HbA1c levels, and improved physical fitness in men with type 2 diabetes.These findings align with Sustainable Development Goal 3 (good health and well-being) by promoting health, reducing the impact of chronic diseases, and improving quality of life.

Keywords: Deep aquatic training, Vital capacity, HbA1c, Type 2 diabetes

1. Introduction

Structured exercise training is considered a very important scientific method that is usually adopted to infuse physiological and functional adjustments that helps to enhance a person's health and physical fitness efficiency. It contributes to an improved cardiovascular efficiency, more oxygen consumption, and an improved level of a nutritional Energy metabolism. Aerobic and resistance exercises also play a huge difference in enhancing insulin sensitivity and increasing glucose utilization by skeletal muscles, which leads to lower blood sugar and improve disease-related health factors (Richter et al., 2025). Type 2 diabetes mellitus is one of the most prevalent chronic diseases worldwide and represents a growing health challenge due to its association with high morbidity and mortality rates resulting from its cardiovascular and metabolic complications. The disease is identified by impaired blood glucose regulation due to insulin resistance and progressively impaired insulin secretion, making a prolonged periods of elevated blood sugar levels plus adding a negative effect on diffrent body systems (American Diabetes Association, 2024). Glycated hemoglobin (HbA1c) is one of the most significant biosigns used in diagnosing and monitoring diabetes.

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It reveals average blood glucose levels over the last three months, and growing levels are linked with an higher risk of chronic diabetes-related complications (Algamdi et al., 2024). With the continuous increase in the quantity of people with type 2 diabetes, looking for a non-pharmaceutical effective treatment has become a scientific and health urgency. Regular physical activity is at the front of these treatments due to its big role in enhancing insulin sensitivity, lowering blood glucose levels, and improving the functional efficiency of vital organs. Scientific proof revealed that regular exercise adds to improved glycemic control, reduced HbA1c levels, and improved cardiorespiratory fitness in people with type 2 diabetes (Colberg et al., 2022). As people age and their physical activity levels reduce, the possibilty of developing type 2 diabetes is higher, and certain physical and functional abilities, such as muscle strength, joint flexibility, and cardiorespiratory efficiency, may get lower. This can limit individuals' capacity to be in a normal, high-intensity training programs. That's why, recent studies have tried to alternate to the explore different training environments that can give a higher degree of safety and efficiency. Among the most important of these is deep water training, which involves performing exercises in deep water using flotation devices without the feet touching the bottom of the pool (Delevatti et al., 2020). The aquatic environment possesses a range of physical and physiological properties that make it a suitable environment for training individuals with chronic diseases. Buoyancy reduces the impact of body weight and the load on joints and bones, while hydrostatic pressure contributes to improved venous return and increased blood circulation efficiency. Furthermore, water resistance provides a gradual training load that helps develop physical abilities and improve cardiorespiratory fitness without increasing the risk of injuries associated with land-based training (Pendergast et al., 2015).

Biomechanical perspective the aquatic environment offers unique advantages that make it particularly suitable for middle aged individuals with type 2 diabetes. The buoyancy force reduces the effective weight of the body and decreases the ground reaction forces acting on the lower limbs thereby limiting the mechanical stress on weight bearing joints such as the knees hips and ankles. This feature is particularly important for individuals who suffer from obesity low fitness levels or musculoskeletal problems associated with diabetes. The viscosity of water and the resistance generated in multiple directions allow for a gradual increase in the intensity of exercise with a low-impact training environment. These features contribute to performing aerobic exercises and resistance training while reducing the risks of injuries and stress associated with physical activity when compared to traditional land-based training programs. Recent biomechanical studies have confirmed the importance of creating training environments that contribute to improving physical performance while reducing the risks of injuries and facilitating the continuation of physical activity. In this context aquatic training is an effect option to promote therapeutic and functional adaptations while maintaining a high level of safety in individuals with chronic metabolic diseases (Ben Ezzdine et al., 2026).

Several recent studies have indicated the effectiveness of aquatic training in improving health indicators in individuals with type 2 diabetes. In a systematic review and meta-analysis by Andrade et al. (2023), it was found that aquatic training programs led to a significant decrease in HbA1c levels, improved aerobic capacity, reduced blood pressure, and enhanced functional efficiency compared to control groups. Furthermore, experimental studies have shown that regular aquatic training contributes to improved cardiorespiratory response to physical exertion and enhances the ability to perform daily activities in patients with type 2 diabetes (Delevatti et al., 2020). Vital capacity is an important indicator reflecting the efficiency of the respiratory system and its ability to meet the body's oxygen needs during physical activity. Studies have shown that patients with type 2 diabetes may experience a relative decrease in some lung functions due to the metabolic and vascular changes associated with the disease. This makes improving respiratory efficiency an important goal of therapeutic training programs (Klein et al., 2021). Scientific evidence indicates that aquatic exercises contribute to the development of respiratory muscles and improve pulmonary ventilation due to the resistance provided by water during inhalation and exhalation. This can beneficially effect the vital capacity and lung function factors. plus, physical fitness is a key example of functional health in middle-aged individuals, because it is connected to an individual's ability to perform daily life tasks and work actively without notcing increased fatigue. Studies have shown that individuals with type 2 diabetes often suffer from lower levels of physical fitness compared to healthy individuals due to lower aerobic capacity, reduced physical activity, and increased insulin resistance (Myers et al., 2019). That's why, enhancing physical fitness is the main goal of training programs for this group. plus physical activity, the recent scientific advises suggest and insist on the significancy of mixing training programs with nutritional guidance to achieve the most therapeutic outcomes for individuals with type 2 diabetesat the same time a healthy diet means improving glucose control and enhances the effectiveness of exercise in reducing HbA1c and enhancing the overall health. The American Diabetes Association has declared that a regular physical activity with a healthy diet is the main system of managing the disease and controlling its complexes (Practice, 2024). That's why, this study is valuable in shaping an aquatic training program.A review of previous studies and field observations indicated that many individuals with type 2 diabetes face difficulties in regularly participating in traditional land based exercise programs due to fatigue stress joint problems and weight gain which may negatively affect their physical fitness level and ability to manage the disease. Despite the growing interest in aquatic exercises as an effective therapeutic and rehabilitative method local studies examining the impact of deep water training combined with nutritional guidance on functional and health variables in this group remain limited.This led to the following research question: Does a deep water training program supported by nutritional guidance improve vital capacity (FVC), reduce glycated hemoglobin (HbA1c) levels, and enhance physical performance in men aged 40–45 years with type 2 diabetes.

The research goal is:

1. Develop a deep-water aquatic training program supported by nutritional guidelines for men aged 40–45 years with type 2 diabetes.
2. Identify the effect of the developed program on improving vital capacity, reducing glycated hemoglobin (HbA1c) levels, and enhancing physical performance among the research participants. The research hypothesis was that there is a statistically significant relationship between the pre-test and post-test results in the research variables.

2. Research methodology

2.1. Research method

The researcher used a pre-experimental with a single group approach using pre- and post-tests, as it is suitable for the nature of the research problem and its objectives. It is considered one of the most scientific methods capable of revealing the effect of the independent variable (the deep-water training program supported by nutritional guidance) on the dependent variables, which are vital lung capacity (FVC), glycated hemoglobin level (HbA1c), and physical fitness in men with type 2 diabetes.

2.2. Research sample

The research sample was selected purposively from men with type 2 diabetes who frequented the Al-Shaab swimming pool, totaling (6) individuals, who all represented the experimental research sample. The ages of the sample members ranged between (40–45) years, and the training program was implemented during the period from 15/3/2026 to 10/5/2026 at the Al-Shaab swimming pool.

2.3. Data collection methods and equipment used

The researcher relied on a set of tools and equipment necessary to conduct the tests and collect data, they are:

Electronic spirometer (Spirobank II, Italy)‘Nose clip.Chair for the subject.HbA1c analyzer.(Wondfo Biotech, China‘Wooden box (30 cm high).Stopwatch.HbA1c analyzer.Wooden box (30 cm high).Stopwatch.Buoyancy belt for deep water training.Data and results recording forms.

Measurement devices was calibrated and checked following the manufacturers instructions to ensure measurements were accurate and reliable before data collection. Prior to the testing sessions, recommended calibration procedures were performed on the electronic spirometer and routine quality control and calibration procedures in accordance with laboratory standards as well as manufacturer guidelines were used for HbA1c analyzer. To use these procedures to reduce the error of measure and gain precision and reproducibility on the data collected.

2.4. Tests used in the research

First: Forced Vital Capacity (FVC) test
Test objective: To measure the largest amount of air that the subject can expel from the lungs after taking a deep breath to the maximum extent possible.
Equipment used: Electronic spirometer, nose clip, and a chair.
Test procedure: The subject sits comfortably, and the nasal clip is secured to prevent air from escaping the nose. The subject is then asked to inhale as deeply as possible and exhale forcefully and rapidly into the spirometer nozzle until the end of a forced exhalation.
Recording: The result is recorded in liters (L). A higher value is a better indicator of respiratory efficiency.

Second: Glycated Hemoglobin (HbA1c) Test
Test Purpose: To measure the percentage of glucose bound to hemoglobin in the blood, thus determining the average blood sugar level over the previous three months.
Equipment Used: HbA1c analyzer, special tubes for collecting blood samples, sterile blood collection instruments.

Test Method: A venous blood sample is drawn from the patient according to approved medical procedures. The sample is then placed in the designated tube and analyzed using the laboratory device for measuring HbA1c.

Interpretation of Results: Normal: Less than 5.7%; Prediabetes: 5.7–6.4%; Diabetes: 6.5% or higher.

Third: Physical Fitness Test (Harvard Step Test – 3 Minutes).

Test Objective: To measure the level of physical fitness and the efficiency of the cardiorespiratory system.

Equipment: A wooden box (30 cm high). A stopwatch.

Test Procedure: Upon receiving the start signal, the subject climbs and steps onto the box continuously for (3) minutes at a steady pace.

Recording: The pulse is measured during the following recovery periods:

After the first minute after the completion of the exercise.
After the second minute after the completion of the exercise.
After the third minute after the completion of the exercise.

Then, the Physical Fitness Index is calculated using the following equation:

$$F.I. = (100 \times 180) \div [2 \times (P1 + P2 + P3)]$$

Where:

P1 = Number of heartbeats during the first measurement period.
P2 = Number of heartbeats during the second measurement period.
P3 = Number of heartbeats during the third measurement period.

The higher the index value, the higher the level of physical fitness.

All subjects were tested for medical screening and were declared medically fit to participate in moderate to vigorous physical activity before taking part. Participants with unstable cardiovascular disease, serious musculoskeletal disorders or other exercise testing contraindications were excluded. Participants performed the Harvard Step Test in controlled settings, with instructions to stop exercising for symptoms like dizziness chest pain unusual short of breath or more serious emergent symptom onset. the measures was undertaken to safeguard subjects during testing procedure.

The Harvard step test is a composite field-based measure to assess the aerobic capacity and recovery ability. Most previous studies have reported acceptable test-retest reliability and validity for estimating physical fitness and cardiorespiratory efficiency among adult populations. In the current study, all the measurements were performed on participants under standardized conditions with respect to equipment, testing procedures and environmental circumstances at both pre-test and post-test time points to ensure measurement consistency (Dhahbi et al., 2016)

2.5. *Exploratory test*

The researcher conducted the exploratory test on Sunday, March 8, 2026, at 11:00 AM on a sample of two men with type 2 diabetes who were not part of the main research sample.

Standardised testing procedures were used with all measures being undertaken in the same way and under the same conditions to ensure that results are valid. The need for standardization of Clinical and Sensor based assessments in both sports and health sciences has been given more attention, as replicable measurements generate greater accuracy leading to better comparability across studies (Dhahbi & Chamari, 2026).

2.6. *Pre-test*

The researcher conducted the pre-tests and measurements on the research sample on Thursday, March 12, 2026. These included all research variables: forced vital capacity (FVC), glycated hemoglobin (HbA1c), and physical fitness. The conditions of the test were all standard for the sample of participants.

2.7. *Deep aquatic training program supported by nutritional guidance*

The researcher created a deep aquatic training program made to the research goals and the properties of the sample of participants. This program was conducted on special scientific sources, former studies, and the researcher's own experience and time. The program was also under the evaluation of a group of experts and specialists in the field of sports training to ensure its scientific and valid practicality.

Training Program Foundations:

Program Period: (8) weeks.
The amount of the Weekly Sessions: (3).
Training Days: Sunday, Tuesday, and Thursday.
The amount of the Training Sessions: (24).
Time of the Training Session: (40–45) minutes.

Location: Al Shaab Swimming Pool.
Dates: From March 15, 2026, to May 10, 2026.
Training Intensity: (60–80%) of maximum heart rate.
Training Method: Deep water training using a flotation belt.
The training load was progressively increased from moderate to high intensity.

Training Implementation Mechanism:

Float belts were used to maintain the trainees' vertical position in the water, ensuring their feet did not touch the pool floor during the exercises. A series of aerobic and motor exercises suitable for individuals with type 2 diabetes were performed. Blood sugar levels were continuously monitored throughout the program to ensure the participants' safety.

Nutritional guidelines accompanying the program:

Participants were provided with a set of healthy dietary guidelines, including:

- ➢ Eating three main meals daily.
- ➢ Increasing vegetable intake with meals.
- ➢ Consuming lean proteins such as fish, chicken, and legumes.
- ➢ Reducing sugar and soft drink intake.
- ➢ Reducing fried foods and saturated fats.
- ➢ Drinking sufficient amounts of water daily.
- ➢ Eating a piece of fruit if experiencing symptoms of low blood sugar.

2.8. *Post-tests*

After the completion of the training program, the researcher conducted the post-tests and measurements on Tuesday, May 12, 2026, under the same conditions and procedures adopted in the pre-tests, in order to ensure the accuracy of the comparison between the pre- and post-test results and to determine the effect of the training program on the research variables.

3. Discussion and interpretation of the results

Table 1 shows statistically significant differences between the pre-test and post-test in all research variables (vital capacity, HbA1c, and physical fitness), favoring the post-test. The significance level (Sig) values indicate the effectiveness of the deep aquatic training program, supported by nutritional guidance, in producing significant improvements among the research participants.

First: Discussion of the Forced Vital Capacity (FVC) Results:

Table 1 presents important Contrasts between the pre-test and post-test in the Forced Vital Capacity (FVC) variable. The mean increased from 3.88 liters in the pre-test to 4.77 liters in the post-test, with a calculated t-value of 9.01 at a significance level of 0.00028. This shows the positive effect of the deep water training program, supported by nutritional guidance, on improving respiratory efficiency among the research sample.

The researcher properties this big enhancement to the quality of deep water exercises, which gives continuous resistance on the inspiratory and expiratory muscles due to the hydrostatic pressure of the water. This makes it add up to increased respiratory muscle strength, improved lung elasticity, and enhanced pulmonary ventilation efficiency. Other than that water training adds to increased gas exchange efficiency and improved oxygen level consumption, this beneficially impacts lung function factors, including FVC.

Delevatti et al. (2020) reveal that regular aquatic training improves cardiorespiratory responses in individuals with type 2 diabetes due to functional modifications in the circulatory and respiratory systems. (Delevatti et al., 2020). also, Pendergast et al. (2015) presented that the hydrostatic pressure of water climbs respiratory muscle efficiency and enhances respiratory mechanics compared to land-based training. (Pendergast et al., 2015). The discovery's of this study are consistent with those of Andrade et al. (2023), who indicated that aquatic training programs improve aerobic capacity and functional factors related to respiratory efficiency in people with chronic diseases, including type 2 diabetes. (Andrade et al., 2023)

Second: Discussion of the Glycated Hemoglobin (HbA1c) Results:

The results in Table 1 presents a big reduce in the level of glycated hemoglobin (HbA1c). The mean

Table 1. shows the arithmetic means and standard deviation of the pre-test and post-test, the t-test value, and the significance of the differences for the research variables.

Variable	Unit	Pre-test (Mean ± SD)	Post-test (Mean ± SD)	t-value	p-value	Significance
Vital Capacity (FVC)	L	3.88 ± 0.29	4.77 ± 0.49	9.01	0.00028	Significant
HbA1c	%	7.00 ± 0.14	6.30 ± 0.29	10.39	0.00010	Significant
Physical Fitness Efficiency	Score	63.32 ± 1.63	74.23 ± 3.47	9.49	0.00022	Significant

Note. Mean = arithmetic mean; SD = standard deviation. The tabulated t-value at df = 5 and p = 0.05 was 2.57.

decreased from 7.00% in the pre-test to 6.30% in the post-test, with a t-value of 10.39 at a significance level of 0.0001. This indicates the effectiveness of the deep aquatic training program, supported by nutritional guidance, in improving blood glucose control.

The researcher believes that this improvement is due to the direct effect of regular physical activity in increasing glucose uptake by working muscles, improving cellular insulin sensitivity, reducing insulin resistance, and increasing the efficiency of metabolic processes related to energy production during physical activity. Furthermore, the nutritional guidance accompanying the training program contributed to improving the participants' dietary habits and reducing factors that lead to elevated blood glucose levels.

Umpierre et al. (2011) demonstrated that regular exercise programs lead to a significant decrease in HbA1c levels in individuals with type 2 diabetes, especially when conducted in structured and consistent training sessions. (Umpierre et al., 2011) The American Diabetes Association (2024) also confirmed that combining regular physical activity with a healthy diet is one of the most important non-pharmaceutical methods for controlling diabetes and improving metabolic markers. (Practice, 2024) The results of the current study are consistent with the meta-analysis conducted by Andrade et al. (2023), which showed that aquatic exercise effectively contributes to lowering HbA1c levels and improving glucose metabolism in individuals with type 2 diabetes (Andrade et al., 2023). Delevatti et al. (2020) also indicated that moderate-intensity aquatic exercise improves insulin sensitivity and increases glucose transport to working muscles, thus contributing to a reduction in HbA1c levels. (Delevatti et al., 2020).

Furthermore, the aquatic environment provides a sense of comfort and relaxation and reduces psychological stress, which helps individuals maintain their exercise routine and adhere to their training program. This, in turn, positively impacts the health and metabolic indicators of people with diabetes.

Third: Discussion of Physical Fitness efficiency Results:

The results in Table 1 show significant differences between the pre- and post-tests in physical fitness. The mean score increased from (63.32) to (74.23), with a t-value of (9.49) at a significance level of (0.00022). This indicates the positive impact of the training program on developing the physical fitness of the participants.

The researcher attributes this improvement to the nature of deep aquatic training, which provides continuous resistance to movement in all directions. This increases the functional load on the body's muscles and the circulatory-respiratory system in a safe and organized manner. Furthermore, training in an aquatic environment helps increase heart rate and improve venous return due to the hydrostatic pressure of the water, leading to improved cardiac and circulatory efficiency. Fukuie noted that aquatic training contributes to improving cardiac and circulatory functions by increasing heart rate and enhancing the efficiency of blood pumping to working tissues. As Alikhajeh et al. (2025) demonstrated, aquatic aerobic exercise allows for greater training volume while reducing mechanical stress on the joints, leading to improved cardiorespiratory endurance and physical efficiency (Fukuie et al., 2021). The enhancement in physical efficiency can also be connected to physiological modifications which results in eight weeks of full training. These adaptations and modifications can be growing cardiorespiratory efficiency and enhanced muscle utilization and energy level production, which give a response of faster recovery and a lower heart rate after exertion, as directly measured by the Harvard Step Test.

Furthermore, the aquatic environment, with its associated sense of psychological comfort and reduced stress and tension, helps increase participants' motivation to continue training. This contributes to better functional adaptations and improved physical endurance. These findings are consistent with Andrade et al.'s (2023) finding that aquatic training improves functional efficiency and cardiorespiratory fitness in individuals with type 2 diabetes (Andrade et al., 2023). Therefore, the researcher believes that the significant improvement that appeared in the variables of vital capacity, HbA1c and physical efficiency is due to the integrated effect of the deep aquatic training program supported by nutritional guidance, which contributed to creating positive physiological and functional adaptations that were reflected in the efficiency of the circulatory and respiratory systems and improved control of blood sugar levels among the research sample.

4. Conclusions and recommendations

4.1. The researcher concluded the following

- Deep water exercises contributed to the development of the circulatory and respiratory systems, as evidenced by the improvement in vital capacity.
- An improvement in blood glucose control, reflected by lower HbA1c values, followed participation in the deep-water training program with nutritional advice.

4.2. The researcher recommended

- Adopting this type of training for individuals with type 2 diabetes, while adhering to dietary programs.
- Conducting similar studies on other groups, such as women with type 2 diabetes.

Author's declaration

Conflicts of interest

None.

We confirm that all tables and figures in this article are ours and written by the researchers themselves.

Ethical-clearance

This manuscript approved by the Scientific Committee of the College of Physical Education and Sports Sciences, University of Baghdad, Iraq, on (2026/01/10).

Author's contributions

All contributions to this study were carried out by the researchers **Suadad Ibrahim Suhail**, who conducted the study procedures, collected and organized the data, participated in the implementation of the experimental program, and contributed to drafting the manuscript; and who developed the research idea, designed the study, supervised the research procedures, interpreted the results, and reviewed and finalized the manuscript and Statistics, with the assistance of a number of experts: **Aya Hasan** in Translation.

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Data availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Appendix 1: Training Program

Unit sections	exercise	intensity	Repeats and sets	rest between repetitions	rest between sets
Warm-up (10)d	Joint movement in water	30%	5 D	30 seconds	60 seconds
	Walking + arm movements	40%	5 D	30 seconds	60 seconds
Main part	Deep water running	60%	40sx3	30 seconds	60 seconds
	Leg extension and extension exercise in water	60%	30 seconds x 2 × 2	30 seconds	60 seconds
	Arm pull exercise against water resistance	65%	20 seconds x 3 × 2	30 seconds	60 seconds
	Bicycle exercise in water	65%	20 seconds x 3 × 2	30 seconds	60 seconds
	Front kicks	65%	20 seconds x 2 × 3	30 seconds	60 seconds

تأثير التدريب المائي العميق المدعوم بالإرشاد الغذائي في السعة الحيوية للرئتين والهيموغلوبين السكري والكفاءة البدنية لدى الأفراد المصابين بداء السكري من النوع الثاني بأعمار 40–45 سنة

سؤدد ابراهيم سهيل

كلية التربية البدنية وعلوم الرياضة –جامعة بغداد

الخلاصة

تكمن مشكلة البحث في ارتفاع مستويات الهيموغلوبين السكري (HbA1c) وضعف بعض المؤشرات الوظيفية والبدنية لدى الأفراد المصابين بداء السكري من النوع الثاني، فضلاً عن الصعوبة التي يواجهها بعضهم في الاستمرار بممارسة التمارين التقليدية، مما يستدعي البحث عن أساليب تدريبية آمنة وفعّالة تسهم في تحسين حالتهم الصحية. هدف البحث إلى إعداد برنامج تدريب مائي عميق مدعوم بإرشادات غذائية والتعرف على تأثيره في تحسين السعة الحيوية للرئتين) وخفض مستويات الهيموغلوبين السكري وتطوير الكفاءة البدنية لدى الرجال المصابين بداء السكري من النوع الثاني بأعمار (40–45) سنة. استخدم الباحث المنهج التجريبي بتصميم المجموعة الواحدة ذات الاختبارين القبلي والبعدي، وتكوّنت عينة البحث من ستة رجال مصابين بداء السكري من النوع الثاني. نُفِّذ البرنامج التدريبي لمدة ثمانية أسابيع بواقع ثلاث وحدات تدريبية أسبوعياً، ليبلغ مجموع الوحدات التدريبية (24) وحدة تدريبية، مع تطبيق إرشادات غذائية مرافقة. وأظهرت النتائج وجود فروق معنوية لصالح الاختبار البعدي في جميع متغيرات البحث، إذ ارتفعت السعة الحيوية للرئتين من (3.88) لتر إلى (4.77) لتر بنسبة تحسن بلغت (22.94%)، وانخفضت مستويات الهيموغلوبين السكري من (7.00%) إلى (6.30%) بنسبة تحسن بلغت (10.00%)، كما ارتفعت الكفاءة البدنية من (63.32) إلى (74.23) بنسبة تحسن بلغت (17.23%). واستنتج الباحث أن التدريب المائي العميق المدعوم بالإرشاد الغذائي يُعد وسيلة فعّالة لتحسين وظائف الجهاز التنفسي، وخفض مستويات الهيموغلوبين السكري، ورفع مستوى الكفاءة البدنية لدى الرجال المصابين بداء السكري من النوع الثاني، وتتوافق هذه النتائج مع الهدف الثالث من أهداف التنمية المستدامة: الصحة الجيدة والرفاه من خلال تعزيز الصحة والحد من تأثير الأمراض المزمنة وتحسين جودة الحياة.

الكلمات المفتاحية: التدريب المائي العميق؛ السعة الحيوية للرئتين؛ الهيموغلوبين السكري؛ داء السكري من النوع الثاني.